ADVISORY REPORT

# Supporting Electric Vehicles in the Wellington Region



Prepared by Jake Roos Consulting Ltd
with assistance from Reytna Limited



Version 1.5.8
2019-09-06

Report commissioned by the Wellington Region EV Working Group for Wellington Electricity, Electra, PowerCo, Wellington City Council, Greater Wellington Regional Council, Hutt City Council, Upper Hutt City Council, Porirua City Council, Kāpiti Coast District Council, Masterton District Council, Carterton District Council and South Wairarapa District Council.

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## Figures and Tables



## Footnotes and endnotes

This report contains both footnotes and endnotes:

- **Footnotes**: are represented by Roman numerals relevant to further information which can be reviewed at the bottom of each corresponding page.
- **Endnotes**: are represented by numbers relevant to further information which can be located in the References section beginning on page 46.

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# 0.2 Executive Summary

## 0.2.1 Purpose

The purpose of this report is to aid the Wellington Region stakeholder organisations (specifically the nine councils and three electricity network companies in the region) with taking a coordinated approach to supporting electric vehicle (EV) adoption in the period 2019-2024, in line with an overarching long-term vision of a Wellington Region where use of fossil fuels for road transport have been eliminated and replaced with vehicles powered with renewable energy.

The report has a recommended set of policies, principles, approaches and targets for signee organisations to endorse, and suggested actions for signees to implement in co-ordination and co-operation with other stakeholders. This will allow all parties to take a consistent approach to achieve the vision. The suggested actions are based on our current understanding of the issues and their remedies, and these may be updated as certain actions are completed, further experience and knowledge is gained or circumstances change.

The recommendations are intended to complement Government targets and programmes for promoting EVs and reducing emissions, not be a substitute for them.

## 0.2.2 Key Findings

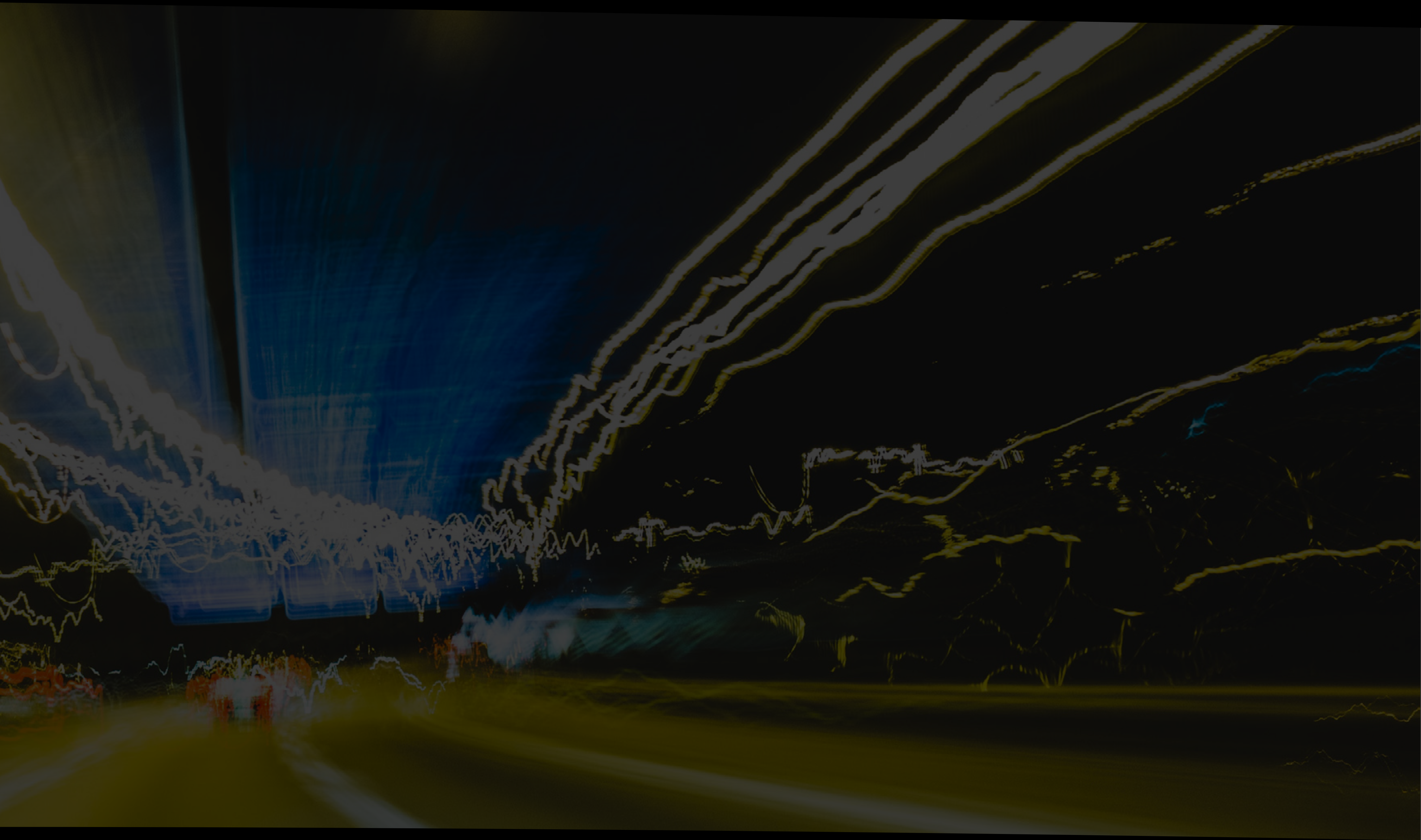
- It is estimated that there will be between 5,000 and 9,000 battery electric vehicles in Wellington Region by mid-2021, and between 15,000 and 28,000 (3.9 and 6.7% of all vehicles) will be EVs by mid-2024. Around 30% of these will be plug-in hybrids (PHEVs) and 70% fully battery electric (BEVs).
- The estimated number of public DC fast chargers required to support this is between 50 and 90 in 2021 and 150 and 280 in 2024. Up to ten times these numbers of public AC chargers (mostly at destinations for shopping, tourism and hospitality) may also be desirable.
- Measures to address upfront cost of EVs are critical to stimulate demand and supply – all can have an advocacy role to government for policies that address this. Prioritising EVs within large organisations for fleet purchases and/or business travel can also help increase supply in the new and second-hand markets.
- A diverse array of supporting measures from a variety of organisations is helpful for boosting EV uptake, and provides 'insurance' against uptake slowing should conditions change, for example the end of the road user charges exemption for EVs.
- Overnight home charging is the cheapest and most convenient method of EV charging for household vehicles.
- As such, it is important to address the issue of EV charging for households without off street parking. This will require a variety of approaches.
- Home charging of household EVs is not likely to exceed the capacity of electricity networks provided maximum demand is managed, although there may be isolated 'hot-spots' to deal with.

- EV incentives do not appear to have a significant impact on use of active transport modes and public transport, but care should be taken in their design to avoid this nonetheless.
- Local authorities and network companies have an important role in ensuring that applications to install public charging infrastructure are handled in a consistent and efficient manner so as not to inhibit its development.
- Significant investment in charging infrastructure is needed to support BEV buses, particularly in depots and also fast charging on route, although the need for the latter can be minimised over time through improving battery efficiency and bus design.
- DC fast charging requires a premium price to recover costs because of the ongoing expense of purchasing the required electrical capacity to accommodate large peaks in demand, so relying on this heavily for meeting the majority of charging needs of an EV is not desirable.
- It is important that time spent charging does not conflict with vehicle utilisation, particularly for commercial vehicles, such as couriers and taxis, which are typically more highly utilised than household vehicles.
- While the batteries from electric vehicles can have a useful second life in stationary applications, they still have the potential to add to e-waste in the future if systems and regulations are not established to avoid it. These must be developed and implemented in the near future as the EV fleet grows and the first wave of EVs ages. Central government involvement in this is essential to set up the regulatory framework.

0.2.3 Recommended strategy summary

## Supporting Electric Vehicles in the Wellington Region – Recommended Strategy

| | | | |
|---|---|---|---|
| **Vision** | Renewable energy replaces fossil fuels in road transport<br>Wellington Region plays its part in limiting global warming to 1.5ºC | | |
| **Pathways** | Public Transport | Electric vehicles | Active Modes |
| **Approaches** | **Leadership**<br>• Include EVs in organisational plans, strategy and operations<br>• Prioritise EVs for in-house transport and fleet<br>• Facilitate e-buses for public transport<br>• Collaborate with our peers, community, government and business | **Infrastructure**<br>• Encourage charging at home and work<br>• Enable sufficient public charging<br>• Users pay for public DC fast charging<br>• Efficiently process applications for public chargers<br>• Encourage systems to replace, repurpose and recycle EV batteries | **Promotion**<br>• Promote EVs to the public and businesses<br>• Promote and encourage EV car share schemes |
| **Ambition** | 6% of vehicles in Region are EVs by 2024 | An increasing number of people view EVs favourably | |
| **Principles** | Priority to active modes and PT; Polluter pays | Just and sustainable | Mitigate any negative impacts |
| **Target** | 50% of organisation light fleets (owned, leased or shared) are EVs by end 2024, 100% are by end 2030 | | |




# Introduction

# Section 1

A Wellington City Council Hyundai Ioniq electric vehicle plugged into a public charger installed in streets where multiple residents lack off-street parking

# Section 1: Introduction

## 1.1 Background

This project is an initiative of the Wellington Region Electric Vehicle Working Group (REV-WG). This group is comprised of officers from councils across the region and other interested organisations from both the public and private sector. The group operates as a coordinating mechanism for the promotion of electric vehicles (EVs) generally and in relation to the development of charging infrastructure specifically. 'EVs' for the purposes of this group and document is defined as road-registered battery electric vehicles (BEVs) and plug-in hybrids (PHEVs) of all sizes, both private and commercial. To be an EV, a vehicle must be able to be recharged with an external source of electricity[1].

