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Enabling ULEV uptake – international leading practice

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Executive summary

Aims

This report aims to highlight leading practices in supporting the adoption of ultra-low emission vehicles (ULEVs) and, based on these, make recommendations on interventions that could be taken in Scotland. Through a series of international case studies and a detailed analysis of what has been effective, the report draws out key areas for action in terms of policy, legislation, investment collaboration and support which could be enacted in the Scottish context to increase ULEV uptake and stimulate related economic activity.

Since the launch of its *Switched On Scotland Roadmap* in 2013, the Scottish Government has taken a co-ordinated approach to enabling organisations and individuals to switch to using electric vehicles; Section 3 of this report summarises the progress made to date. Many of the interventions set out in the Roadmap were inspired to some extent by international best practice. Several years on, the Scottish Government has set a target of phasing out the need for fossil fuelled vehicles by 2032, with the additional aim to phase out the need for all new petrol and diesel vehicles in Scotland's public sector fleet by 2030. Therefore, this report seeks to take a fresh look at international best practice to see what approaches other countries and regions are taking – as well as identifying where there is a lack of best practice.

Findings

Section 4 of this report sets out case studies which explore what has been achieved around ULEV adoption in particular regions, and investigates how this success has been achieved. The case studies were selected based on identifying features of a national or regional ULEV ecosystem which are indicators of holistic and sustainable ULEV growth. The case study regions included:

- Shenzhen, China (see Section 4.1) was the first city in the world to have a fully electric bus fleet and has achieved this whilst maintaining the same number of buses in the fleet. This has been underpinned by an annual subsidy for the three major bus operators in the city to make the transition for each vehicle meeting certain requirements. The ability to charge all electric buses efficiently was achieved through an extensive charging network and by ensuring that the majority of buses were charged overnight whilst taking advantage of lower energy tariffs and then scheduled to recharge at off-peak times during the day.

- The Netherlands (see Section 4.2) has the most comprehensive charging network in Europe with a ratio of public chargers to electric vehicles of 1:7, delivered by a dynamic and competitive market of charging network operators. Key to achieving this has been enabling interoperability across operators in both the fast and rapid charging markets through the creation of a Central Interoperability Register in 2011. This now supports roaming for over 210,000 EV cards/tokens, 90,000 charge stations, and 22 national charge point operators and mobility service providers.
- Japan (see Section 4.3) has a strong ULEV manufacturing industry (e.g. the Nissan Leaf is the biggest selling Battery Electric Vehicle (BEV) in the world). This has been stimulated over a number of years by long term R&D investment due to the strong electric vehicle industry and its economic impact;
- Shanghai, China, features twice (in Sections 4.4 and 4.5) because of the large-scale electric car share scheme, supported by free parking and subsidies for infrastructure, platform development and operation, and their EV consumer awareness campaign centred around an EV demonstration centre;
- California, USA (see Section 4.6) has a high uptake of ULEVs and a dynamic ULEV manufacturing industry as a result of the Zero Emission Vehicle policy introduced 20 years ago which forced manufacturers to produce a defined number of low emission vehicles.;
- Norway (see Section 4.7) is considered the world leader in electric mobility with BEVs making up over 30% of new car sales in 2018. This has been significantly enabled through a sustained and generous programme of incentives, such as an exemption from VAT on purchasing and leasing and 50% reduction in company car tax for EVs.

Recommendations

The case studies outline strong examples of ULEV uptake from around the world and Section 5 sets out a range of policy recommendations which the Scottish Government could consider in this space. It is clear there are still some significant areas to be developed in order to have a fully integrated approach to ULEV deployment. These present real opportunities for Scotland to become world leaders. In particular:

- While there has been significant development of charging infrastructure to date, there is an opportunity to further develop through the design and manufacture of fully integrated charging solutions that encompass on site generation and battery storage solutions as well as incorporating innovative charging techniques.
- The lack of capacity in battery manufacturing across the globe is currently creating a major supply issue effecting the uptake of electric cars. There is an opportunity to explore establishing a battery manufacturing facility to Scotland through a partnership with one or more of the well-established battery manufacturing companies.
- Battery end-of-life management is central to reducing the need for critical raw materials and limiting the risk of shortages. Establishing a large-scale operation recycling/repurposing batteries in Scotland could lead to a number of spin-off opportunities for organisations to be at the cutting edge of what is set to be a major part of the automotive industry.
- Current world leaders in ULEV uptake have been successful in promoting one or two categories of vehicles only. As yet a fully developed holistic approach to the electrification of transport has not been implemented to scale successfully. In conjunction with Transport Scotland's Mobility as a Service initiative, Scotland could become a leader in delivering a fully integrated low carbon solution that encompasses all vehicle types.

Contents

1. Introduction

The global market for Ultra Low Emission Vehicles (ULEVs) is growing; in 2018 over 2.1m plug-in vehicles were sold worldwide, a 64% increase on 2017.[1] Governments across the world have set ambitious targets for ULEV growth in the coming decades; Norway, for example, is aiming for 100% of new cars, urban buses and light commercial vehicles sold in 2025 to be zero emission vehicles, and 75% of new long-distance buses and 50% of new trucks to be zero emission vehicles by 2030.

The Scottish Government's own strategy focuses on the pledge made in 2017 to phase out the need for new petrol and diesel cars and vans across Scotland by 2032, eight years ahead of the UK Government target. In line with advice from the Committee on Climate Change, the Scottish Government has recently proposed amendments to the Climate Change Bill which will set more ambitious targets, including a 2045 target for net-zero emissions of all greenhouse gases. Transport (including aviation and shipping) accounts for approximately 37% of Scotland's total greenhouse gas emissions in 2016; the roll-out of ULEVs is a key to meeting these targets.[2]

Beyond setting targets, the role of national governments in working closely with industry and consumer bodies can significantly influence the development of ULEV markets. Whether it be setting standards, providing subsidies to support the roll-out of ULEVs, funding charging infrastructure or embedding requirements and incentives in legislation and guidance, the interventions that governments take are having an impact on the willingness and ability of businesses and individuals to buy and use ULEVs.

The development of the Scottish Government's '*Switched On Scotland Roadmap*'[3] in 2013 took inspiration and learning from other regions across the world. Building upon this, the '*Switched on Scotland Phase Two Action Plan*'[4] published in 2017 defined Transport Scotland's actions for the second phase of the Roadmap (2017-2020). These focussed actions aim to accelerate the uptake of ULEVs as part of both a wider sustainable transport system and a smart energy grid.

As we approach 2020, it is important to review progress to date and consider future steps that should be taken. Transport Scotland recognise the next stage is critical to supporting the uptake of ULEVs in the broader context of Future Mobility as well as incorporating elements such as Connected and Autonomous Vehicles and Mobility as a Service. As such, new and ambitious approaches will need to be taken particularly in areas which can be advantageous for Scotland's economy.

This report identifies and investigates international best practice which could support Transport Scotland in this next stage of development. It highlights areas in which Scotland can take a leading role and thereby support opportunities for economic growth. At the heart of the Scottish Government's approach to tackling climate change is the concept of "just transition", to make sure no one is left behind. This dimension is also a key consideration within the study.

The report focuses on these key areas:

[1] Electric Car Reports (2019). Global plug-in sales top 2.1M units in 2018.
[2] Transport Scotland (2017). Environment and emissions.
[3] https://www.transport.gov.scot/media/30506/j272736.pdf
[4] https://www.transport.gov.scot/media/39306/switched-on-scotland-phase-2.pdf

Review: To understand what best practice is, it is first necessary to define the 'measures of success'. The measures of success discussed in this report were developed recognising that ULEV uptake is driven by a range of financial, social and societal factors. This report draws on previous analysis and therefore 'Scotland's progress to date' is defined. This ensures that outputs are tailored to enhance existing activities and avoid replication.

Research: The heart of this report is the case studies focussing on seven regions which can be considered as examples of 'international leading practice'. To understand how they have achieved success, information was gathered through in-depth interviews with key representatives from each of the regions, and through detailed desktop research, utilising industry sources (for further information on research methodology and a full list of interviewees see Appendix 1). Each case study focuses on:

- What has been achieved?
- How has this been achieved?
- Who has been instrumental in this?
- What market conditions have made it possible?

Recommend: Having understood the baseline position in Scotland along with international best practice, the final section of the report forms recommendations on how this can be used. Firstly, policy recommendations are made that focus on market conditions to ensure Scotland meets its climate change objectives whilst remaining an attractive investment market. Secondly, the report highlights the industry opportunities, focusing on specific market applications where Scotland could become an industry leader.

Defining ULEVs

ULEVs are defined as vehicles which have tailpipe emissions of less than 75gCO_2/km and have an all-electric range of greater than 10 miles[5]. Throughout this report we will primarily focus on the Battery and Plug-In Hybrid Electric Vehicle (EV) market. Vehicles using alternative fuels such as hydrogen are highlighted where appropriate but, at present, the EV market is considerably more developed and therefore is the dominant technology discussed.

[5] SMMT (2019). Ultra-Low Emission Vehicles.

2. Measures of success

To identify examples of international leading practice, it was first necessary to define what 'good' looks like. The ULEV market is still emerging and uptake remains relatively low, even in leading countries. Therefore, the measures of success that this study has focussed on are features of a national or regional ULEV ecosystem which are indicators of holistic and sustainable ULEV growth. The seven measures of success are defined in Figure 1 and discussed in this section.

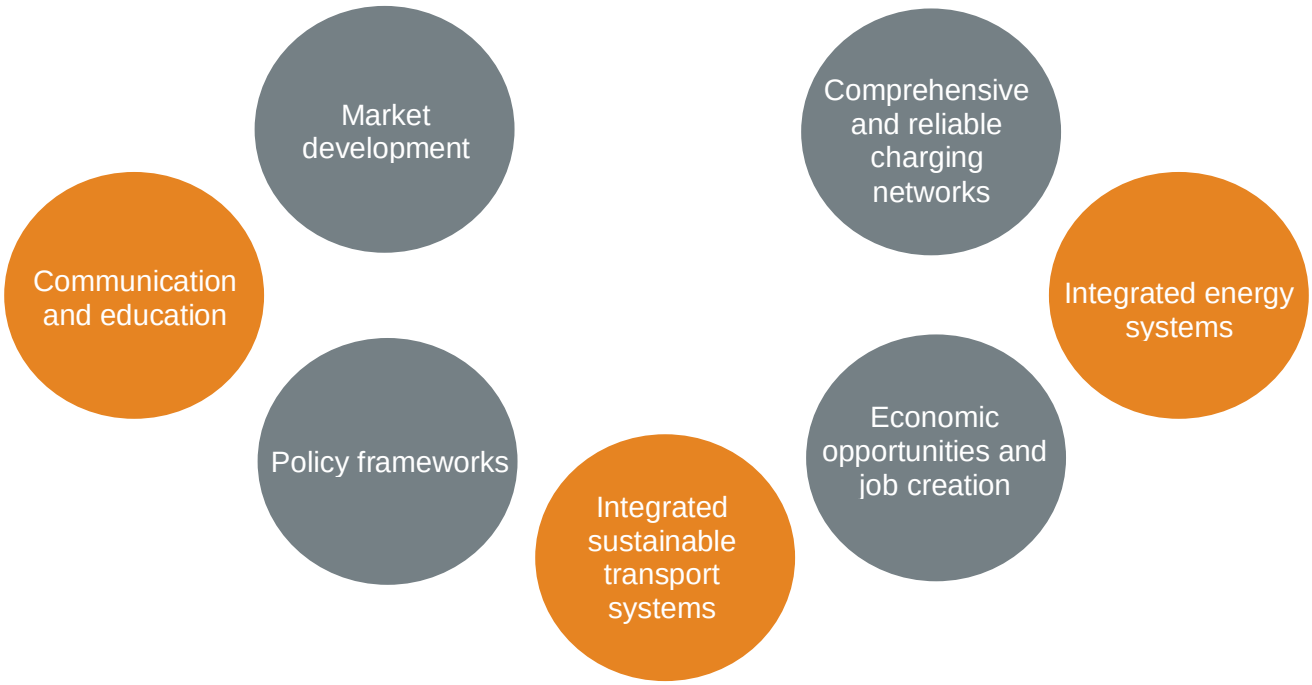


Figure 1: Measures of success

Comprehensive and reliable charging networks

There is a clear link between the availability of public charging infrastructure and the uptake of EVs. Research has shown that once EVs constitute more than 5% of vehicle registrations, then charging infrastructure availability has the strongest impact on further uptake[6]. Charge points need to be well maintained, available and meet drivers' needs. A range of solutions are typically required to accommodate diverse driver habits and domestic accommodation types, for example, those without access to off-street parking. The overall charging network should also cater for a range of different users / vehicle types, such as logistics vehicles and public transportation.