The purpose of this report is to aid the Wellington Region stakeholder organisations (specifically the nine councils and three electricity network companies in the region) with taking a coordinated approach to supporting EV adoption in the period 2019-2024, in line with an overarching long-term vision of a Wellington Region where use of fossil fuels for road transport have been eliminated and replaced with vehicles powered with renewable energy.

The report builds on the existing work of REV-WG including their six-monthly co-ordination updates published on the Greater Wellington Regional Council's website[2], and existing guidance for local authorities published by EECA in 2018 'Driving a Low Emissions Economy – How Local Authorities can support and promote electric vehicles'[3]. Current information on the development of EVs in New Zealand can be found in the NZ EV Guide, which is updated monthly[4].

Support for EV uptake is part of a broader effort to move to a low (and eventually net-zero) emissions economy to reduce the drivers of climate change. EVs can be supplied by renewable energy sources so provide an option to 'decarbonise' transport in Wellington, in concert with other methods.

The Central Government target for EVs is for 64,000 to be on the road nationally by the end of 2021, charting an exponential rate of growth to this point[5]. Local government, electrical utilities and other large public and private sector organisations can play important roles in achieving this, for example by helping provide whatever charging infrastructure is needed, and by using EVs themselves. The report focusses on the period to 2021, and considers what is likely to happen and be needed in the following three years to 2024. The report also sets durable, long term guiding principles for the signee organisations and other stakeholders to use indefinitely.

## 1.2 Rationale

In order to reach net zero emissions nationally and globally, the transport sector must be addressed. This has been recognised by NZ Government and various expert advisory bodies, including GLOBE-NZ[6] and the Productivity Commission[7]. Elected leaders of 47 local authorities, including all of those in the Wellington Region, have also recognised this by signing the Local Government Leaders Climate Change Declaration in 2017, which says that they will reduce their own emissions and that of their communities through shifting to electric vehicles[8]. For further discussion of the rationale for local authority involvement, see the EECA guide[3].

Electricity network (distribution) companies also have a critical role to play in decarbonising the economy, including the transition to EVs, for the obvious reason that they provide the infrastructure to supply end users with electricity, which increasingly will be generated from renewable sources. In the Wellington Region, Electra distributes electricity to the Kāpiti Coast District, PowerCo distributes to the Wairarapa, and Wellington Electricity (WE*) serves Wellington City, Porirua and the Hutt Valley.

### 1.2.1 EVs are critical to decarbonising road transport

Greenhouse emissions must begin to reduce within the next few years order to have any realistic prospect of staying within the 1.5 degree C warming limit specified by the international Paris Agreement[9]. Net emissions globally must be halved by 2030 and reach zero by 2050 to make exceeding 1.5 degree C very unlikely. The Government ratified the Paris Agreement, but presently its policies (and those of all other countries) are not consistent with limited warming to either 1.5 or 2.0 degrees C. If efforts globally are not scaled up to the required level by 2020, the window of opportunity to meet either of these goals will be missed. This will lead to a radically different global and local climate in the second half of the century, as modelling for the region carried out by NIWA in 2017 shows[10].

Modelling by the Ministry of Transport (MoT) carried out in 2015 shows that based on their projections of EV numbers, the substitution of petrol and diesel vehicles will start to reduce the total emissions from the transport sector by 2023-24. The delay is a result of the overall growth in the vehicle fleet and total number of vehicle kilometres travelled (VKT) – the rate of EV adoption (in concert with any improvement in fuel efficiency) must first exceed this growth before it has a net effect. It can be seen from this modelling that by 2030 road transport emissions have declined only slightly, and have reduced by only around a third from their peak by 2040. It should be these projections chart a 35% increase in VKT nationally between 2016 and 2036, whereas modelling for the Let's Get Wellington Moving project projected a maximum increase of 22% for the same period[11]. This would suggest EV adoption would have a greater impact on overall transport emissions in the Region than the national modelling indicates.

The Productivity Commission in their 2018 report on moving to a low carbon economy[7] highlighted any new fossil fuelled vehicles bought now 'lock-in' a significant volume of cumulative emissions over their lifetime, shrinking New Zealand's remaining emissions budget and creating a higher future emissions price across the economy. The average of age of light passenger vehicle fleet in NZ is over 14 years. Accounting for this, they concluded nearly all new registered vehicles must be EV from 2030.

The 2017 report by Vivid Economics on 'Net-Zero NZ' for the Globe-NZ group reached similar conclusions, but said that almost all new cars sales must be EV from the 2020s to keep on track to a net-zero greenhouse gas emissions goal for 2050 without resorting to scrapping fossil fuelled vehicles before the end of their useful life.

Both the Productivity Commission and Vivid Economics identified light vehicles as relatively straightforward to decarbonise compared to other sectors, meaning that it did not make sense to decarbonise these slowly and make up the shortfall in other sectors.

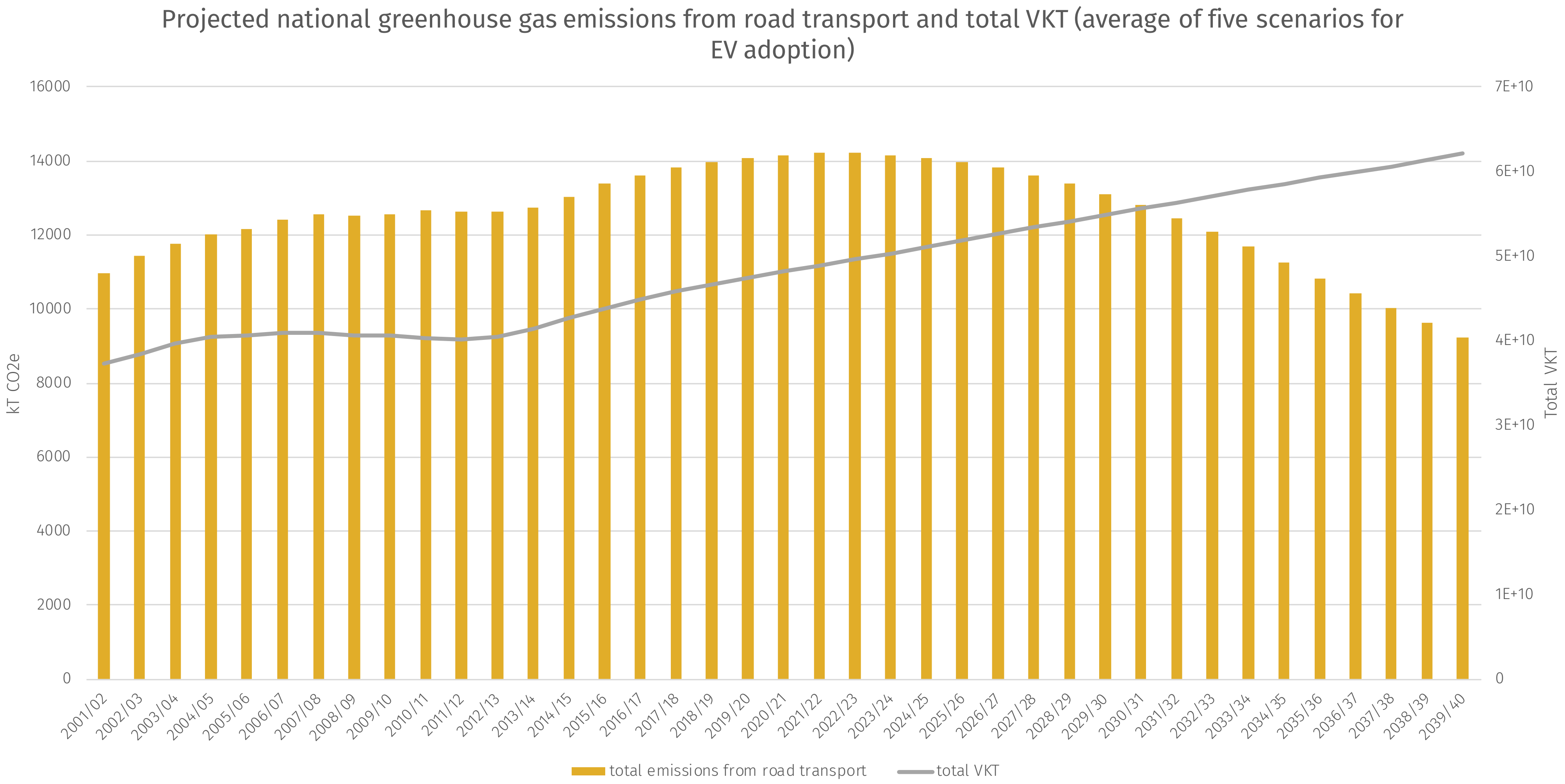
The Ministry of Transport modelled five different scenarios for EV uptake for the whole of New Zealand, which it used to base their target for 2021 on. The average of these scenarios projects 58,500 EVs in NZ in by the middle of 2021 and 180,800 by the middle of 2024. The middle scenario forecasts two-thirds of new cars added to the fleet in 2030 are EVs (53% BEV, 13% PHEV) and 90% are by 2040.

## 1.3 EVs reduce air pollution

In addition to reducing greenhouse gas emissions, the replacement of diesel vehicles with electric can reduce air pollution. Diesel engines are much higher emitters of harmful air pollutants, such as fine particles, nitrogen oxides and black carbon, than petrol engines. Electric drive systems do not produce these pollutants at all, however it should be noted that all kinds of vehicles produce some particulate pollution from tyre and brake pad wear. Local improvements to air quality from switching from diesel to electric vehicles will be of greatest benefit on streets which currently have a high proportion of diesel vehicles and a high pedestrian, worker or housing density resulting in greater human exposure to pollution with detriments to human health. Replacing diesel buses and other diesel vehicles on routes in the CBD will be particularly important.

The 2012 Health and Air Pollution in New Zealand study[12] estimated that the social costs of air pollution in New Zealand were $4.28 billion per year. The study estimated that air pollution from motor vehicles results in 13 premature deaths per year in the Wellington region. The social costs motor vehicle pollution in the Wellington Region were estimated at $48 million per year. 22% of the anthropogenic sources of these costs can be attributed to air pollution from motor vehicles. The social costs of air pollution from motor vehicles in the Wellington region is estimated at $18 million per year.

**Figure 1 – greenhouse gas projection for transport sector**



## 1.4 Present distribution of EVs in Wellington Region

Wellington as a region presently has the third highest number of EVs per head of population (3.1 EVs per 1000 people) in the country. The distribution of EVs within the region is shown in Table 1, over the page.

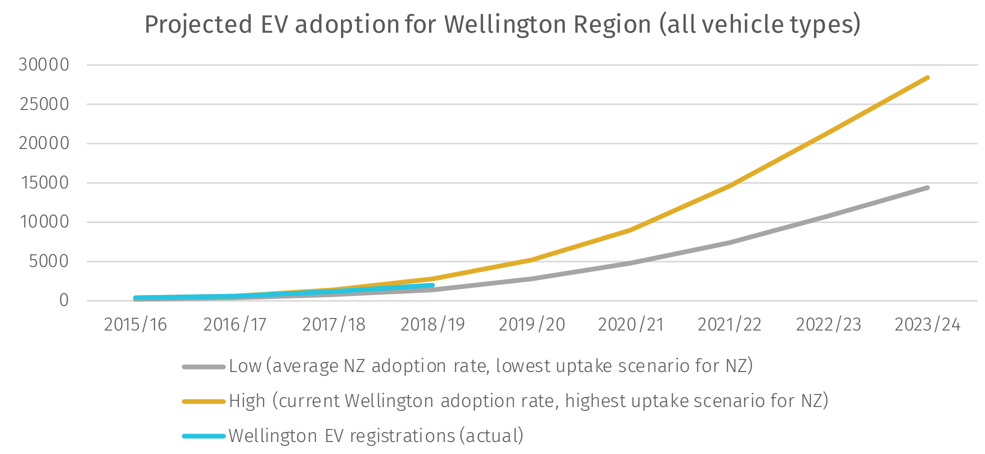
Wellington City and South Wairarapa have the highest rates of ownership, followed by Upper Hutt and Lower Hutt. There is no obvious correlation between ownership rates and the number of public DC fast chargers. The lowest rate of EV ownership is in Masterton District, which due to its rural nature and distance from Wellington means a limited vehicle range presents more of a barrier compared to other areas.

## 1.5 Projections of EV numbers in Wellington to 2024

Upper and lower estimates for the number of EVs in Wellington have been derived from the highest and lowest of MoT's scenarios, using the national average EV ownership rate and present Wellington Region ownership rate. The scenarios give a range of between 5,000 and 9,000 EVs in Wellington Region by mid-2021, and between 15,000 and 28,000 EVs in Wellington Region by mid-2024. Around 30% of these are projected to be PHEVs, and 70% are BEVs. Expressed as a percentage of the fleet, the range is from 1.3% to 2.3% by mid-2021, and from 3.9% to 6.7% by mid-2024.

MoT's projections also estimate the share of each vehicle type amongst the total number of EVs. The average of the five scenarios show 8% of EVs by the end of 2024 are vans and utes, and there are 200 BEV buses nationally. Further data can be found on the MoT website[13].

**Figure 2 – scenarios for EV adoption in the Wellington Region**




> ***"EVs are critical to decarbonising road transport"***

**Table 1 – EV ownership rates and number of public DC fast chargers in the Wellington Region**

| Area | EV registrations at 30-01-19 | Population estimate 30-06-18 | EVs per 1000 people devices Jan 2019 | Number of DC fast charging | EVs per fast charger |
|---|---|---|---|---|---|
| Wellington City | 816 | 216300 | 3.8 | 6 | 136 |
| Hutt City | 311 | 105900 | 2.9 | 3 | 104 |
| Porirua City | 156 | 56800 | 2.7 | 1 | 156 |
| Upper Hutt City | 142 | 43700 | 3.2 | 1 | 142 |
| Kapiti Coast District | 129 | 53200 | 2.4 | 3 | 43 |
| South Wairarapa District | 39 | 10450 | 3.7 | 1 | 39 |
| Masterton District | 30 | 25700 | 1.2 | 1 | 30 |
| Carterton District | 17 | 9340 | 1.8 | 0 | N/A |
| Wairarapa (combined) | 86 | 45490 | 1.9 | 2 | 43 |
| Wellington Region | 1640 | 521390 | 3.1 | 16 | 103 |

## 1.6 Summary of findings

The costs of carbon emissions and air pollution associated with use of fossil fuelled vehicles are not paid for by their users – they are transferred to wider society in the forms of environmental damage and poor health. This means they have an artificial financial advantage compared to EVs, which are not as harmful. This creates a strong rationale for intervention on the part of Government to address this market failure.

Present MoT projections of EV adoption on which the government EV target is based are not consistent with the road transport sector contributing as much as is required of it to meet the goal of becoming net-zero emissions by 2050.

Local authorities, electricity network companies and the private sector can advocate to central government for stronger policies and assist with implementation to help ensure the full potential of EVs to cut emissions is realised, along with other measures to reduce the growth in vehicle kilometres travelled, which will also contribute to lowering emissions. By winding down their own purchase of fossil fuel vehicles, organisations can prevent the 'lock-in' of future greenhouse gas emissions over the vehicles' life, which may be over 20 years.

## 1.7 Electric vehicle promotion and funding

The government via EECA operates the Low Emission Vehicle (LEV) contestable fund to assist the implementation of EV related projects provided they fit certain criteria including their strategic aims and investment focus. Rounds are run twice per year. Local authorities and electricity network companies can and have successfully bid for this funding, including to develop the national network of DC fast chargers.

EECA alongside EV owner association the Better NZ Trust and industry association Drive Electric undertake to promote EVs to the public and businesses, both through the media and at test drive events[14]. Partnerships with other parties are useful to them to increase the scale and reach of these efforts, and Wellington councils have collaborated with them in this way before. EECA monitors the success of these efforts with regular representative surveys. Results from late 2018 show 55% of the public view EVs favourably.


# Issues and analysis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# Section 2

# Section 2: Issues and analysis

There are a number of perceived, actual or potential barriers to EV uptake. These will be discussed in turn with reference to existing research and experience locally and internationally, with analysis and summary of key findings that will be used to inform the recommend policies and suggested actions in this report.

## 2.1 Demand for EVs

There are many reasons for people and organisations to purchase EVs – such as reduced operating costs and the environmental benefits. These benefits create demand, however achieving high levels of EV adoption means motivating increasing numbers of people to make the switch, which will require an increasingly compelling proposition, up to a certain point. Once EVs are ubiquitous, outright bans on the sale of fossil-fuelled vehicles can be used achieve a full change-over, and many countries' governments have already signalled when they intend to bring in such restrictions[15].