Integrated energy systems

The uptake of EVs and the deployment of EV charging infrastructure creates opportunities for the increased use of renewable energy, particularly in conjunction with demand side management and energy storage. ULEVs can support the role out of renewable energy generation by better balancing supply and demand, thereby reducing the carbon footprint of transport. The 'My electric avenue' project[7] investigated the impact of EV charging on the UK electrical network. The project found that at EV penetration levels beyond 40%, around 32% of the existing local distribution network would require

[6] https://theicct.org/sites/default/files/publications/EV-charging-best-practices_ICCT-white-paper_04102017_vF.pdf
[7] SEPD (2016). My Electric Avenue (I2EV) Project close-down report

upgrading to alleviate thermal and voltage issues. By deploying smart charging methodologies approximately £2.2 billion could therefore be saved in network reinforcement costs in the UK by 2050.[8]

Figure 2: Integrated solar, storage and charging hub. Dundee, Scotland. Sourced from Drive Dundee Electric (2019).

An analysis of EV uptake across Europe[9] found that the EV fleet could be used to 'absorb' excess renewable energy which could produce a net benefit forecasted at around €1 billion per year by 2050. Locations which have demonstrated this integrated approach between ULEVs, the energy network, generation and storage to deliver value are therefore considered in this study.

Economic opportunities and job creation

The development and deployment of ULEVs and associated infrastructure represents significant economic activity. Therefore, this study will also explore how certain regions have created economic prosperity as result of increasing ULEV uptake. Jobs could be created from the manufacture of EVs and batteries as well as design, installation and maintenance of associated charging apparatus. Additionally, there are further opportunities in the sales, servicing, finance and insurance sectors. By 2040, the net impact on the UK supply chain from fuelling EVs rather than fossil fuels could result in the generation of an additional 2,956 jobs[10]. In a wider context the overall impact across Europe of the transition to ULEVs could account for up to 1.1 million jobs by 2030 and 2.3 million by 2050. The case studies featured in this report, therefore, focus on regions where there is a productive ongoing relationship between government and industry, supporting the development of EV technology, infrastructure or associated services.

[8] This project was funded by the Distribution Network Operators innovation allowance.
[9] European Climate Foundation (2018). Low-carbon cars in Europe: A socio-economic assessment
[10] University of Strathclyde centre for energy policy (2019). Who ultimately pays for and who gains from the electricity network upgrade for EVs?

Integrated sustainable transport systems

ULEVs should play an important role in the broader transport system, supporting decarbonisation whilst avoiding additional congestion. A successful EV market will not just be one in which privately owned fossil fuelled vehicles are replaced with privately owned ULEVs, but one which embraces the electrification of transport in the context of a smart, integrated, sustainable mobility system. Global vehicle sales are expected to continue to grow for the foreseeable future, reaching 115 million vehicles per year by 2030[11]. Therefore, without intervention, existing congestion challenges will only continue to be exacerbated. An integrated transport system will therefore include aspects such as highly utilised electric car share schemes, electrification of fleets, logistic vehicles and public transport. Several factors are key to achieving this such as understanding business models used, timescales of deployment and key drivers behind electrification.

Policy frameworks

A successful EV market needs to have a set of cohesive policies that support the adoption of EVs across different modes and ownership types as well as both the public and private sector[12]. This includes regulation which is standardised across departments and considers multiple policy drivers, e.g. climate change, air quality, and energy security. Consideration into how successful EV policy frameworks have been constructed, how policies have been phased in and phased out, as well as evaluation of policies which have catalysed uptake of EVs efficiently should all be analysed to understand best practice in this area.

Communication and education

To ensure fair and equitable access to EV ownership it is important to have education, awareness and marketing that supports confidence in the adoption of EVs. Information provided should be designed for all demographic groups in a country or region. Consumer awareness campaigns which provide reliable information on the benefits of EVs (such as the comparative cost) and support on the practicalities of transitioning to an ULEV are important in increasing EV adoption across different user groups.

Market development

Market success can be defined as the point when EVs become more desirable than conventional fossil fuelled vehicles across different ownership types and modes; this in turn leads to greater market share and the development of a healthy second-hand EV market. The case studies below explore examples from around the world where electrification across different modes is widespread, including the political backdrop to these examples, and the policy levers used to create this success.

[11] McKinsey & Company (2016). Automotive revolution – perspective towards 2030.
[12] International Energy Agency (2018). Nordic EV outlook.

3. Scotland progress to date

In September 2013, Transport Scotland published '*Switched On Scotland: A Roadmap to Widespread Adoption of Plug-in Vehicles'*. This document sets out a strategy for supporting EV growth in the country and freeing Scottish towns, cities and communities from the damaging effects of petrol and diesel-fuelled vehicles by 2050.

During 2019 Scotland hit the milestone of installing over 1000 publicly available EV charge points (see Figure 3). The ongoing development of one of the most comprehensive charging networks in Europe has sought to match the increased demand from EV uptake. Currently, the average distance between any given location to the nearest public charging point is just 2.78 miles in Scotland – compared to 3.77 miles in England[13].

To date, most of the charging infrastructure has been installed and owned by the local authorities. This has been funded by the Scottish and UK Governments through a variety of grant awards and challenge funds, with the private sector only delivering on a small scale.

This method of funding charging infrastructure has led to the Scottish Government having control over the introduction and continued operations of a single back office provider for all the chargers hosted on the ChargePlace Scotland Network. This means that the EV user needs to register with only one organisation and carry one Radio Frequency Identification (RFID) card to gain access to a majority of the chargers in Scotland.

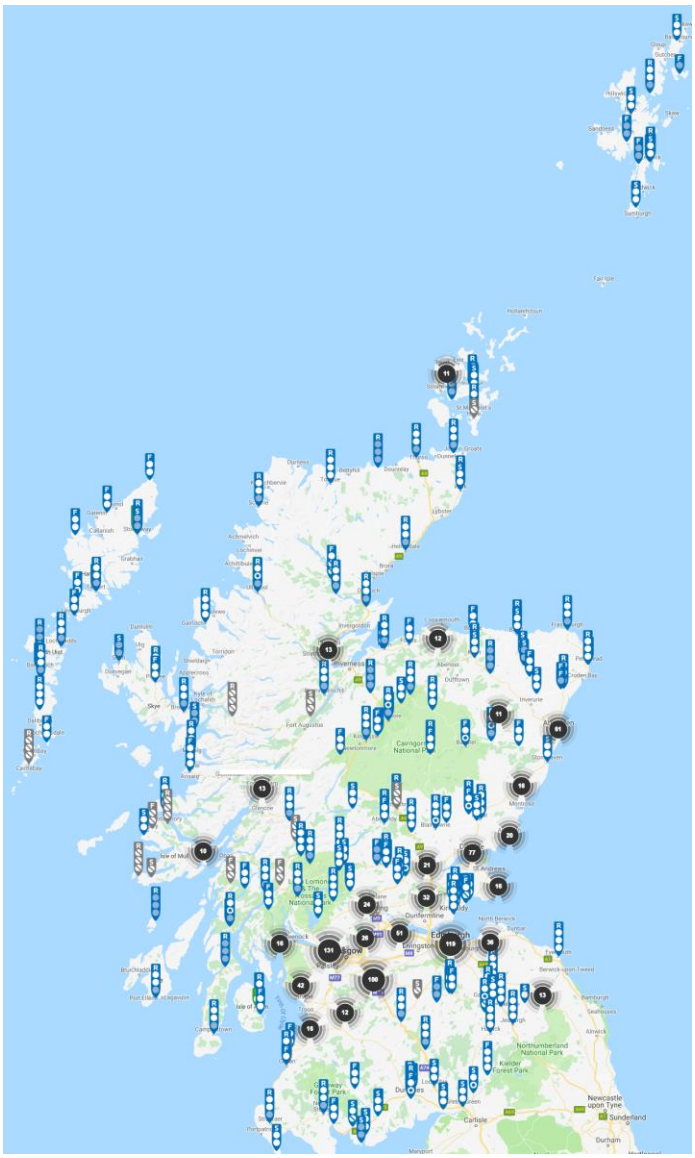


Figure 3: ChargePlace Scotland, charger availability map. (Sourced from Charge Place Scotland)

The UK Department for Transport's vehicle licensing statistics[14] suggest that a total of 7,831 plug-in vehicles will have been registered in Scotland by the end of the first quarter of 2018.

Scotland has also benefitted from identifying Dundee as an exemplar city in the adoption of EVs. The Scottish Government has supported Dundee to realise their ambitions with recognition of this through the award of '*Europe's Most Visionary EV City*' in 2018 by the World Electric Vehicle Association. Dundee has installed some of the most innovative and extensive charging infrastructure of any city in the UK, it achieves the highest utilisation rate of chargers in Scotland.

The original *'Switched On Scotland roadmap'* was refreshed in 2017 with an updated version '*Switched On Scotland Phase Two: An Action Plan For Growth'.* This summarised the work undertaken to date

[13] Transport Scotland (2019). Over 1,000 electric vehicle charge points in Scotland.
[14] DfT (2019). Vehicle Licensing Statistics.

as well as reviewing and updating the actions identified in the original report.

The Scottish Government also delivered an ambitious *'Scottish Energy Strategy'* which was launched in December 2017. The strategy included the role of EVs in its whole-systems approach to introducing new and smarter ways to generate and store renewable energy. Similarly, EVs also feature in the Scottish Government's *'Climate Change Plan'*. The Scottish Government's ambitions were furthered enhanced in 2017 with the commitment to phase out the need for petrol and diesel vehicles by 2032, eight years ahead of the UK Government. The Scottish Government invested £15 million for an additional 1,500 new charge points in homes, businesses and local authority land to ensure that EV owners across Scotland have access to EV charging infrastructure.

The Scottish Government has supported local authorities in stimulating EV uptake in three main ways:

- Providing a significant allocation of funding for the delivery of charging infrastructure as well as financial support for the back-office systems required. This funding has primarily been in the form of grants to local authorities to install and manage infrastructure in their area. This funding has also been available to businesses to support them with installing infrastructure on their premises.