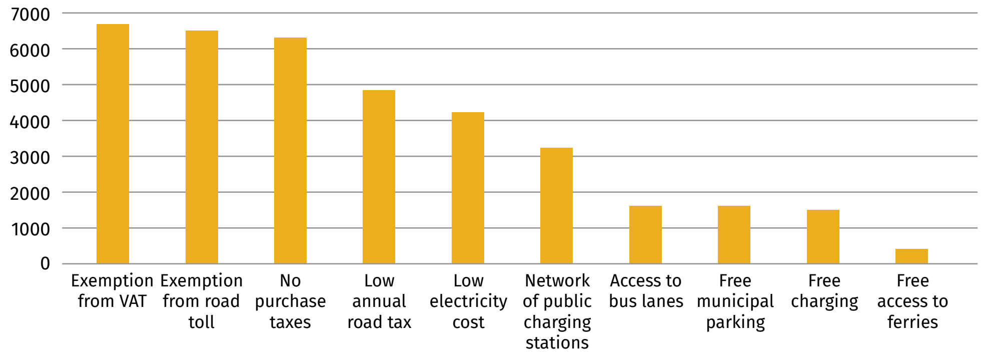
Norway has the highest percentage of EV market share in the world, and highest rate of ownership per capita, as a result of a concerted effort on the part of their government[16]. As of November 2018, Norway had 190,000 BEVs and 90,000 PHEVs on their roads after experiencing year-on-year doubling of the number from very low levels at the beginning of the decade[17]. EVs went from 4.2% of new car sales there in 2011 to 49% in 2018. There are many similarities between Norway and NZ, making their experience instructive, given where they are now is approximately where NZ aims to be in five years' time.

In the 2017 paper 'Charging infrastructure experiences in Norway - the worlds most advanced EV market'[18], the authors from the Norwegian EV Association concluded that measures that lowered the initial purchase cost of EVs were key drivers to creating demand for EVs, for the simple and obvious reason that by eliminating the difference in purchase cost between EVs and petrol and diesel vehicles, it made them as affordable at the point of purchase and more overall attractive, when the other benefits were considered. Exemption from road tolls and other local incentives correlated well with variances in EV uptake across the country, suggesting these incentives played a role as well.

In 2017, the Norwegian EV Owners association surveyed their members, gaining 12,000 responses. They asked respondents to select the three most important incentives offered by the government to them for owning an EV. Exemptions from sales tax (their GST), road tolls and car purchase tax were rated the most important (see Figure 3). Reasons 1 and 3 are incentives that address the initial purchase costs. Slightly lower rated was lower annual road tax and low electricity cost, which along with no road tolls are measures that lower ongoing costs for operating a vehicle. The presence of a network of charging stations, a measure related to practicality and convenience, rather than cost, was ranked sixth.

New Zealand's incentives for EVs are very limited by comparison. The main measure, the exemption of EVs from road user charges (RUCs) is scheduled to end for light EVs on 31 December 2021[19]. For light EVs the exemption is worth around $600 per year on average. For heavy EVs the exemption to Road User Charges ends when heavy EVs make up 2% of the heavy vehicle fleet. For heavy EVs this exemption is worth $5,000-80,000 or more per year depending on the vehicle size and utilisation.

**Figure 3: Most important EV incentives according to Norwegian EV owners from 2017 survey. Question: Select the 3 most important EV incentives[viii]**



### 2.1.1 Summary of findings

Councils and electricity network companies in NZ cannot adjust or introduce taxes or introduce regulation in relation to the sale of vehicles in general or EVs in particular. However, they may take an advocacy role for such measures with central government. It is within the power of councils as road controlling authorities and providers of parking to introduce local incentives for EVs. A diverse array of incentives is desirable to continue to stimulate demand and build consumer confidence.

## 2.2 Supply of EVs

Presently two-thirds of all EVs in the country are second Nissan Leafs imported from Japan. These vehicles, which are typically only a few years old, are available in a price range which is affordable to many NZ consumers, which helps explain their popularity. NZ presently has around 5% of all Nissan Leafs originally sold new into the Japanese market, and this percentage has increased over time. It seems unlikely that this supply will be cut off, but on its own is unlikely to be sufficient. Meeting the demand for EVs will require a greater variety of EV makes, models and vehicle types to be available in the country at an affordable price, to satisfy the requirements of different owners. EVs sold new into NZ also have a greater level of after-sales support from the vehicle manufacturers, which is desirable also, particularly with regard to battery replacement.

However, NZ is not alone in attempting to convert its fleet, and may struggle to obtain a diversity of EV models in sufficient quantities from international vehicle manufacturers while they scale up production. In Norway, consumers have pre-ordered an estimated 30,000 EVs from international car-makers, indicating how supply is presently falling short of demand there[20]. Norway has used a direct approach to addressing purchase price, adjusting sales taxes on cars to make EVs cheaper to buy relative to petrol and diesel vehicles.

Another policy mechanism that could be used to encourage EV supply is a vehicle fuel economy standard. A vehicle fuel economy standard requires manufacturers/importers of light vehicles to have the average fuel efficiency of the vehicles they import and sell to be at or below a certain level of $CO_2$ per 100 km. This encourages them to offer, market and price a greater variety of EV and fuel-efficient vehicles to help meet the standard.

New Zealand and Australia do not have vehicle efficiency standards, unlike Japan, EU, South Korea, USA, Canada, India, China, Brazil, Mexico and Saudi Arabia.

As EV supply is constrained globally, manufacturers may prioritise supply of their EVs to countries where they need them to help meet a fuel economy standard.

### 2.2.1 Summary of findings

The presence of incentives in the country has a role to play in attracting supplies of EVs from abroad, as well stimulating demand, although supply is likely to lag behind demand. Measures to address upfront cost are key, as previously discussed. By committing to convert their organisation's fleets to EV, organisations help increase supply by encouraging vehicle suppliers to support the NZ market, and eventually providing a supply of affordable EVs to the second-hand market within NZ when they are ready to sell them on.

Greater Wellington Regional Council, Hutt City Council and Wellington City Council all have an 'EV first' policy for fleet purchases, and Wellington Electricity has already converted its light vehicle fleet to EV. A group of 34 large NZ corporates committed in 2016 to convert 30% of their fleets by the end of 2019[21]

*"incentives [have] a role to play in attracting supplies of EVs from abroad... although supply is likely to lag behind demand"*

## 2.3 AC (slow) charging and potential grid impact

All EVs can recharge using their onboard AC charger. The rate of charging is limited by the capacity of the charger and power supply it is connected to. AC charging is often called 'slow' charging, with the slowest rate being at 8A (1.8kW) using a common three-pin power socket, typically used by private owners for overnight charging at home. Faster 16A and 32A charging is also affordable and practical in a domestic situation, but requires a modest amount of effort and expenditure on the part of owners to set this up. Half of the participants in the Wellington Electricity EV Charging Trial[22] reported they used an three-pin household socket for home charging, and in Norway, 63% of EV owners do[18]. For those households or businesses with off-street parking, using AC overnight is the cheapest and most convenient method of EV charging. The US Department of Energy EV Project found home AC charging accounted for 86% of the energy delivered to EVs[23].

For a light passenger EV, the amount of range that can be added in ten hours of AC charging is approximately 100km at 8A, 200km at 16A, and 400km at 32A, assuming they have sufficiently large batteries. Data from the NZ Household Travel Survey shows 95% of household vehicles in the Wellington Region are driven less than 116 km/day[24]. The average is 40 km/day, meaning that on average most light EVs only need to be charged for a few hours each day.

Clearly overnight AC charging is and will remain the predominant method for EV charging for the foreseeable future for household EVs. The question of what impact this will have on electricity distribution networks has been investigated in NZ and abroad.

Electricity networks are designed to manage a peak in demand for electricity, which typically occurs in the morning and evening in residential areas. EV charging, once common, will increase these peaks, possibly exceeding the tolerances of networks. Conversely, charging may be spread across the day, reducing impact and improving utilisation and return on investment of networks. EVs could even be used to support the grid at peak times (known as 'vehicle to grid' or V2G). Real world studies and experience provide considerable assurance that EV charging will not have a detrimental effect on grid stability.

**My Electric Avenue 2012-2015, OFGEM, United Kingdom[25]**

In this project 100 households were given a Nissan Leaf EV. They were grouped in 10 clusters across the UK. All households had 16A charging facilities installed in their homes and were extensively monitored. The study found EV charging increases after-diversity maximum demand (ADMD)[i] by 1kW.

Modelling showed that across Britain, 32% of low voltage (residential) networks will require intervention of some kind when 40% – 70% of customers have EVs, based on 16A charging being the norm. However, the study also successfully trialled the use of a system 'Espirit' to manage EV charging load across multiple households, reducing the cluster's peak demand at low cost. The trial participants found letting Espirit manage their charging was not a significant imposition.

**The EV Project 2009-2013, US Department of Energy**

This study including monitoring of over 8,000 EV households, and included the installation of a mature charging infrastructure (home, workplace and public) for them to use. The home chargers were rated at 16A-equivalent[23].

This study of the EV Project data showed the ADMD of all residential EV chargers spread across the country was 1.0kW on weekdays (and 0.8kW on weekends[26]). There were differences between regions. For example the ADMD in Nashville, where they did not have time of use electricity pricing to motivate people to charge off-peak, was 1.1kW at 8pm. In San Francisco, where households could get a cheaper electricity price after midnight, the ADMD was 1.3kW at 1am.

i After diversity maximum demand (ADMD) is the aggregate maximum electricity demand at any one time of many individual connections to an electricity network, given as an average of all connections. An electricity network must be designed to meet ADMD whenever it should occur, with a margin of error. 'Demand-side' measures such as load shifting can be used to reduce ADMD.

**EV Charging Trial 2017, Wellington Electricity[22]**

This trial involving 92 EV-owning households found that home EV charging by owners in the Wellington Electricity Supply area increased ADMD by 0.5 - 0.8kW, which is within the capacity of most low voltage networks. Half of the trial participants used an 8A socket for home charging (1.8kW). Most charged off peak even when they did not receive a reduced price for this, and some changed their behaviour in response to information about the public benefits of charging off-peak. A greater proportion of EV consumers who received time-of use electricity pricing charged their vehicles outside peak periods that those that did not. The majority of participants were comfortable with the idea of having the timing of home charging managed for them by a third party to reduce peak demand.

### 2.3.1 Summary of findings

These real-world studies found that the diversity of home charging behaviours across multiple households greatly reduces the impact on electricity networks compared to what it would be if all EVs were charged at exactly the same time. It is clearly important that this diversity is maintained, which can be achieved via electricity pricing and non-intrusive services to co-ordinate charging, but it would appear that most existing residential electricity networks will be able to cope with very high levels of EV penetration. This is further supported by the experience in Norway, where no significant issues of this kind have arisen so far from home charging in urban areas, with the exception that some remote, rural holiday destinations have experienced issues from recharging during peaks in visitor numbers. Care should be taken by utilities and councils to identify and address such 'hot spots'.

### 2.3.2 Vehicle to Grid

Vehicle-to-grid (V2G) EV chargers (and similarly equipped vehicles) facilitate energy flow both to and from an EV, allowing it to act as a rechargeable energy source. When connected to a V2G charger at home or work, charge from an EV can be used as a cheaper power source when electricity prices are at their peak, reducing peaks in electrical demand. It may eventually be able to be used to power homes during power outages.

V2G has to managed in a way that ensures the EV owner still has enough energy to drive when and where they want. The purpose of V2G is to boost the resilience and flexibility for the electricity network during peak demand while also giving EV owners a financial benefit through reduced electricity costs and/or a payment for the service their battery provides.

The technology is in use in Japan[27] and network company Vector is conducting a trial of V2G in Auckland[28].

## 2.5 On-street residential charging

While home AC charging is the cheapest and most convenient option for those that are in detached or semi-detached homes, accounting for the majority of households in the region, there are many households where this is not available. One in four dwellings in Wellington City lack off-street parking. Also apartment dwellers and other people in rental accommodation may not be able to arrange a charging point with their landlord or body corporate. People in such situations need viable alternatives in order to successfully operate their own EV.

In 2015 consultants working for Transport for London (a city where 85% of dwellings lack off-street parking) extensively studied these options, including existing approaches in use across Europe[29]. Those they judged were effective and deliverable were:

- Public, bookable on-street AC charging stations, located in residential areas
- Basic, secure sockets installed on street furniture outside EV owners' homes (this is being implemented in Germany by a private company Ubitricity, and in the London Borough of Southwark by the company char.gy)
- Running a lead from the home to the street over the footpath and covering it with secured matting (allowed in Amsterdam)
- Relying on public DC-fast charging, away from home
- Alternative arrangements nearby to home– e.g. using sharing apps, accessing commercial parking outside of business hours.

Each option has its own pros and cons. The consultants saw the greatest potential in creating 'socket networks'. DC fast charging was also seen as very important, though the higher cost and lower convenience of this meant it was ranked lower.

Subsequently, the UK government has created a funding programme via their national Energy Saving Trust (EST) and local authorities to establish residential on-street chargers. The fund is in its second year and only three projects have been implemented so far. The reasons for this given by EST were other residents objecting during consultation; the street works required were too expensive; and electricity network operator objections. Also for various reasons the projects also take a long time to implement. The criteria of the fund have been changed to include nearby local authority off-street carparks, with the chargers being available for public use during the day and residents' only at night, in order to avoid conflict with neighbours over the limited parking space outside their homes[30]. As of early 2019, there were approximately 700 'slow' chargers in Greater London[31].

Amsterdam's City Authority has a dedicated EV Charging Infrastructure bureau. They provide on-street EV charging points when they are requested (for overnight use by residents, so-called 'pillow', chargers). The target for the end of 2018 was to have 4,000 of these chargers installed. The chargers provide data to the municipality, which they use to co-ordinate further development of the network. The City has also developed clusters of chargers in some neighbourhoods[32].

Wellington City Council has secured 50% funding with EECA's Low Emission Vehicle Contestable Fund for trialing on-street charging in 25 residential streets, which will be operational later in 2019. Given almost 20,000 homes in Wellington City lack off street parking, and could be reliant on such a scheme being expanded, the learnings of this trial will be valuable to guiding the future of the city's charging network.

### 2.5.1 Summary of findings

It is perhaps unsurprising that allocating space in the public realm for the exclusive use of a limited number of people is contentious, especially when such space is scarce. However the experience of cities such as Amsterdam shows that this resistance can be overcome if the municipality is committed to EVs and the general public understands and accepts the reasons why.

Support for private use of EVs must be part of a package of measures for personal mobility whose primary focus is on alternatives to private car ownership, such as walking, cycling, e-mobility and public transport for the majority of journeys, and access to electric car-share schemes and rentals when necessary. See the case study on the City of Portland's EV Strategy and its transport hierarchy on page 30.

Regarding new apartments, when parking is provided, councils can require charging to be provided alongside them to avoid any problems getting it installed in the future. This is recommended by the Norwegian EV Association[18].

Councils themselves are also providers of rental accommodation. Councils could allocate charging bays in shared council housing resident car parks when residents request them, or pro-actively.

## 2.6 EV incentives versus public transport and active modes

In providing incentives for EVs, will public authorities inadvertently attract travellers away from more preferred modes such as active and public transport? There is a dearth of research on this topic. However a 2015 masters thesis by Eric Nygaard[33] on Norwegian EV uptake and substitution effect for other modes found that:

"The tests conducted on the data sample indicate minor, but statistically significant EV substitution effects on public and manual transportation for commuting. Although some respondents decreased their use of public and active transportation, the median use did not change. 70% and 86% respectively held on to their public and manual transportation habits when they became EV owners. Moreover, the tests indicated no significant EV substitution of public and manual transport for everyday activities or long journeys. The implication is that EVs only to a limited extent substitute public and manual transportation, and when substitution takes place it is mainly for trips to and from work… In light of the strong link between car use and timesaving versus public transport, increasing the frequency and convenience of public transport could help offset this effect."

This finding is generally reassuring that any effect is limited. However, it is still useful to consider carefully the design of any incentives or policy measures for EVs with such potential effects in mind, and mitigate them if possible.

In Oslo, after a decade implementing strong incentives for EVs such as free parking, free charging, free use of toll roads and use of bus lanes to complement government policies for EVs, EVs make up 57% of all new car sales (45% BEV and 12% PHEV) there. Because of this success, the municipality is now rolling back some of these incentives (such as free charging and the road toll exemption). EV cars are not exempt from their plans to make their inner-city car-free and more people-centric. However, electric delivery vehicles will be permitted access[34].

## 2.7 Demand for public charging infrastructure

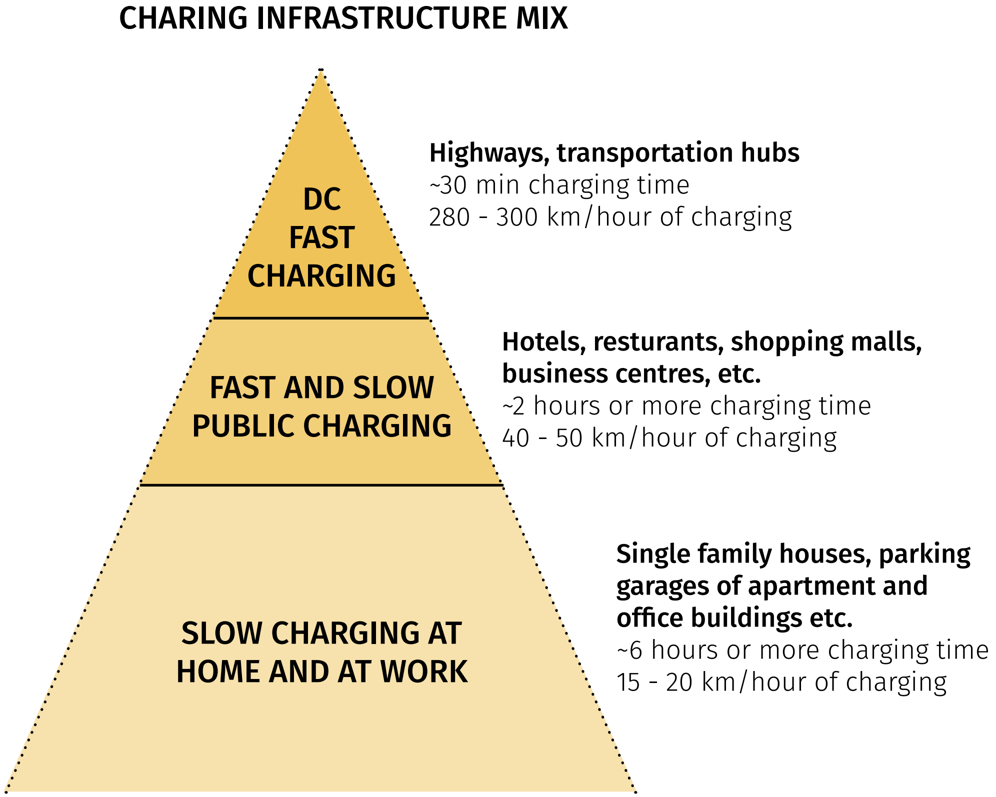
The number of public charging stations relative to EV fleet size has been examined for a selection of different countries. See Table 2 (over page).