- Making significant funding available to support the deployment of EVs into public sector fleets through a programme of grant funded programmes. The Scottish and UK Governments have also provided financial support and incentives to businesses to make that switch.

- Delivering a policy framework and roadmaps that not only support the introduction of EVs but fully embed the introduction of EVs into all policy areas. This is clearly visible in the role EVs take in the overarching energy strategy.

Local authorities have also played a key role in the progress that has been made to date. Successful local authorities have recognised how the introduction of EVs in their area can tackle a number of local issues, such as poor air quality in cities.

The Scottish Government has introduced the EV loan scheme which offers zero interest loans to EVs under £35,000. This builds upon the subsidies offered by the UK Government's Office for Low Emission Vehicles. In addition, the Scottish Government has supported a number of policies that reduce the whole life costs of owning a vehicle. Some of the key interventions to date have been the support for free electricity for a fixed period as part of the infrastructure funding as well as the offer of free parking in certain locations for EVs.

4. International best practice: Case studies

In this section seven case studies will be discussed relating to regions that have exhibited leading practice in relation to the measures of success detailed in Section 2. The regions investigated are shown in Figure 4.

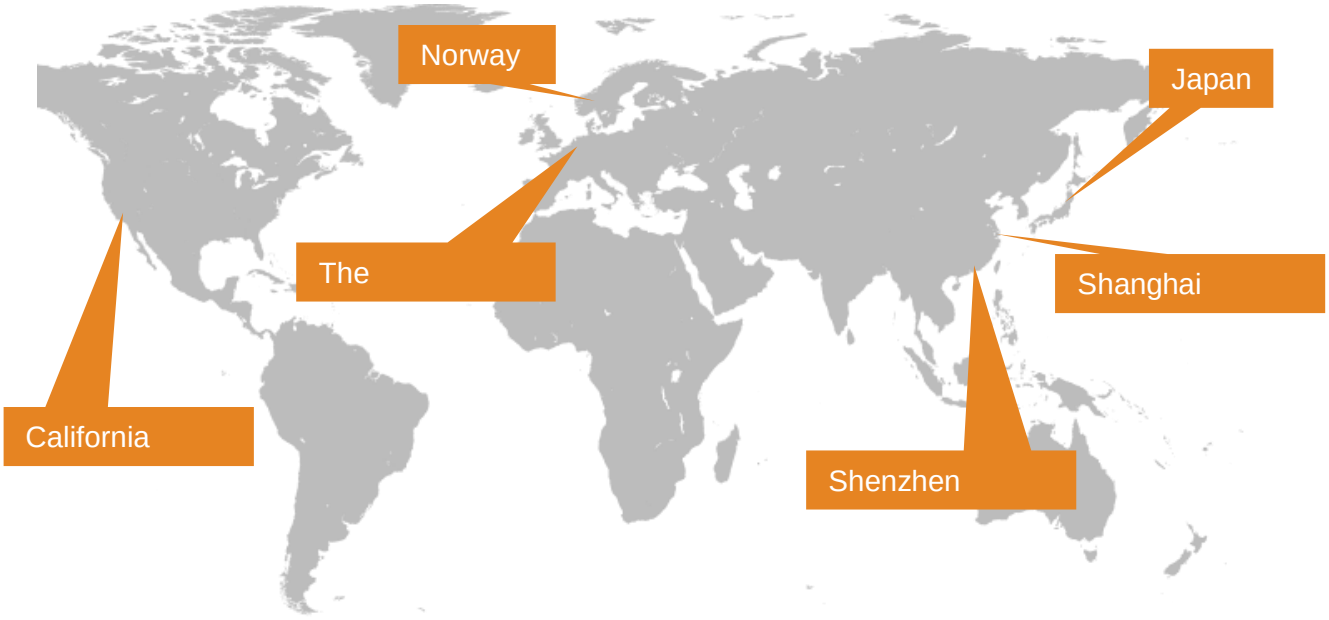


Figure 4: International best practice case studies

4.1. Shenzhen (China): Efficient charging of electric buses

What has been achieved?

The city of Shenzhen in China was the first city in the world to fully electrify its entire bus fleet. This was completed by the end of 2017 when all 16,359 of its buses were replaced, notably without increasing the overall number of buses in the fleet. Other cities that have tried to achieve the same goals as Shenzhen have found themselves requiring up to 100% more buses than the diesel alternatives due to the reduced range of the buses and the time requirement to charge. This achievement has been made possible by completely optimising its operations to account for the range of the vehicles and accounting for the requirement to recharge.

All 16,359 of Shenzhen's buses were replaced, without increasing the overall number of buses in the fleet.

How has this been achieved?

Managing the complete transition of a city's bus fleet to electric-only has been underpinned by a long-term plan with full buy-in from all parties. The process in Shenzhen started in 2013 when the city became a pilot city for the introduction of New Energy Vehicles (NEVs). In 2016, the electrification of the bus fleet became the top priority public transportation project in the city.

To incentivise the three major bus operators in the city to make the transition, each was provided with an annual subsidy of 500,000 yuan (approximately £58,000) for each vehicle. This was made up of 400,000 yuan from the local Shenzhen authorities and 100,000 yuan from the central government in China. To be eligible for the subsidies, an electric bus must travel more than 60,000 km per year,

encouraging high utilisation. The key driver behind the subsidies was to provide the bus operator with price parity with diesel buses and so allow them to compete on an even playing field.

One of the key challenges that the bus operators had to overcome was the ability to charge all their electric buses efficiently. This was achieved by ensuring that the majority of buses were charged overnight whilst taking advantage of the lower energy tariffs. The buses were then scheduled to recharge at off-peak times during the day. The reality of this extensive charging requirement is that the city had to introduce 510 bus charging stations with a total of 8000 charge points. The city government assisted in supporting the accelerated provision of charging locations and the associated infrastructure required to facility the rapid change.

More than 80% of the electric buses that have been deployed have been supplied by BYD, and a key factor in achieving bus fleet electrification was that the bus manufacturers' headquarters are based in the city of Shenzhen. This partnership model was central to overcoming some of the initial challenges that were faced when introducing the first generation of the buses. There were a number of safety issues identified at the beginning of the trial. However, as all parties were committed to the project's success these issues were overcome by the introduction of strict safety standards and a 'lifetime guarantee' on BYD buses.

Figure 5: BYD EV charging station (Sourced from Flickr)

Who has been instrumental in this?

The success of this project in Shenzhen has been made possible by the clear direction that was given by the central Chinese government. This was initially evident in the introduction of pilot city projects in relation to their New Energy Vehicle (NEV) programme. This early support was then followed by long term strategies, which were boosted by clear electrification targets and financial support in the early stages, to recognise the requirement from operators to have price parity with conventional vehicles. This support for the programme was further enhanced when the government recognised that to reach the levels of electrification targeted, interventions to support the accelerated deployment of charging infrastructure were needed.

Another important factor in the large-scale deployment of the new technology has been the positive relationship between the local authorities, government and bus manufacturers. It is imperative for the success of projects on this scale that all parties involved understand the mutual benefits of the strategic goals and are willing to work together to overcome any issues that arise.

What market conditions have made this possible?

One of the key conditions that has made the deployment of a fully electric fleet of buses in Shenzhen possible has been the direction from the Chinese government in enacting their NEV policy (see adjacent text box).

The market in Shenzhen has been supported by a number of national government interventions. Some of the most successful have included the incentives and tax exemptions to the manufacturers of NEVs. This has then been further supported by the NEV credit system and the introduction of subsidies for EV operators as described previously in this case study. These interventions have been introduced at the same time as ambitious electrification targets for market segments such as the requirement for 70% of new vehicles purchased by the local government to be electric.

The New Energy Vehicle policy

The New Energy Vehicle (NEV) policy is a long-term supply-side policy to increase the number of EVs manufactured and sold in China. Similar to the Zero Emission Vehicle mandates in California (see section 4.6), this mandates the number of NEVs (e.g. fully electric, plug-in hybrid, hydrogen fuel cell vehicles) which are produced in the country by each manufacturer. Different NEVs are assigned different numbers of credits and manufacturers must meet their average NEV credit target. Credits can either be sold or used to support other projects.

Unlike other regions where equivalent approaches have been deployed, such as California, the Chinese government has faced little resistance from manufacturers.

The government has also introduced a suite of interventions that are targeted at improving the uptake of EVs. These include free roadside parking and the deployment of public charging infrastructure. While the government has significantly contributed to the introduction of EVs through its programme of subsidies and credit exchange programmes, it has begun the process of slowly decreasing the subsidy available by increasing the threshold. The government clearly understood that they had to incentivise authorities and businesses to create a market for the products that would eventually drive down costs through market pressures, thus removing the requirement for long-term interventions.

Shenzhen also has the world's largest heavy-duty fleet of vehicles and a fleet of 22,000 pure EVs.

The government in China has continued to use NEV pilots in various cities to test and prove the new technologies work and at the same time create the market conditions to drive down costs; these were first introduced in 5 cities in 2009 and will run through to 2020. The government has also created 4 ministries to support the transition to ULEVs due to the complex nature of the industry, but this is also in recognition that the country as a whole contains the entire supply chain for the manufacturing of EVs.

The pilot EV cities were identified from central government and therefore central government has been a driving force for the electrification of transport modes in these cities. Although there are some devolved powers given to city authorities such as Shenzhen there is largely a centralised government mandate they have followed.

All of these factors have led the city of Shenzhen to not only have a full bus fleet of EVs but the world's largest heavy-duty fleet of vehicles and a fleet of 22,000 pure EVs.

4.2. The Netherlands: The region with the best charge point coverage in Europe

What has been achieved?

The key success of the Netherlands has been the rapid deployment of the most comprehensive EV charging infrastructure in any European country; the Netherlands has Europe's most charge points installed per head of population as well the most charge points per EV. This has removed one of the most significant barriers to private EV ownership - the reliable availability of charging infrastructure. The infrastructure that has been installed has mainly been fast (Level 2) chargers in cities where there is very limited private parking. This has led to there being a ratio of public chargers to electric vehicles of 1:7[15] , much higher than the figure of 1:10 detailed in European Directive on Alternative Fuels.

Figure 6: Typical vehicle charging in The Netherlands

The key to this success has been the large-scale adoption of standardisation for public charging in The Netherlands. This has been achieved through a focus on the interoperability of the chargers to ensure that the end user not only receives a consistent experience, but it allowed for competition within the market while retaining a degree of control.

How has this been achieved?

The success of the infrastructure deployment in The Netherlands has been down to a number of organisations following the same deployment model. The early deployment of infrastructure was carried out by the foundation ElaadNL that was created by six power network operators in the country and is responsible for the upkeep of around 3,000 stations across the country. This initial rollout of infrastructure has then been backed up by some innovative partnerships in regions across the country. In Amsterdam, the city-operated the Elektrisch programm, (run in partnership with the utility company Noun) which has installed a significant number of on-street chargers, with the aim of ensuring that all residents of Amsterdam have a place to charge an EV. This partnership approach has also been adopted by other cities including Utrecht and The Hague.[16]

The Central Interoperability Register supports roaming for over 210,000 EV cards/tokens, 90,000 charge stations, and 22 national charge point operators and mobility service providers, ensuring that an EV driver could charge at any charging station across the country.