Norway has the highest number of EVs per DC fast charger and the second highest per all public chargers. This reinforces the finding of the Norwegian EV Association[18] that beyond a certain point, the provision of charging infrastructure is not the main driver of EV uptake, rather, it is other policies. While the spread of BEVs per fast charger is very wide, per all EVs it is within a factor of 2.1, suggesting this is a better guide to charging needs. Interestingly, New Zealand has the fewest EVs per fast charger of the group, which is perhaps related to the early stage of EV adoption in the country which coupled with the widely dispersed population requires a relatively widely-dispersed but lightly-used network of chargers.

The number of EVs per public charger is within a factor of 2.5, if the Netherlands is excluded. The Netherlands has a very low number of EVs per public chargers per EV, but it is unusual in that it has a very high proportion of PHEVs. Given the small size of battery packs in PHEVs, arguably they have a reduced need for fast charging. Also the Dutch municipalities have had a strong focus on installing on-street residential 'pillow' (overnight) chargers in their cities (see the case study on Amsterdam in the previous section). These are technically public chargers, so have skewed the numbers somewhat compared to the other countries.

Guidance for municipalities in Europe assembled by consultants Cleantechnica and Greenway with the help of a working group of charging infrastructure professionals[35] recommended a 'rule of thumb' of one DC fast charger per 100 EVs, and one public[ii] AC charger per 10 EVs. This rule appears to be broadly consistent with Table 2. The mix of charging types they recommend is illustrated in Figure 4 (right).

**Figure 4: CleanTechnica and Greenway's recommended charging infrastructure mix.**




ii 'Public' chargers include those which are reserved for patrons such as at hospitality and retail businesses, but excludes workplace chargers for employees.

**Table 2: EV numbers and public chargers for a selection of countries**

| | As at... | BEVs | PHEVs | Total EVs | DC fast chargers | All public chargers | BEVs per DC fast charger | EVs per DC fast charger | EVs per public charger |
|---|---|---|---|---|---|---|---|---|---|
| Norway | Oct-18 | 190000 | 90000 | 280000 | 1600 | 10600 | 119 | 175 | 26 |
| Netherlands | Dec-17 | 20000 | 100000 | 120000 | 750 | 32000 | 27 | 160 | 4 |
| UK | Dec-18 | 60792 | 138765 | 199557 | 1900 | 19000 | 32 | 105 | 11 |
| Germany | Dec-18 | 105115 | 89629 | 194744 | unknown | 16,100 | - | - | 12 |
| USA | Dec-18 | 630000 | 480000 | 1110000 | 8244 | 57586 | 76 | 135 | 19 |
| New Zealand | Jan-18 | 9140 | 2927 | 12067 | 148 | 447 | 62 | 82 | 27 |

Applying the ‘rule of thumb’ of one DC fast charger per 100 EVs and one public AC charger per 10 EVs, the range of possible public charging requirements for Wellington Region is summarised in Table 3 (right).

## Table 3: estimated range of future public charging needs

| | EVs | AC chargers (3 - 22kW) | DC fast chargers (25 - 50kW) | Total capacity (MW) |
|---|---|---|---|---|
| Jan 2019 | 1,640 | 39* | 16 | ~1 |
| Jun 2021 | 5,000-9,000 | 500-900 | 50-90 | 6-11 |
| Jun 2024 | 15,000-28,000 | 1,500-2,800 | 150-280 | 18-34 |

* Note that the majority of these public chargers are at hotels and campgrounds

### 2.7.1 Public AC (slow) charging

Public AC chargers are useful in areas where EVs will dwell for long periods, given the relatively long charging times associated with them. Such locations are airports, hotels, holiday parks, shopping and entertainment premises, and parking complexes near to these places. There is a business case for the owners of these premises to provide charging as a value-add service to patrons, similar to 'free wi-fi'. Private property is already likely to have an adequate electricity supply for AC charging, so the incremental cost of installing and operating acharging point is often low. As such, there is limited need for public sector involvement, other than promotion, unless they themselves are the public parking provider.

Electric car share schemes may also wish to install public AC charging on-street to support their fleet of vehicles. This network could also potentially be used by others. Potentially there could be other private companies wishing to install AC charging (e.g. as a standalone business). However, the costs and business risks associated with a third party installing and operating an AC charger on-street relative to the return can be challenging. Road controlling authorities can help by having clearly laid out policies and processes for applications for public chargers, and by co-ordinating with electricity network companies to identify the areas where electricity supplies for chargers can be established at least cost. These systems would be equally useful for applications to install DC fast chargers.

### 2.7.2 Fast charging

DC fast charging (namely charging at rates higher than 25kW) is critical for extending the range of EVs on long journeys, especially for those EVs that have smaller battery packs, such as the Gen 1 and Gen 2 Nissan Leafs. They may also be the main means of recharging for those EV owners without off-street parking, as previously discussed. Referring specifically in relation to household vehicles, as EVs with larger battery packs become more common, the number of fast chargers that are required relative to the total number of EVs in the country can be expected to reduce, given it is possible to add hundreds of kilometres of range to a light EV using overnight charging. (This does not include taxis, couriers and other commercial vehicles, that typically have higher utilisation rates than household vehicles – see the following sections for further discussion) However, in the interim, we can expect demand for fast charging to increase roughly in line with the total number of EVs.

Citizen science organisation 'Flip the Fleet' surveyed of 102 EV owners in New Zealand about fast charging in 2018[36]. It found that the sample group almost unanimously thought that more fast chargers were required. The most desirable characteristic of fast charging (determined via a choice experiment) was found to be immediate and predicable access. The authors recommended the introduction of usage fees to fast chargers that are presently free to discourage unnecessary use of chargers by EV owners that could charge at home, and to support the expansion of fast charging on a commercial basis. This is the same recommendation made by the Norwegian EV Association[18], but in any case, all public fast chargers in the Wellington Region already require payment to the provider Charge.Net. The authors also suggested that a greater number and variety of chargers should be made available at presently congested sites. Charge.Net did this in 2018 at their chargers at the Vivian St Z station and at the Dowse, putting a 25kW unit alongside the existing 50kW unit at each. The available electrical capacity (or the upfront investment in upgrades to get more) is a constraint on further development. Queuing will increasingly be a problem if the development of fast charging infrastructure does not keep pace with the number of vehicles. Another potential constraint is the suitability of the placement and configuration of fast chargers for larger vehicles (e.g. commercial vehicles, campervans and motor homes), or those users with special mobility requirements. However, this may not necessarily slow households from adopting EVs significantly overall as most people will be able to charge at home[18].

Goldman Sachs[37] estimated the potential market for DC fast charging infrastructure in their report 2017 report 'EVs: From Pump to Plug'. They estimated globally that overnight home charging would account for 80% of all charging, and DC fast charging would be 6%, with the remainder being AC charging at workplaces or other destinations. Following from this, the report authors estimated that while the distribution of fast charging stations must be similar to filling stations, their utilisation will be around 10 times lower (around 20 customers per day), meaning a significant margin above operating costs must be charged to recover the capital costs and make a profit. This can be observed in NZ presently, where fast charging using commercial chargers is approximately three to four times more expensive than charging at home. Despite this, presently DC fast charging is still around one third cheaper than petrol to drive an equivalent distance. However, the end of the RUC exemption for EVs would significantly reduce this difference.

### 2.7.3 'Ultrafast' charging

In the near future, new EVs will be capable of fast charging at rates much higher than the present norm of 50kW (e.g. at 350kW, seven times faster). In theory this will allow EVs to be recharged in a similar fashion to how petrol and diesel cars are refilled, within a few minutes. However, the electrical capacity that will be needed at such 'ultrafast' charging stations, assuming there are multiple units at each site as there are at filling stations, will be substantial.

To gain a better understanding of the capability and costs of the electricity network to accommodate ultrafast charging stations, estimates were obtained for hypothetic installations at logical locations for a hub of either four or eight 350kW charging units.

- Cnr Arthur and Taranaki Street, Te Aro – Lowest cost option: $750K +- 20%
- 140 Hutt Rd, Kaiwharawhara – Lowest cost option: $400K +/- 20%

In addition, network companies typically charge commercial clients per kW of their supply's connection, capacity and annual maximum demand, as well as per unit of electricity (In the Wellington Region, only Electra does not). For the Wellington Electricity (WE*) network area, a 350kW supply would cost between $100 and $150 per day in such 'fixed' fees, depending on whether it fell into the highest or second highest load group. See table below for a comparison. These costs would have to be recovered from users e.g. 20 users/unit/day means $5.00 -$7.50 per customer, on top of energy costs, capital cost recovery and any other expenses.

Given this, ultrafast charging may only be profitable where utilisation is very high, meaning in locations where it is especially useful (so it can command a premium price) and there are many potential customers – e.g. in the middle of long-distance journeys on arterial routes. Therefore, they seem unlikely to supplant the network of regular DC fast chargers, but rather occupy a niche of their own.

***"…new EVs will be capable of fast charging…within a few minutes… however, the electrical capacity that will be needed at such 'ultrafast' charging stations…will be substantial."***

**Table 4: Fixed network costs per DC fast charger per day for different load groups and network areas[iii]**

| | Fast (50kW) | | | Ultrafast (350kW) | | |
|---|---|---|---|---|---|---|
| Load group | WE* | PowerCo | Electra[iv] | WE* | PowerCo | Electra[iv] |
| <300kVA | $11.35 | $62.87 | $1.64 | N/A | N/A | N/A |
| 300-1500 kVA | $35.90 | $45.14 | $1.64 | $104.36 | $315.99 | $1.64 |
| >1500kVA | $21.46 | $35.90 | $1.64 | $49.87 | $230.52 | $1.64 |

iii Calculations assume transformer capacity is perfectly matched to peak demand and the power factor is 1. Based on network pricing schedules valid for 1 April 2018 to 30 March 2019.

iv Electra recovers their costs mainly on the energy component of their charges. As these are volume based, a lightly used fast charging station will face lower overall electricity costs in their supply area compared to the WE* and PowerCo areas. The difference with the other areas will be lower if utilisation is higher.

### 2.7.4 Regional differences in charging needs

Each of Wellington's districts have different characteristics which will influence the type, amount and distribution of public charging infrastructure that they need.

**Wellington**

As previously discussed, the quarter of properties lacking residential off-street parking in Wellington City is the most striking difference with other areas, and Wellington is the 'end of the line' for many journeys, including interregional ones, and receives high volumes of commuter traffic on weekdays. Wellington City will therefore need more public chargers on a per capita basis relative to other parts of the region. Providing charging facilities at popular destinations, the airport and ferry terminal, or on the ferries themselves is therefore a key consideration. Significant growth in the central city of both residential and commercial development is expected, meaning issues relating to car-parking and air pollution will become more acute if not addressed. Electric car-share schemes, amongst other measures, present a possible remedy to both.

**Hutt City, Upper Hutt, Porirua and Kāpiti**

As suburban districts, these areas have a very high prevalence of residential off-street parking. They are relatively close to Wellington itself, meaning fast charging should not be needed for visits to the city in the majority of EV models presently available. Also major arterial routes pass through these areas, meaning their charging facilities may be needed by visitors more frequently than locals.

These areas do not presently have a significant proportion of apartment dwellers, but these will increase with time as the urban density increases. This presents a significant opportunity to ensure that EV charging facilities are required as part of new medium and high-density development.

**Wairarapa districts**

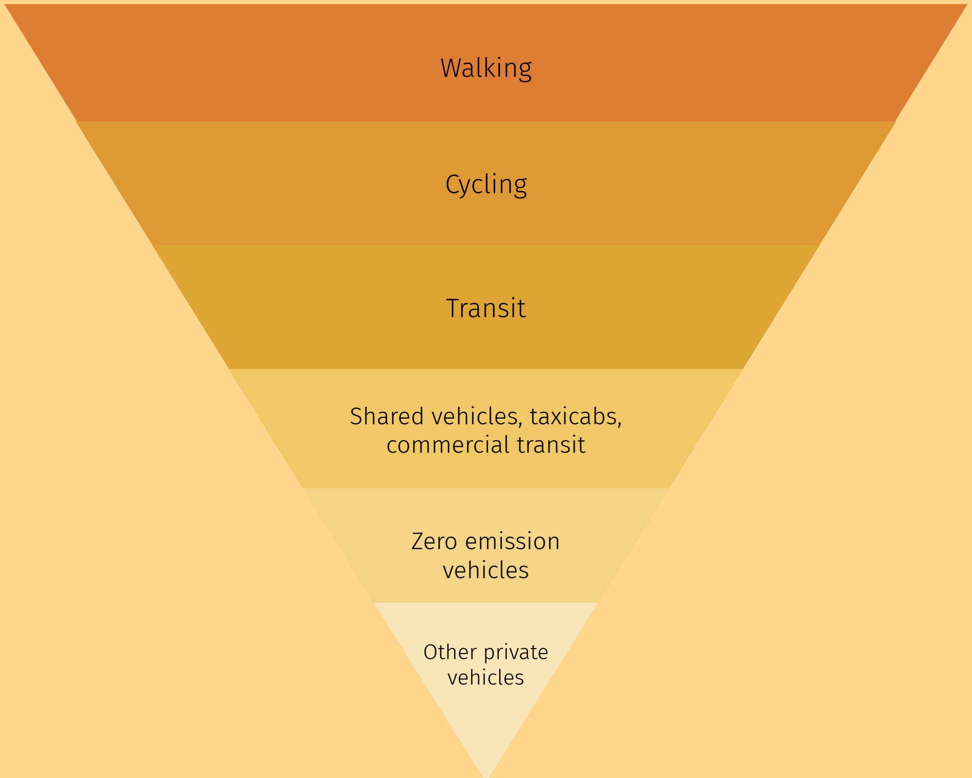
These districts are relatively large and rural, so public charging (both AC and DC) in the main settlements would enable residents living in outlying areas to more easily operate EVs. Tourist destinations such as Castlepoint and Martinborough, although not on major routes, would benefit from having charging facilities for visitors. As a sparsely populated area, there is naturally a greater need for cars for personal transport, meaning EVs will have greater importance in emissions reduction plans relative to other low-emissions modes such as public transport. The availability of longer range EVs and utility EVs would assist the Wairarapa with adopting this technology.


**Masterton District Council's mayoral EV charging at their offices**

## 2.8 Portland, Oregon USA

The City of Portland's 2017 Electric Vehicle Strategy[38] focuses on electrification of the public transit system, shared vehicles and the private automobiles that remain in use, and is one of many strategies the City is taking to reduce carbon emissions from the transportation sector. Their transportation hierarchy shows the priority order of different modes:

**Figure 5: Portland's transportation hierarchy for people movement**




This strategy also seeks to maximize the benefits of air quality and affordability for low-income residents and parts of Portland that are the most dependent on private vehicles.

The explicit goals of the strategy are to:

- Replace at least 10,000 gas- or diesel-powered vehicles with electric vehicles in their County.
- Increase access to electric vehicle charging infrastructure by doubling the number of 'Level 2' (AC) and DC Fast Chargers available to the public.
- Increase access to affordable electric vehicle transportation options for low-income populations and communities of colour.
- Maximize the air quality and cost savings benefits of electric vehicles for low-income populations and communities of colour.
- Add 60 electric vehicles to the City's fleet to increase the percentage of electric vehicles from 20 to 30 percent.
- Prioritize the electrification of shared use vehicles, bikes and buses to reduce the need for personal vehicle ownership.
- Encourage the electrification of automated vehicles to improve safety and mobility options for people who don't drive.

The City of Portland prioritizes charging infrastructure in areas of Portland that have:

- Fewer existing public charging stations.
- Limited access to frequent transit and bike routes.
- Higher proportions of multifamily housing and garage-free homes.
- Large businesses with employees commuting long distances.
- Residents with higher average vehicle miles travelled.
- Destinations (recreation sites, event venues, etc.) people tend to travel longer distances to access.

The strategy has actions relating to establishing charging infrastructure in a wide variety and type of locations, adoption of EVs into fleets, promotion, gathering information and supporting innovation.

## 2.9 Buses

Electrification of buses in the Wellington Region has begun with the two major public transport contracts in the Region.

### 2.9.1 NZ Bus

NZ Bus have 160 buses operating at any one time in the region. They already have a single BEV bus in service and are working with the Regional Council on introducing more.  Their BEV buses will have three axles so which allows them to carry batteries with a capacity of 300kWh and still fall within the cheaper 'General Access' Road User Charges category. This higher battery capacity means there is no need for fast charging while on route. NZ Bus estimates each BEV bus will use 180kWh of energy per day on average. The difference in daily requirements and battery size is an allowance for battery degradation over time and operational contingencies.

The buses can carry 75 passengers maximum and have air conditioning. Their energy efficiency is 1.3kWh/km (air conditioning increases energy consumption by 30%).