To ensure that the infrastructure installed does not become redundant or overtaken by a new network, The Netherlands has had standardisation and interoperability controls in place since 2011. This is controlled by the Central Interoperability Register (CIR)[17] which was established to ensure that all cards or tokens issued for the charging infrastructure across The Netherlands by active service providers would be supported on any charger. By 2018, the CIR supported roaming for over 210,000 EV cards/tokens, 90,000 charge stations, and 22 national charge point operators and mobility service providers, ensuring that an EV driver could charge at any charging station across the country. The ability for e-roaming across the country's network is made achievable through the communication protocols that are responsible for the transfer of information between stakeholders, including charge point

[15] ICCT (2017). Emerging best practices for electrical vehicle charging infrastructure.
[16] Gemeente Amsterdam (2017). Openbaar oplaadpunt aanvragen [Public charging station applications].
[17] World Electric Vehicle Journal (2018). Advancing e-roaming in Europe: towards a single "language" for the European charging infrastructure.

operators, mobility service providers etc. The Open Charge Point Information (OCPI) protocol facilitates a simplified solution for the end user and can support enhancements to any infrastructure such as remote start and stopping of sessions, online booking of charging points and the exchange of information regarding tariffs at each site.

In 2014, The Netherlands Knowledge Platform for Public Charging Infrastructure (NKL) was formed. The NKL, an independent, not-for-profit organisation, took up the development of OCPI protocol to further enhance the interoperability of charging, their protocols are now seen as the standard in Europe and North America. In 2017, the Fast Charging Alliance agreed to join the e-roaming initiative across the country. This group of fast charger operators agreed to implement the latest OCPI protocol to enable the interoperability of fast chargers across Europe.

Who has been instrumental in this?

As mentioned, the success of the infrastructure in The Netherlands has been the interoperability across a variety of operators in both the fast and rapid charging markets. The ability to make this happen was down to the early creation of the CIR which has been in place in 2011 and was created with the support of the Dutch Government. This set the standard for current and future operators so providing a consistency and stability to the market.

The Netherlands has also benefitted from a number of the utility companies having an early engagement in the installation and maintenance of charging infrastructure across the country. This initial deployment kickstarted the market.

What market conditions have made this possible?

The Dutch Government has played a key role in ensuring that the market conditions existed in The Netherlands for the large-scale adoption of EVs. The country is one of the most densely populated in Europe with 90% of the population living in urban areas. The country does not have any large-scale car manufacturers and only a limited vehicles parts manufacturing industry.[18] The absence of a strong car lobby, can at times make it easier to implement targeted government interventions.

In 2009, in response to rising greenhouse gas emissions from the transport sector, the Dutch Government introduced its first action plan for delivering large scale adoption of EVs, this recommended the setting up of a task force that would have overall responsibility for the adoption of EVs in the country. As well as setting up the governance to oversee the adoption of EVs, the taskforce also introduced a wide range of activities that would support the uptake of vehicles, including pilot projects in various cities that would support research and development in this area, the installation of infrastructure in major cities, and the more direct introduction of financial incentives for the purchase of EVs.[19] A number of the financial incentives were devised to directly encourage businesses to make the switch, these included subsidies for electric taxis and delivery vans. The Dutch Government also set targets for adoption of 15,000 to 20,000 registered EVs by 2015, 200,000 by 2020, and 1 million EVs by 2025.

All these activities in The Netherlands have been supported by a variety of promotional activities from showcasing the country's mobility solutions at international trade shows to Clean Air Rallies in a number of major cities in the country. These activities are also backed up by websites (such as Nederland elektrisch) which provide information to educate the consumer on the advantages and cost savings associated with the owning of an EV.

[18] ICCT (2016). Comparison of electric vehicle policy and deployment in Europe.
[19] Netherlands Enterprise Agency (RVO) (2011, October 3). Electric Mobility Gets Up to Speed—2011–2015 Action Plan. Ministry of Economic Affairs.

4.3. Japan: A strong ULEV automotive industry

What has been achieved?

Japan is a country that can boast some of the largest car manufacturers in the world, including Toyota Group, Mitsubishi, Mazda, Nissan, Honda, Suzuki. A number of these large manufacturers have been at the cutting edge of the development of electric vehicles for the mass market, with the Toyota Prius as the Low Emission Vehicle with the greatest worldwide deployment and the Nissan Leaf as the BEV with greatest cumulative sales worldwide. The ULEV market is still at its early stages of development and offers significant opportunities in Japan.

Figure 7: A Nissan Leaf plugging in (Sourced from Pixabay)

How has this been achieved?

The Japanese Government has utilised economic and regulatory instruments for both consumers and manufacturers[20] to stimulate the ULEV market. Since the 1970s, the Japanese Government has initiated several research and development projects for ULEVs which have not only assisted in creating a significant ULEV manufacturing base in the country but has also created a local knowledge base which has led to spill-overs within and beyond the car industry, as other firms such as battery producers were also included[21]. Competition between Japanese car firms seems to have been an important driver to battery developments[22]. The ZEV mandate in California influenced policy measures in other countries with significant car industries; it pushed Japan to adopt its BPEV (Battery Powered EV) expansion plan.

Japanese fuel efficiency standards also provide an incentive to manufacturers to develop and deploy ULEV technologies. The Ministry of International Trade and Industry (MITI) has favoured a voluntary approach, but it led to compliance as firms did not want to risk being excluded from receiving benefits from the Ministry in return[23]. Under the Energy Conservation Law, standards were implemented under the technology neutral "Top Runner" program. Energy efficiency targets are set to be achieved within a given number of years on the basis of the most efficient model on the market (the 'Top Runner'). Products which do meet the energy efficiency standard receive a Top Runner label at the point of sale; those which do not are labelled differently. This drives companies to try to make ever more efficient models to compete for the award of Japan's 'Top Runner'. Both domestic manufacturers and importers of more than 2000 vehicles are covered by the standards. From 2007, vehicle efficiency improvements were implemented using a sliding scale depending on vehicle weight, these improvements have been reassessed on a regular basis incentivising gradual decarbonisation of the fleet.

[20] Styczynski, Hughes (2019). Public policy strategies for next-generation vehicle technologies: An overnew of leading markets. Environmental Innovation and Societal Transitions 31 pp. 262-272.
[21] Ahman (2006). Government policy and the development of electric vehicles in Japan. Energy Policy 34 (4) pp. 433-443.
[22] H. Pohl, M. Yarime (2012). Integrating innovation system and management concepts: the development of electric and hybrid electric vehicles in Japan. Technology Forecasting and Societal Change., 79, pp. 1431-1446.
[23] Ahman (2006). Government policy and the development of electric vehicles in Japan. Energy Policy 34 (4) pp. 433-443.

Who has been instrumental in this?

The Japanese Government has adopted a mix of policies, using fiscal incentives targeting both manufacturers and consumers to promote research, development, and deployment of BEVs, Plug-in Hybrid Electric Vehicles (PHEVs), and Fuel Cell Electric Vehicles (FCEVs). These incentives included regulatory benefits for consumers, and deployment targets for manufacturers. The Japanese Government implemented policies domestically to enable Japanese firms to better compete in foreign markets such as ensuring that standards aligned with California's ZEV mandates[24].

What market conditions have made this possible?

The Japanese Government has implemented long term support of ULEV deployment. The Japanese Government formulated its next-generation vehicle (NGV) policy priorities in the 'NGV 2010'. The strategy set deployment targets across NGV technology types, with a FCEV target of 1% of vehicle registrations by 2020, and 3% by 2030. For BEV and PHEVs, the target was 15–20% of vehicle registrations by 2020, and 20–30% by 2030. The inclusion of BEVs, PHEVs, and FCEVs shows the government adopted a technology-neutral approach to NGV deployment, similar to UK Government policy.

The next-generation vehicle policy is targeting 15–20% of vehicle registrations to be BEV or PHEVs by 2020, and 20–30% by 2030.

A number of additional policies were implemented at the regional level through the "EV/PHV Town" initiative. Regions were selected, in two rounds in 2009 and 2010, with the national government then helping develop a series of best practices for promoting NGVs. This included measures such as information provision and labelling, along with the deployment of NGVs in local public transport which included FCEVs.

On the consumer side, both tax and subsidy instruments have been implemented. The Ministry of Land, Infrastructure, and Transport oversees an "Eco-car Tax Reduction", and "Preferential Measures on Greening Autos". This applied to vehicles that outperform established emissions or fuel consumption standards, these approaches were therefore technology-neutral. In addition, under the 2014 Clean Energy Vehicle subsidy, a fixed payment which was graduated by vehicle technology was made to consumers in order to lower the purchase price[25].

Due to the large market share of Japanese car firms in the US, US policy has affected Japanese vehicle policy [26]. For this reason, the Japanese Government therefore deliberately tried to mirror US policies. This started in the 1970s, when Japan started regulating local car pollutants to help domestic firms to be better able to comply with the regulatory demands in the US market and continued in the 1990s when the Californian ZEV regulation gave a push the Japanese BPEV programme[27].

[24] D. Gerard, L.B. Lave. (2005). Implementing technology-forcing policies: the 1970 Clean Air Act Amendments and the introduction of advanced automotive emissions controls in the United States. Technological Forecasting and Societal Change, 72, pp. 761-778,
[25] GOJNihon Saiko Senryaku Kaitei (2015). Japan Revitalization Plan – 2015 Revision.
[26] D. Gerard, L.B. Lave. (2005). Implementing technology-forcing policies: the 1970 Clean Air Act Amendments and the introduction of advanced automotive emissions controls in the United States. Technological Forecasting and Societal Change, 72, pp. 761-778,
[27] Ahman (2006). Government policy and the development of electric vehicles in Japan. Energy Policy 34 (4) pp 433-443.

4.4. Shanghai (China): Because of their successful EV car share scheme.

What has been achieved?

Shanghai has delivered one of the largest electric vehicle car sharing schemes in the world with over 7,700 electric vehicles to serve a population estimated to be over 26 million people. The introduction of car sharing schemes is becoming a key part of any cities transport network and the majority of these are looking to include at least some electric vehicles. Shanghai currently uses the EVCard service which is now being used by 38 other cities in China, however there are other companies competing in this space in China including United Journey in Shenzhen.

Figure 8: A Roewe Ei5 in the EVCard scheme (Sourced from Wikimedia)

The EVCard program was first launched in 2014 and is a membership based self-service scheme. This scheme attracted central government support as one of the first car share schemes in China, it started with a single Chinese vehicle model and has now expanded to more than 20 cities with a fleet of 8,400 electric vehicles made up of a number of different EV models.[12]

How has this been achieved?

In February 2016, the Shanghai local government set targets for car-sharing of 6,000 locations throughout the city with 20,000 new energy vehicles (NEV) and 30,000 charging points by 2020. This was enhanced by offering free parking spaces to car-sharing operators. The local government is looking to influence all aspects of electric vehicle car sharing; therefore subsidies were granted for platform development, charging infrastructure development as well as the operation of car sharing schemes. In addition, Shanghai's Jiading district is supporting car-sharing via a subsidy of EUR 5,180 per NEV per year. This level of local intervention can also be seen in Chengdu and Wuhan.[13]

The Chinese Government has identified a number of pilot cities across the country to introduce new incentives to promote the uptake of electric vehicles. Six of these cities including Shanghai have imposed a cap on the number of new license plates that can be issued every year, with the aim of controlling the number of vehicles in the city in order to mitigate traffic congestion. This process has allowed these cities to offer incentives for electric vehicle ownership, for example, Shanghai free licence plates are offered to electric vehicles while an internal combustion engine (ICE) vehicle has to go to auction to secure its plate. In Shanghai's plate auction system only 11,388 out of 244,868 applicants received a plate for an average price of about EUR 11,400. In Beijing the new licence plates are given out through a lottery while other pilot cities use a mix of both auctions and lotteries in order to increase licences for electric vehicles over ICE vehicles.

Who has been instrumental in this?

The local governments in pilot cities have been key to this adoption of electric car-sharing vehicles by making it easier and less expensive to receive a licence for an EV. They have also set some stringent targets for the introduction of electric car sharing schemes.

As well as controlling the vehicles arriving in the city the districts within Shanghai have also been providing additional subsidies to the car-sharing operators if they introduce new energy vehicles to their fleets.

What market conditions have made this possible?

The sharing economy is expected to account for more than 10 percent of China's GDP by 2020.

In June 2017, the National Development and Reform Commission (NDRC) released a guideline for the development and promotion of the sharing economy, which is expected to account for more than 10 percent of China's GDP by 2020. This aims to guide the balance between encouraging innovation in sharing while regulating the sector and ensuring orderly competition. The call for innovation covers car-sharing as part of the sharing economy, even if car-sharing is not specifically mentioned in the guideline. This was supported in August 2017 when the Ministry of Transport together with the Ministry of Housing and Urban-Rural Development released a guiding policy draft for the promotion of car-sharing with the use of NEVs as a priority.

Despite significant investment and expansion, the public transport system in Shanghai still cannot meet the demand of the city's population and leads to overloaded systems and low levels of comfort on journeys. There is also a limited number of taxis available in the city and during rush hours there are often supply issues at the key transport hubs in the cities. These limitations in public transport options along with the number of new licence plates available in the city have ensured that the market for electric car-sharing operators is well developed, according to Roland Berger, in 2020 there will be 355 million driver license holders but only 195 million passenger cars in China. The car sharing model also addresses the high cost of vehicle ownership with the user having no purchase or maintenance costs and the vehicles being exempt from parking fees in the city.

4.5. Shanghai (China): Increasing awareness through the EV demonstration centre

What has been achieved?

Shanghai has created an EV Zone which is dedicated to establishing strong integration of LEVs into people's lives in the city through direct and interpersonal interactions, that address the specific issues of the visitors to the centre. The EV Zone is devoted to helping individuals understand how and why LEVs are a viable option for transportation, by providing real life examples of important benefits. This is helping overcome existing barriers to LEV adoption. This is being achieved by promoting a number of key initiatives including EV car sharing in the city (as discussed in Section 4.4), an electric vehicle rental plan and providing the opportunity to test drive electric vehicles through an agreement with manufacturers giving access to 160 vehicles, which has provided up to 80,000 free test drives to date. The EV Zone also features charging infrastructure and runs educational programmes for the public.

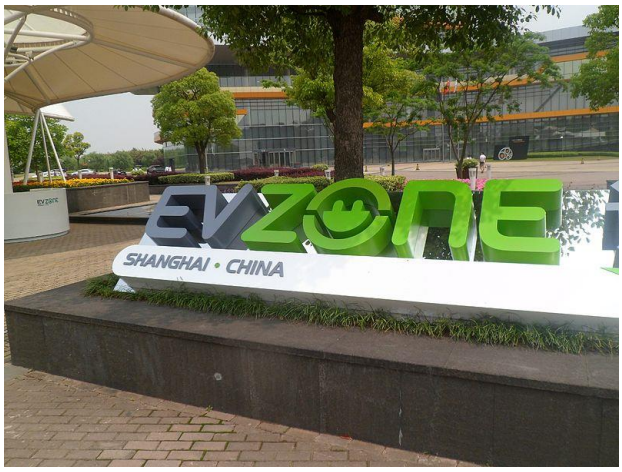


Figure 9: Shanghai's EV Zone demonstration centre (Sourced from Wikimedia)

It also has a centre to support the importing of electric vehicles into the country by making easy the customs procedures for the consumer as simple as possible.

How has this been achieved?

The EV Zone is a multi-faceted facility that can boast more than 50 organisations representing different areas of the industry as partners in the Zone, including Nissan, General Motors, BYD, Chery, Das Auto, ABB, Siemens, Bosch, ThyssenKrupp, Hertz, State Grid, Tongji University, SAE China, China Pacific Insurance Group. The Zone has four centres that each serve a different purpose, these

are YTest Drive area, Business Innovation, Data Collection and Monitoring and Operation and Service.

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. The 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.

Who has been instrumental in this?

The EV revolution has been given impetus in Shanghai as it was conferred the status "International EV Demonstration City" by the Chinese Government. The EV Zone has been achieved through a partnership of organisations with a common goal to support the integration of electric vehicles in to the residents' lives.

What market conditions have made this possible?

See Section 4.4 for a discussion on the market conditions in Shanghai that have made this EV Zone successful as well as the adoption of EVs in the city.

4.6. California (USA): Long-standing policy success in stimulating ULEV adoption

What has been achieved?

The work done in this field has not only produced high EV sales but has also created a car manufacturing industry in the area utilising the expertise that already existed in the region.

How has this been achieved?

The high number of electric vehicles and the associated supply chain activities in California are mainly down to a three-legged strategy from the state government. Policy can be categorized into either supply side policy, incentives for both business and consumers or infrastructure provision and accessibility.

Figure 10: Tesla's Headquarters in Palo Alto (Sourced from Wikimedia)

Over 20 years ago ZEV (Zero Emission Vehicle) mandates were introduced in the region with the aim of improving urban air quality by forcing vehicle manufacturers to produce a defined number of low emission vehicles, this was implemented for manufacturers who were producing over 20,000 units. These mandates were regularly readdressed by the California Air Resources Board (CARB) to continue to direct manufacturers to innovate beyond current low emission technology. The ZEV mandates have been updated a number of times since their introduction and are set to become more stringent. Credits are awarded to a manufacturer on the delivery of a vehicle and are based on the battery electric range and battery size of the vehicle. These targets are set to result in a market share of about 8% of ZEVs

The Zero Emission Vehicle Mandates were introduced in California over 20 years ago and are set to result in a market share of about 8% of ZEVs in California by 2025.

in California by 2025 according to the CARB[28]. The system does offer the manufacturers some flexibility with the ability to bank excess credits until a future date or trade them with other manufacturers, however, there are financial penalties for any manufacturer who does not comply. This policy is seen as a cost-effective way of increasing the sales of electric vehicles in a region, it is argued that it is more successful than offering financial incentives to the purchaser. Since 2008 the ZEV mandates have also applied emission limits to buses and public transit vehicles in the region. This has mandated the operators of large fleets to abide by minimum ZEV quotas when replacing their fleet. This policy was updated in 2018 to significantly increase the number of ZEV buses in the region, therefore by 2023 25% of new buses purchased annually by the larger organisations will be ZEV and this will increase to 50% by 2026 and then 100% by 2029.

The 2nd part of the strategy was to offer fiscal incentives to the end user to stimulate the demand for the product. The vehicle rebate project offered up to $7000 for the purchase or lease of a new and eligible ULEV. These incentives were enhanced in certain areas including Los Angeles, San Diego, San Francisco and San Jose where electric vehicles have full access to High Occupancy Vehicle (HOV) lanes as well as discounts on the bridge tolls in the area.

The final part of the strategy in California is centred around the deployment of infrastructure in the region to support the large-scale adoption of electric vehicles. There have been several schemes administered to try and encourage the increase in infrastructure required, these include.

- An Electric Vehicle Service Equipment (EVSE) loans and rebate program: The EV Charging Station Financing Program was introduced to provide loans for the design, development, purchase, and installation of EVSE at small business locations in California. [29]
- EVSE Pilot programs: The California Public Utilities Commission (PUC) provides funding for pilot utility programs to install EVSE at school facilities, other educational institutions, and state parks or beaches.
- EVSE Incentive program support: provides guidance and funding for local governments and organisations to develop and implement EVSE incentive programs.
- Residential EVSE Financing Program: Property-Assessed Clean Energy (PACE) financing allows property owners to borrow funds to pay for energy improvements, including purchasing and installing EVSE.

Who has been instrumental in this?

The CARB has been instrumental in delivering a series of interventions known as ZEV Mandates that have successfully led to an increase in electric vehicle activity. This organisation is a Public Board that is made of several political figures and industry experts and is nominated by the Governor of California. The organisation forms part of the California Environmental Protection Agency and is responsible for regulating emissions of local pollutants and greenhouse gases in California.

The California Energy Commission again nominated by the Governor of California has also played a significant role in the increased uptakes of electric vehicles in the region mostly through their work in delivering programmes to increase the number of chargers in the region.

The Public Utilities Commission is also nominated by the governor and regulates the state's electric investor-owned utilities. This board plays a critical role in the state's transition to ZEVs, it applies its expertise in electric rate design, electric system infrastructure deployment, grid management, and safety to accelerate ZEV deployment.

[28] ICCT (2019). Overview of global zero-emission vehicle mandate programs.
ICCT (2019). Regulatory pathways for zero-emission vehicle mandates.
[29] Guinn (2018). EVSE Rebates and Tax Credits by State.

What market conditions have made this possible?

When the ZEV mandates were introduced in California there was not a vehicle manufacturing industry in the state, therefore this policy did not directly impact the industries in the region. These mandates have led to an increase in the number of EV vehicle models available in this region with manufacturers innovating to meet the requirements of the latest mandate. This along with the Federal tax credits[30] detailed above have led to a positive market for the sales of electric vehicles.

The Clean Air Act enabled the EPA to set national vehicle emissions standards. However, because California was already developing such standards it was exempt from following federal law and therefore could set its own laws regarding the vehicles which could be sold within the state. Standards in California had to be at least as strict as federal legislation. Other states can opt to follow either federal legislation or standards set by the state of California.

4.7. Norway: The most successful market for light duty EVs

What has been achieved?

Norway is renowned for being the World leader in electric mobility with the current levels of sales out stripping most other countries by a considerable margin with the current figures showing that the levels of new car registration in the country have reached a 30% share in 2018. [31]

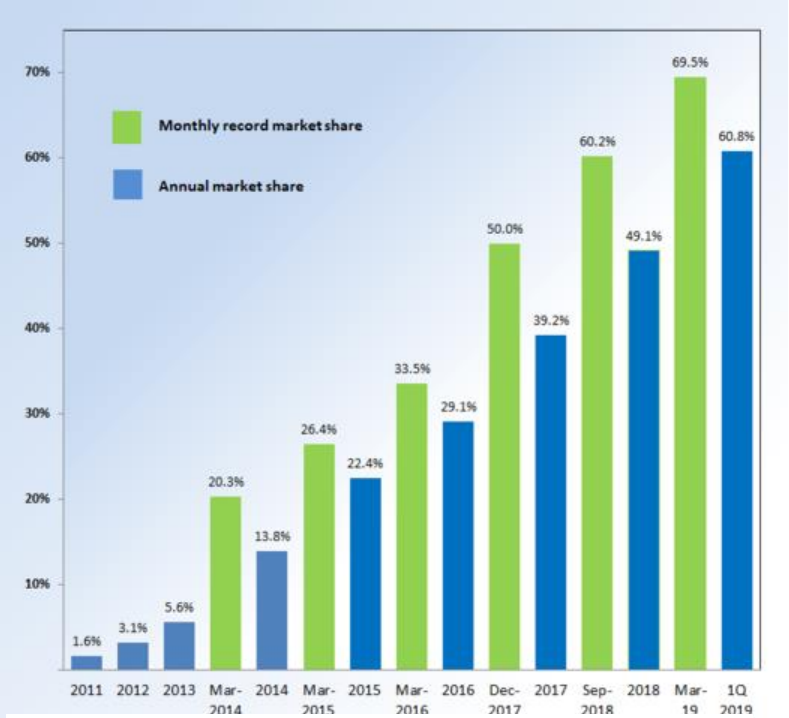


Figure 11: Norwegian plug-in passenger car segment market share of new car registrations (2011 – 1Q 2019) (Sourced from Wikimedia)

How has this been achieved?

There have been three significant factors in Norway achieving their envious position as world leaders and they are: making electric vehicles cheap to buy; cheap to use and making them practical and; convenient for the end user (for example by allowing access to bus lanes). [32] It is not unexpected that the government that has implemented the world's most generous program of incentives have achieved the best results. This has been achieved through early, comprehensive and consistent policies that not only tackle the difficult upfront cost associated with electric vehicles but have focussed on all aspects of the switch to ULEVs including focusing the ease of use.

The regulatory framework for EVs in Norway goes beyond targeting consumers at the point of the purchasing decision however it cannot be underestimated the influence that the exemption from the 25% VAT on purchase or leasing and no import or purchase taxes alongside a 50% reduction in

[30] California Centre for Sustainable Energy (2019). State and Federal Electric Vehicle Incentives.
[31] Norsk elbil forenig (2019) Norwegian EV market.
[32] Kester, Sovacool (2018). Policy mechanisms to accelerate electric vehicle adoption: A qualitative review from the Nordic region. Renewable and Sustainable Energy Reviews 94 pp. 719-731.

company car tax can have on the purchase decision of the consumer. However, their policies to do include political incentives for the rollout of charging infrastructure, research activities, information and marketing.[33]

The above governments incentives have been enhanced by cities further promoting EVs by allowing preferential access or reduced fees to use bridges, tunnels, HOV lanes, and bus lanes. These programs depend on local geography and transportation policy but can generally provide valuable benefits to drivers at a low cost to the city. These policies were pioneered in Norway, where local governments including Oslo and are now being replicated across the globe with Norway being the go-to country for organisations looking to develop a program of incentives. However, some of these programs have since been scaled back as the popularity of electric cars has resulted in higher levels of traffic in lanes supporting EV use than in other lanes.

Enova, a public agency set up to support clean transport projects, funded a nation-wide build-out of BEV charging infrastructure, with a non-statutory target of installing at least one charging station every 50 km by the end of 2017.[34]

Who has been instrumental in this?

Analysis has found a high degree of support and acceptance of electromobility from both the political establishment and the general public and industry. Norway EV Association have played a key role in supporting the uptake of electric vehicles through their outreach programmes and by providing a key link between EV users and the government.

What market conditions have made this possible?

By 2020, Norway aims to cut greenhouse gas emissions by 30% relative to 1990 emission levels and to achieve total carbon neutrality by 2050[35]. Norway follows a strong national climate policy; it aims to be carbon-neutral by 2050 and to have all new cars emission-free by 2025.[36]

Additionally, projects and organisations supporting EVs have been initiated nationally and locally. For example, in Norway, the public body Transnova was set up in 2007 to reduce CO_2 emissions from the transportation sector, the Gronn Bill was established in 2009 with the aim to have 200,000 EVs on Norwegian roads by 2020, and the Electric Mobility Norway project in the Kongsberg-Drammen-Oslo region was initiated in 2012 to promote innovations in electric mobility[37].

In contrast to other countries with high uptake of electric vehicles such as China, Norway and the Netherlands, do not have major car manufacturers. Hence, their governments do not face severe industrial resistance to EVs[38].

[33] Steinbacher, Goes, Jorling (2018). Incentives for Electric Vehicles in Norway.
[34] Norsk elbilforening, (2018). Norsk elbilforening, Norwegian EV Policy.
[35] Fridstrom (2013). Norwegian Transport Towards the Two-Degree Target: Two Scenarios.
[36] E. Figenbaum, T. Assum, M. Kolbenstvedt Electromobility in Norway – experiences and opportunities. Research Transportation Economics, 50 (2015), pp. 29-38.
[37] M. van der Steen, R.M. van Schelven, R. Kotter, M.J.W. van Twist, P. van Deventer. (2015) EV policy compared: an international comparison of governments' policy strategy towards E-mobility. W.L. Filho, R. Kotter (Eds.), E-mobility in Europe: Trends and Good Practice, Springer, Cham (2015), pp. 27-53.
[38] S. Bakker, K. Maat, B. van Wee (2014). Stakeholders interests, expectations, and strategies regarding the development and implementation of electric vehicles: the case of The Netherlands. Transportation Research Part A Policy Practice 66, pp. 52-64.

4.8. Other regions that have displayed international best practice:

The case studies in Sections 4.1 to 4.7 illustrate regions that have demonstrated international best practice in achieving different aspects of ULEV measures of success. There are many other regions across the globe that have achieved some degree of success in these areas and several of these regions are highlighted in Table 1.

Table 1: Other regions which have demonstrated best practice

Region	Area of best practice
Denmark	Adopting consumer awareness practices after withdrawal of fiscal incentives affected EV adoption significantly.
Canada	Strong EV policy framework across different departments has been introduced recently to stimulate adoption of EVs.
Sweden	High EV adoption without high fiscal incentives and with a strong automotive industry.
Portland (Oregon, USA)	Portland adopted a particularly comprehensive electric vehicle strategy that sets key goals and identifies unique actions that the city will take to accelerate the transition to electromobility.
Finland	The Whim app operates in Helsinki which offers all-in-one mobility for ridesharing, public transit and rentals, encouraging the shift away from private car ownership.

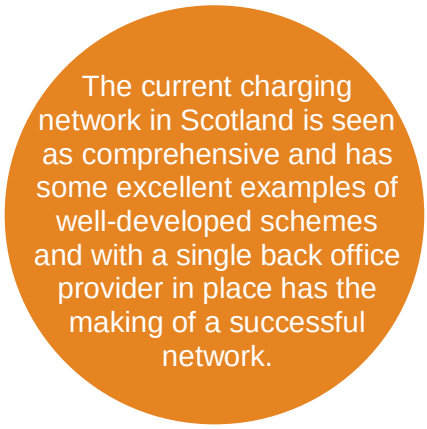
5. Policy recommendations

Section 2 of this report identified a number of criteria that we can measure success against. This part of the report will review these against the various international case studies included as well as other examples of best practice identified in Section 4. This will identify how this good practice can be integrated into current policy with Section 6 summarising the identification of any gaps that can be used to create economic opportunities in Scotland.

5.1. Policy discussion

Comprehensive and reliable charging network

In terms of progress to date for the Scottish Government, this is an area identified as having made significant progress while still having the opportunity to develop a national network that becomes internationally recognised as demonstrating best practice. The current network in Scotland is seen as comprehensive and has in pockets some excellent examples of well-developed schemes. With the ChargePlace Scotland network bringing the vast majority of public charge points under a single operator, it has the making of a successful network.



The Netherlands case study highlights the scale of effort required to encourage the population to switch to EVs; the Netherlands, in places, has deliberately over-provided infrastructure to ensure confidence in availability, with examples of ratios of up to 1 charger for every 2 electric vehicles.

The Netherlands has also enabled an open market which has been used to create competition across the charging network. This has not only been successful in driving down the cost of the service to the end user but has also led to an improved user experience as companies compete for business. In the Scottish context, successfully creating a more open market for charging will depend on enabling interoperability between networks in a way which builds upon the work of Charge Place Scotland network. By ensuring interoperability, customers receive the best possible service while retaining the ease of a single back office supplier.

The delivery of a comprehensive and reliable infrastructure will come from a mix of continued Local Authority deployment and private infrastructure delivery. There needs to be a proper understanding of the scale of infrastructure required to meet deployment targets, taking in lessons from countries with developed EV markets. It is important to understand how other regions have delivered a customer focussed infrastructure that reduces prices while improving service.

There are a number of examples of new technologies beginning to come to the market to support the charging of EVs. These can provide opportunities if they are to be fully rolled out in line with meeting 2032 and 2050 targets. Some of these include wireless charging solutions and innovative on-street solutions which could be delivered at scale for cities with issues regarding on-street parking.

Another excellent example of a comprehensive infrastructure supporting the electrification of transport is Shenzhen (China) where a fully electric bus fleet has been delivered without having to increase the size of the fleet. This has been achieved by fully understanding the infrastructure requirements to completely change the fleet of buses to electric and then strategically building the supporting network. This long term and strategic approach with a clear and defined outcome enabled all parties to work

towards the identified target with confidence. Identifying ambitious but detailed future goals can provide focus to all involved.

This is an area identified as having made significant progress with the opportunity to develop a national network that could be internationally recognised. Opportunities include supporting innovative charging solutions such as wireless charging solutions and innovative on-street solutions which could be delivered at scale for cities with issues

Integrated Energy Systems

A number of case studies were carried out on International best practice for ULEVs however none of these identified a country which had clear and defined plans in relation to integrated energy systems.

There are a number of micro projects looking at how EVs can be part of a fully integrated energy system and a number of the more relevant case studies are identified below:

- Dundee: Charging hubs for up to 18 vehicles that include solar generation on site and battery storage on site. This allows for real life data to identify maximum power required on site to facilitate the large-scale charging of EVs with minimal grid upgrades.
- We Drive Solar (Utrecht): This project supplies shared EVs for use in the Utrecht area. The charging stations for this project are supplied by solar energy generated by 4,000 solar panels in the region with this set to grow.
- The ReFLEX (Responsive Flexibility) (Orkney): This project will demonstrate a Virtual Energy System (VES) interlinking local electricity, transport, and heat networks into one controllable, overarching system. The project will demonstrate flexible energy balancing technologies through a software platform controlling generation and demand. The project will include domestic batteries, large-scale batteries, Vehicle-to-Grid (V2G) chargers, increase in EVs, electric bus and e-bike deployment, flexible heating system and a hydrogen fuel cell.

While the Scottish Government currently has an all-encompassing Energy Strategy, fully integrated energy systems that have EVs at their heart are still in early stages of development. There are opportunities to develop a full range of integrated energy solutions from small scale individual properties to significant industrial scale projects. From a policy perspective this should be focussed on two areas, firstly influencing the UK Government to ensure that the transition to Distribution System Operators creates an open electrical network which allows all customers to attain economic and environmental benefits. Secondly, for the Scottish Government to drive legislative and funding opportunities which deliver demonstrations and innovations at scale so as to maximise the economic growth opportunities in Scotland.

To date, no region has had a clear and defined plan in relation to integrated energy systems. Fully integrated energy systems that have EVs at their heart are still at an early stages; this presents an opportunity for development.

Economic Opportunities and Job Creation

One of the key success criteria for investment in the introduction of a new technology is the economic opportunities that they bring to a country which can be measured in the number of jobs associated with that development.

The case studies identify two examples of where significant economic benefits have been identified through the large-scale adoption of EVs.

The first area is California where the local government introduced significant legislation around the supply chain for EVs through their ZEV mandate. This strong leadership and commitment has led to a whole industry being developed in the region as well as the supporting supply chain, this has created significant employment and opportunities in the area.

The second example of government interaction with an industry can be seen in the case study of Japan, where the government had close links with industries that would be associated with the development of EVs, this included battery manufacturers as well as charging technology companies. Again, this provided a number of opportunities for companies to grow with the emergence of this new technology with support from government.

One area that is still in its infancy is the recycling of batteries from end of life EVs. Battery end-of-life management is an important practice to reduce the need for critical raw materials and to limit risks of shortages. The options fall within the 3R framework (reduce, reuse, recycle), which, for batteries, is specifically for reuse and recycle. Regarding reuse, it is important to ensure that end-of-life regulations for automotive batteries allow their use in second-life application (rather than disposal and as an alternative to recycling). Regarding recycling, several countries have set standards for battery waste management including the recycling rate for the entire battery. These regulatory frameworks could be strengthened to ensure suitability with the electric mobility transition. There is also a need for the development of a regulatory framework for environmental requirements on the design phase of battery products. It should take account of the need to maximise the recovery of materials at battery end-of-life treatment while minimising costs, as well as the importance of thorough stakeholder consultation, given today's dynamic nature of battery technology developments.

To date there has been work in The Netherlands, Germany and Belgium relating to end of life battery recycling and Scotland has one of the leading academic organisations in this field in St Andrews University.

Regions such as California and Japan have supported the whole EV supply chain. Supporting a battery recycling industry could create economic opportunities for Scotland.

Integrated Sustainable Transport Systems

While the case studies included in this report give details of some significant progress in the electrification of fleets across the globe, they tend to be contained within specific areas. For example, the 100% bus fleet in Shenzhen or the extremely successful electric car share scheme identified in Shanghai. However, a fully integrated sustainable transport system must include all modes of transport. There are small pockets of work taking place in Dundee such as having a significant percentage of the taxi fleet electrified, a number of electric car club vehicles, the upcoming introduction of the e-bike sharing scheme and the significant EV charging infrastructure in the city. However, there needs to be an approach created that stimulates EV adoption whilst supporting public transport and active travel trips.

To fully integrate a sustainable transport system into a region or country not only must all aspects of the transport system be converted to ULEVs where possible but the introduction of MaaS (Mobility as

a Service) must be fully integrated into that model, making the switch to ULEVs convenient and cost effective to the end user. There must be a joined-up approach to supporting different public transport modes, enabling users to easily switch between transport modes and reducing the dependency on private vehicle ownership. A good example of MaaS is the Whim platform that is currently deployed in the West Midlands, Antwerp and Helsinki however fully integrating this with a complete ULEV transport system with the scale of adoption necessary is still to be achieved.

It is vital that any future intervention or procurement from the Scottish Government with regards to delivering MaaS has Ultra Low Emission vehicles at its heart and drives the future sharing model to be delivered in the most sustainable way

There is an opportunity to support the development of a fully integrated sustainable transport system that stimulates ULEV adoption whilst encouraging public transport and

Policy Frameworks

A number of the case studies in the report identify effective long-term policy success stories in the adoption of EVs. For example, the success of Norway is a result of a series of policy interventions that are designed to encourage uptake rather than a singular dedicated EV strategy or programme. This long-term strategic approach to interventions gives the private sector confidence to invest in vehicles or infrastructure.

Investigation into Canada identified a very strong cross departmental strategy for the deployment of EVs which ensures that it is embedded in all areas of the government. This is also true of the ZEV mandate in California which gives strong and clear commitments that allow the private sector to invest in the region.

Scotland currently has a very clear Road Map for the introduction of EVs and the Scottish Energy Strategy launched in 2017 includes the switch to ULEVs as playing a key role in the changing energy markets. While these long-term policies and strategies are vital to give confidence to the public and private sector investment some of the shorter term and immediate actions taken by cities like London must be included in the policy thinking of any country, these are to include ideas like Congestion Charges and Low Emission Zone Charges. These however must be considered in a local context with a full assessment of the economic impact of them explored before introduction.

A long-term strategic approach with a series of policy interventions at a local and national level that are designed to encourage uptake of EVs across modes and ownership types are needed for greater adoption of EVs.

Communication and Education

This area has been identified as crucial in the large-scale introduction of ULEVs in any region with lessons also available on the effect of incentives in relation to consumer awareness campaigns.

A key learning from the case studies is the importance of providing reliable and accurate information from a reputable source such as a government website regarding the use of EVs. This not only provides prospective users with the information required to allow them to make an informed decision

but at the same time can be used to dispel a number of the myths and misinformation that seems to exist around the introduction of EVs.

A good example of this public awareness campaign can be seen in the Shanghai EV demonstration Centre where reliable and accessible information available to the users can support the switch to ULEVs, recognising that local information is a positive factor in allowing people to make the switch to ULEVs. This type of centre is also available in Milton Keynes where the EV Experience Centre is providing impartial advice to users while allowing them access to try out the vehicles.

Figure 12: The EV Experience Centre in Milton Keynes (Image courtesy of EV experience Centre)

Another example of where communication and education have proved successful in increasing the numbers of EVs is Norway through the EV Association. This organisation has been around for over 20 years and works with the government to promote EVs as an alternative to fossil fuel.

However, a positive communication campaign on its own is unlikely to achieve the significant numbers of EVs required. This can be seen from Denmark where the removal of incentives early and replacing them with a communication strategy has not delivered the same results. Furthermore, all communication strategies should consider the different segments which make up the EV market in Scotland (see CXC research on ULEV Market Segmentation, 2019), helping to target different user group with the appropriate level of information.

It is important to provide reliable and accurate information from a reputable source such as a government website regarding the use of EVs. For a successful communication campaign there needs to be buy in from a wide array of stakeholders such as local authorities, vehicle manufacturers and vehicle user associations.

Market Development

The case studies have repeatedly highlighted the role of government interventions in supporting markets for successful in the adoption of EVs. These interventions have been successful in a

particular area and do not necessarily transfer to all areas of electrification across all groups of vehicles. The main markets identified through the case studies are:

- Norway: The government has had a long-term strategy of intervention where they have introduced policies that bring down the cost of ownership of an EV compare to that of a fossil fuel vehicle. One of the keys lessons to learn is the long-term strategic approach they have taken to provide confidence to consumers and private concerns.
- California: The government introduced its ZEV mandates in the 1990s which provided a real focus to local businesses to drive the switch to EVs. Again, the long-term strategic approach to this not only ensured consumer confidence but provided a real opportunity to supply side businesses to commit to the industry to develop new markets.
- China: The successful introduction of fully electric bus fleets in Shenzhen was in part down to government intervention and committing to having an all-electric fleet of buses without increasing the total number of buses in the city. This again provided confidence for the suppliers to get involved with these projects with a full understanding of the scale required.

It is clear from international examples that clear government direction alongside fiscal interventions can significantly enhance the transition to ULEVs.

5.2. Policy recommendations

Table 2 below summarises a series of recommendations on the potential for Scotland to adopt successful international policy and practice to accelerate ULEV uptake. These are presented in terms of both their potential impact on enabling ULEV uptake in Scotland and where there might be potential for Scotland to carve out a leading international position and generate economic success.

Other reports have highlighted that the market can be split by factors such as vehicle size, ownership type, and charging location. [39] Where appropriate, we have also identified particular segments of the market that we would expect the interventions to have an impact on, as well as the associated timescales, costs and dependencies.

[39] 'ULEV Market Segmentation in Scotland' completed by Element Energy (2019), a full list of the market segments is given in Appendix 2.

Table 2: Policy Recommendations for Scottish Government

Policy Recommendation for Scottish Government	Potential Impact	Potential for Leadership position and economic growth	Market sectors impacted	Time horizon	Costs and dependencies.
1a. Outline and publish anticipated stages of growth to meet 2032 target, particularly in terms infrastructure required.	Would give a clearer long-term picture to both local authorities and the supply chain to enable investment decisions to be made	Take a holistic approach to targets across all sectors with a fully integrated infrastructure.	All segments	Recommended that this is implemented in the shortest possible timescale but with a 15-year view	Dependent on Scottish Government having enough confidence in how the path to 2032 could look. However, this should be mitigated by proposing as a "best guess" with working assumptions.
1b. Encourage UK Government to enable interoperability with infrastructure back office whilst maintaining a single network for users	Would introduce competition and private investment in infrastructure. Could drive down cost and maintain seamless user experience	Develop a world leading approach to a countries infrastructure building on work completed to date. Unique opportunity to develop CPS network in a controlled manner while introducing market forces.	EV drivers that charge on street.	Short-term (1-3 years)	Would require some costs in terms of developing the existing back office system. Dependent on appropriate contractual terms with back office supplier.
1c. Provide financial assistance to Local Authorities to support the delivery of innovative infrastructure projects.	Would enable local authorities to work collaboratively with industry in the development of charging infrastructure that best needs the needs of citizens, e.g. those without access to off-street parking	Many of the challenges faced by Scotland in providing flexible and effective charging infrastructure at scale are faced by countries throughout the world. Actively investing in innovation in this space could put Scotland at the forefront in particular areas.	EV drivers that charge on street.	Investment could be made in the short-term (1-3 years) although the full benefits may not be realised until to the medium to long term	Would require investment but this could be maximised through the requirement for match funding from the private sector. Dependent on enabling a culture of risk taking, experimentation and shared learning across the local authorities in Scotland.
1d. Phase in regulation requiring ULEV buses and provide long term financial support for the	Would support the phased roll-out of ULEV buses.	Scotland unlikely to be in a leadership position due to progress made in other countries.	Buses	Medium (3-8 years)	Costs could be high but could be a co-investment with bus companies and public transport operators if staged to align with natural turnover of vehicles.

Policy Recommendation for Scottish Government	Potential Impact	Potential for Leadership position and economic growth	Market sectors impacted	Time horizon	Costs and dependencies.
public transport industry to make the transition.					
2a. Publish guidance for the deployment of integrated EV and energy systems in new housing developments.	Significant impact on fuel poverty and access to sustainable transport options	Utilise opportunities for renewable energy to be fully integrated into housing developments to deliver long term benefits to the communities	EV drivers that charge off street.	Investment could be made in the short-term (1-3 years) although the full benefits may not be realised until to the medium to long term	This would involve additional upfront capital costs but would deliver return on investment over lifetime of technology. Dependent on all aspects of planning guidance being co-ordinated
2b. Set guidelines and standardisation for charging hubs in Scotland to fully utilise on site energy generation and storage	Reduced impact on grid reinforcement required across Scotland	While several countries have been deploying rapid charging hubs, Scotland's are among those receiving international recognition. This could be further built on through this initiative.	EV drivers that charge on street.	Short term (1-3 years)	This can be implemented at little cost to Transport Scotland, building on learning of the hubs deployed to date and continue to standardise and further develop through the several hubs already planned and funded for the coming years.
3a. Implement the regulatory conditions that would support the recycling of batteries from end of life EVs[40].	Create significant job opportunities in Scotland and develop academic skills in this field.	This is an area that is still in its infancy and there is therefore and opportunity for Scotland to push for a leadership position. Success in this area would also be a job-creator and lead to economic growth.	EV drivers that adopt in the second-hand market.	Medium term	Dependent on commercial partners and academic excellence in this field to supply cutting edge technologies.
3b. Deliver financial support for the creation	Deliver direct and indirect jobs resulting	Scotland unlikely to be market leader due to progress in	All segments	Short – Medium Term	Dependent on managing to convince one of the world's

[40] Waste battery regulation is devolved to the Scottish Government, see Waste Battery (Scotland) Regulation 2009.

Policy Recommendation for Scottish Government	Potential Impact	Potential for Leadership position and economic growth	Market sectors impacted	Time horizon	Costs and dependencies.
of a battery manufacturing facility	from the large scale of production required to deliver economies of scale	other countries. However, such an investment could lead to significant job creation and economic growth.			largest battery manufacturers to locate to Scotland and finding suitable location.
4.a Deliver financial and regulatory frameworks to facilitate electrification of services within Mobility as a Service implementation.	Significant impact on the future shape of transport in Scotland with the ability to tackle air quality, congestions and promote low carbon transport solutions.	Deliver the first fully low carbon MaaS application that can be replicated across the globe	All segments	Short - Medium	Funding already in place to develop the MaaS opportunity, long term will be self-sustaining Significant investment will be required to support the transition of all industries to Low Carbon options.
5.a Implement a Scotland-wide guidance framework for tariffs.	Deliver certainty to organisations looking to operate or invest in infrastructure in Scotland.	Unique position building on CPS network but combining with world leading interoperable networks benefits.	EV drivers that charge on street.	Short Term	No cost to Scottish Government however is dependent or retaining an aspect of control over network.
5.b Implement Scotland-wide framework policies that supports EV adoption in relation to LEZs and are flexible to the differing needs in particular regions (including parking and use of bus lanes).	Deliver long term certainty to local authorities when developing LEZ's as well as to the end users.	Deliver world leading LEZs that not only tackle the issues in Scotland cities but provide flexibility to support local economic requirements	All segments.	Short - Medium	Scottish Government to provide financial support Local authorities in providing free parking and other incentives to ULEVs
6.a Co-ordinate and deliver a communication and education programme that promotes the shift to low carbon transport while	A successful campaign to promote the uptake of ULEVs will ensure all interventions achieve their maximum impact	Opportunity to become recognised globally for an integrated and successful long-term communication strategy to drive ULEV uptake	All segments.	Short - Medium	The cost of a significant communication and education should be shared across the funding identified for all interventions and combining for a greater impact.

Policy Recommendation for Scottish Government	Potential Impact	Potential for Leadership position and economic growth	Market sectors impacted	Time horizon	Costs and dependencies.
providing specific guidance on benefits of EV ownership to the individual and their community					
6.b Deliver an official exemplar city or region to focus efforts and achieve maximum international recognition.	Enhance Scotland's reputation as a leading country in the uptake of ULEVs and renewable energy field.	Delivering an exemplar region/city has proven successful in delivering additional investment	All segments	Short	No cost to Scottish Government, build on the work achieved to date in Dundee and expand to the region.
7.a Deliver a series of financial incentives across the ULEV market that support economic opportunities to meet the targets of 2032.	Encourage the initial investment in industries supporting the uptake of ULEVS through fiscal policies and staged targets.	A large number of countries are looking to develop this approach, but Scotland has a unique opportunity associated with fully integrated energy solutions harnessing renewable technologies	All segments	Medium	This would come at a significant cost, but a series of targeted fiscal incentives could bring long term financial benefits through economic opportunities and job creation.
7.b Develop policy guidance to support all aspects of procurement through local and Scottish government to include measures to drive the uptake of ULEVs.	Significant opportunity to influence businesses and operators in Scotland to make the transition to Low Carbon Options	Significant opportunity to deliver world leading procurement drivers to support the delivery of low carbon vehicles.	Captive fleets.	Short	No direct cost to Scottish Government to change procurement criteria to drive the uptake of EVs across all areas of business.

6. Opportunities for Scotland

Section 5 of the report identifies policy recommendations based on an analysis of international case studies, framed in the context of the measures of success set out in Section 2. From this analysis it is clear that, while there are good examples of leading practice in certain areas, there is no country or region that is fully addressing all of the measures. There are clearly still some key areas that require further development by countries and regions seeking to meet all seven measures of success. Some of these areas present real opportunities for Scotland to become a world leader.

6.1. Innovative EV charging design and manufacture

An opportunity exists around the design and manufacturing of innovative EV charging solutions. Governments across the globe have made significant commitments to phase out the need for fossil fuel vehicles, therefore there is a significant opportunity to enter the market as it expands.

While there has been significant development of charging infrastructure in Scotland to date, there is a significant opportunity to further develop this line of work. At present there are a number of related developing technologies being brought for charging solutions. However, there is an opportunity to design and manufacture fully integrated charging solutions that encompass on site generation and battery storage solutions as well as incorporating innovative charging techniques. These solutions will become increasingly important for rural and island communities where there are significant costs associated with upgrading the grid in remote locations.

Furthermore, there are a number of new technologies being developed and trialled across the UK including inductive charging and innovative approaches to on-street charging such as in the use of ‘pop-up’ chargers; these are still at a relatively early stage of development. The infrastructure required to support the ambitious Government pledges to phase out of fossil fuel vehicles is significant and, with the pace of development of EVs, technology requirements could start to change quickly.

6.2. Lifecycle of battery systems

There are currently over a billion diesel and petrol vehicles in the world and the supply chains around them are fully matured and are primed to deal with changes in makes and models as they emerge. The introduction of EVs is seen as a disruptive technology as it requires significant changes to supply chains and growth in new industries to support the demand. This can currently be seen with a global supply issue for electric cars which has predominantly been caused by the lack of capacity in battery manufacturing across the globe. This is being further squeezed as other groups of vehicles such as buses and refuse collection vehicles chose batteries as their preferred option.

There is an opportunity for Scotland to look at bringing one or more battery manufacturing facilities to Scotland in collaboration with some of the well-established battery manufacturing companies.

Battery end-of-life management is an important practice to reduce the need for critical raw materials and to limit risks of shortages, through either reuse or recycling. To enable the potential reuse of batteries, as an alternative to disposal or recycling, it is important to ensure that end-of-life regulations for automotive batteries allow for reuse in second-life application.

Regarding recycling, several countries have set standards for battery waste management including the recycling rate for the entire battery. These regulatory frameworks could be strengthened to ensure suitability with the electric mobility transition. There is also a need for the development of a regulatory framework for environmental requirements on the design phase of battery products. It should take account of the need to maximise the recovery of materials at battery end-of-life treatment while minimising costs.

Battery recycling is still at a very early stage of its development. To date this has been a relatively small market as the 1st generation of EVs has generally lasted significantly longer than was first estimated and these vehicles are only just coming to the end of their life. A number of the 2nd life batteries have also been used to support battery storage solutions and other developing industries.

There are currently processes being developed across Europe to try and increase the recycling rate for lithium-ion batteries from 35% to 85%, these processes are still in the early stages. This provides opportunities not only for academic organisations to be involved but the physical recycling of the batteries or repurposing to be located in Scotland. A large-scale operation recycling/repurposing batteries at a site such as the Michelin Scotland Innovation Parc in Dundee is likely to lead to a number of spin off opportunities for organisations to be at the cutting edge of what is set to be a major part of the automotive industry.

Figure 13: The Michelin Scotland Innovation Parc

6.3. Fully integrated mobility solutions

The international case studies in Section 4 have identified a number of areas where countries have achieved international recognition for their work in the introduction of ULEVs. However, the majority of countries have been successful in promoting one or two groups of vehicles and as yet a fully developed holistic approach to the electrification of transport has not been implemented to scale successfully.

It is vital that in achieving a fully low carbon Mobility as a Service solution that all groups of vehicles are included, and that the country fully embraces the challenge. There have been excellent examples of whole bus fleets, private car ownership, car sharing schemes and electric bikes and scooters across the case studies. However, a fully integrated low carbon solution that encompasses all vehicle types with a single platform is still the target.

A number of organisations are looking to develop this; however, this requires a full range of policy interventions and guidance that pushes all sectors towards the goal. The launch of the MaaS Innovation fund is the start of the journey towards the full integration.

Appendix 1: Research methodology

Our research methodology was based on using a systematic and structured approach to identify the most suitable and up to date information for this report. We used our knowledge of the international ULEV market and extensive global network to identify and understand international best practice in accelerating ULEV uptake. We then applied a systematic approach to ensure a holistic, robust and achievable assessment of the interventions that could be of benefit to Scotland.

Measures of success

Defining measures of success was be done on a sector-by-sector basis in conjunction with the market segmentation report commissioned in parallel by ClimateXChange. The measures selected were based on achieving a multi-layered approach which address a broad range of financial, social and societal challenges. This allowed for the assessment of both quantitively and qualitive data to be considered in the selection of international best practice.

Scotland progress to date

Progress in Scotland was assessed based on the currently available information on ULEV uptake figures. This was placed in the context of key development strategies to date and also our wider understanding of current implementation progress.

International best practice: Case studies

A lot of high-level information already existed in the public domain around ULEV adoption internationally through sources such as the UN's Global Electric Vehicle Policy Database and the IEA's Global Electric Vehicle Outlook. We used this to undertake an initial assessment of world-leaders against the defined measures of success. We then reached out to our network of experts in the public/private sectors to validate this assessment via key stakeholder interviews. For each country/region identified we produced a Country/Region Study. These described what the location has achieved (with reference to the relevant measures of success), how these achievements have been reached (considering policies, investment, organisation, etc), who has been instrumental in achieving (from public, private and academic sectors) and what market conditions have made these achievements possible. The experts interviewed as part of this project included:

- Ben Holland (Rocky Mountain Institute)
- Gil Tal (UC Davis)
- Gent Grinvalds Harbro (Capital Region of Denmark)
- Nellie Zhang (BYD)
- Richard Li (BYD)
- Ellen Hiep (Dutch EV Association)
- Dee West (Charge Net)
- Elinor Chalmers (EVA Scotland)

Policy recommendations

The interventions explored within then the country/region studies were then compared against each other to identify any themes, inconsistencies or gaps. We also compared these against Scotland's progress to date to form specific policy recommendations. These recommendations are in the context of the market conditions that have allowed certain interventions to be successful internationally and how similar these conditions are to the external conditions shaping the ULEV market in Scotland.

Opportunities for Scotland

These specific recommendations are to enable Scotland to develop a leading international position and generate economic success. The latter frames the sectors used in this study in terms of Scotland's current relative performance (with reference to the measures of success), the possibility of development that the interventions could create and the potential size of the economic "prize" for the Scottish economy. Recommendations given are clear and actionable. We identified which sectors of the market we expect them to have an impact on, as well as the associated timescales, costs and dependencies. Recommendations relate to and are framed in the wider context of Future Mobility.

Appendix 2: List of market segments

Earlier this year Climate XChange commissioned a report seeking to understand how to stimulate electrification of the road transport sector to meet road transport targets through understanding the makeup of the current vehicle market. The 'ULEV Market Segmentation in Scotland' report was completed by Element Energy (2019) splitting the vehicle market into 15 segments by factors such as vehicle size, ownership type, and charging location. This report identified the key barriers in each segment, indicating which policies could address the barriers to adoption in each segment and therefore stimulate adoption across the market for Scotland to meet the 2032 target.

The segments identified in this report are:

1. Private buyers of new cars and vans who can park off-street at home;
2. Company cars and vans which can park off-street at home;
3. Car commuters who park on-street;
4. Private buyers of new cars and vans who park on-street, and do not use their vehicle to commute;
5. Depot-based cars and vans with relatively low daily mileage;
6. Company vans which are stored on-street, with relatively low daily mileage;
7. Depot-based vans with relatively high daily mileage;
8. Private buyers of used cars and vans who can park off-street at home;
9. Private buyers of used cars and vans who park on-street, and do not use their vehicle to commute;
10. Private buyers of used cars who park on-street, and use their vehicle to commute;
11. Small rigid HGVs;
12. Medium & large rigid HGVs;
13. Very large rigid HGVs;
14. Small & large articulated HGVs;
15. Waste collection vehicles.