NZ Bus plan to use 150kW AC chargers in their depots using a smart dispatch system to coordinate charging. They have two depots, one in Karori and one in Rongotai. Initially there will be around 20 BEV buses at the former and 30 at the latter. The main issue NZ Bus sees is grid capacity at the depots and the cost of electrical upgrades – the entire cost of the upgrade needs to be recouped within the contract period, as there is no certainty of income beyond that period (10 years). The EECA grant NZ Bus have already received is for depot infrastructure does not cover the full cost of transformer upgrades[39].

Assuming all buses would be charged by 180kWh each within an eight-hour window with a flat profile, using as many chargers as required, the depot charging capacity requirement for 57 BEV buses is estimated to be 1.4MW. For 160 buses it is 3.8MW.

### 2.9.2 Tranzit

Over the total Greater Wellington Region, Tranzit operate 60% of the total fleet, around 265 buses.

As of early 2019, there are ten BEV double-decker buses in the Tranzit fleet, and there are plans to expand this by 10 more in 2020 and 12 in 2021 (32 by the end of 2021). Their BEV buses are dual axle and do not have air conditioning. They carry up to 80 passengers and are not as long as a three axle bus, making them more manoeuvrable.

The buses are equipped with between 109 and 161kWh of batteries and these can be recharged in the depot at Rongotai in 3-4 hours using their 30kW chargers.

The BEV buses have a range of 100km which limits their utilisation, hence they are deployed at peak times (rather than all day) and/or on short routes. On-route fast charging is essential for extending their daily range. Tranzit are experimenting with for weight saving options to increase range and stay on general access RUCs. Ultimately, they want their buses capable of 250km and being on duty for up to 20 hours per day. The majority of buses in their fleet drive 150-200km per day.

The electrical capacity at Rongotai Depot is at maximum. However, staff believe by staggering charging times they could double the number of EV buses charging there. Tranzit's other depot sites in Grenada and Hutt Valley were selected based partly on the electrical capacity for charging.

The Island Bay bus fast charger is rated at 450kW and using it BEV buses can be charged from 20% to fully charged in 12 minutes[40].

Assuming all of Tranzit's buses would be charged 90kWh within an eight-hour window with a flat profile using as many chargers as required, the depot charging capacity requirement for 32 BEV buses is estimated to be 0.4MW. For 235 buses it is estimated at 2.8MW. This would be only half of their charging requirement. The remainder would be on-route fast charging.

Tranzit's estimate is for ten to fifteen 450kW fast chargers to support their share of an all-electric bus fleet in Wellington, a total of capacity/peak electrical demand of between 4.5MW and 6.8MW. Calculations suggest that this number of 450kW chargers would need to be in use for 4 hours per day on average to deliver all the required energy. Each charger would need to be used by an average of 19 buses per day. This is a high level of utilisation and would need to be co-ordinated carefully.

Tranzit should be able to increase the range of their vehicles without increasing their weight as battery efficiency (kWh/kg) improves.

### 2.9.3 Analysis

NZ Bus and Tranzit are taking markedly different strategies to EV buses. Both methods will require significant investment in charging infrastructure and grid capacity at key locations. However, Tranzit's model will require 29 to 37kW of charging capacity per bus (17 to 25kW on route and 12kW in-depot), spread across up to 19 locations. NZ Bus's model will require approximately 24kW of charging capacity per bus at just two locations.

A study by Element Energy estimated that in order to electrify Auckland's bus fleet, the existing 15 bus depots in Auckland collectively would need $32M in electrical upgrades for recharging, assuming the buses were exclusively charged in-depot[41]. This gives an indication of the scale of the investment that is needed. Element Energy's model could be used to produce an estimate of costs for Wellington bus depots.

Regarding fast charging locations, it would be better for buses to have a number of short, fast top-ups throughout the day to avoid queues in the middle of the day, when battery levels across all buses that had a full overnight charge in the depot would be getting low. Bus fast chargers need to be provided on areas of routes where buses can connect to them quickly and automatically and achieve a high level of utilisation. Fast chargers would be less useful at the tops of hills as fully charging the buses there would forego the energy that would be recovered from regenerative braking as the buses went back downhill. Another consideration is that changes to bus routes may mean fast chargers and the attendant electricity infrastructure are no longer in the most effective locations, incurring significant capital costs to re-establish them.

#### 2.9.4 Summary of findings

As the contract holder, the Regional Council are in a position to accelerate adoption of BEV buses This would presently require a larger capital investment than for diesel, but analysis by Bloomberg[42] shows BEV buses already can have a lower total cost of ownership than a diesel bus, depending on the method of charging and daily usage, meaning the cost to ratepayers over the asset life is not necessarily more. There will be a long-term requirement for an increased electrical capacity at the depots to support BEV buses, longer than a single 10-year contract cycle with a bus operator (as the increased capacity will be useful for far longer than ten years). This raises the question who should own these assets.

BYD electric bus in Santiago, Chile
Photograph courtesy of insideevs.com

Santiago in Chile has added 200 BEV buses to its fleet. Two different electricity utilities each own 100 of the buses and lease them to the bus operators along with the supporting charging infrastructure.

## 2.10 EV refuse collection trucks

Palmerston North City Council purchased two purpose-built EVs to replace two leased refuse trucks. These began work in 2018 on kerbside collections for solid waste (3600kg payload) and glass (1900kg payload).

The Energy Efficiency and Conservation Authority (EECA) contributed half of the cost of the trucks – more than $300,000 of the $736,000 – from its low emission vehicles contestable fund.

An on-site co-generation plant at the Resource Recovery Park generates electricity is being used to recharge the trucks, which have a 180km range.

This follows Kāpiti Coast District Council, which has been operating an all-electric refuse collection truck since 2013, and Waste Management who introduced battery electric vehicles to their collection fleet in 2017.


One of Palmerston District Council's two EV refuse collection trucks.

## 2.11 Taxis and private hire vehicles (e.g. Uber and Lyft)

Taxis and private hire vehicles are operated by owner-drivers. There are an estimated 2,500 taxis and 3,000 private hire vehicles in Wellington. (For the purposes of brevity hereafter they will all just be referred to as 'taxis'). Taxis have a greater level of utilisation than regular private light vehicles, an average of 150km/day in Wellington for a full-time driver, but will occasionally they will drive much further[44], and average is higher for shared taxis that operate two or more shifts per day. Taxi operators are very focussed on vehicle operating costs, which is why nearly all taxis in Wellington are hybrids. BEVs appeal to taxi companies because of the further operational savings which are possible, but capital cost is still a major barrier. Around 10% of the taxi fleet is replaced each year.

Most taxis drivers own their vehicle and take it home at night – there is no central taxi depot where they could be kept and charged. Anecdotally most taxi drivers live in flats and do not have access to overnight charging. This means to operate BEVs as taxis, they would currently be dependent on public fast charging facilities.

Taxi company Greencabs had seven Nissan Leafs operating in Wellington in 2017, but reduced this to four in 2018 because of queues for fast charging at Vivian St fast charger. Drivers cannot afford to have long periods off-duty during the day for charging because of the lost fares and income.

In London, new taxis need to be 'zero-emission capable' (a definition that includes all BEVs and some PHEVs) to be licensed for the first time, but this does not apply to renewed licenses[45]. This is part of an effort to address air pollution in London.

Transport for London (TfL)'s strategy for EV taxis includes the development of their fast charging network, with some charging points reserved exclusively for taxis. There are also dedicated on-street parking bays for EV taxis.

TfL are helping to fund a Government-led Plug-in Taxi Grant, which will give taxi drivers up to £7,500 off the price of a new e-taxi. They also encourage taxi drivers with EVs to apply for government/council grants to have charging points installed on-street near their homes, which mostly do not have off-street parking.

#### 2.11.1 Summary of findings

Given their focus on operating costs, and the precedent of the taxi fleet becoming nearly exclusively hybrid, taxis may be an area that could adopt EVs relatively quickly, provided certain barriers can be overcome, namely affordable and convenient charging. The issues with this are essentially the same as for all potential EV owners that lack off-street parking, with the added challenge that being utilised more highly, the cost and convenience factors for taxis are even more important.

### 2.12 Delivery vans and other commercial vehicles

The two major freight companies in NZ, Frieghtways and NZ Post, in most cases use contractors for courier deliveries and line haul functions and majority of these are contractors owner-drivers who take their vehicles home when off-duty. There is 10% growth in parcel volumes each year, meaning the courier fleet is growing too, and this growth will presently all be met with petrol and diesel vehicles.

NZ Post is presently running five BEV courier vans which their contractors can try for free. They have committed to becoming net zero emissions as an organisation by 2030. The average mileage of their couriers is around 100 km/day, and they have 200 courier vans in the Wellington Region. They are investigating the practicality of home charging for their courier drivers. This is part of a review of how their present contractor payment model can be changed to be suitable for BEV. NZ Post sees the public sector giving clear direction to industry as important. Dialogue with industry is important as well as providing incentives to help drive the transition to EVs[46].

If BEV courier vans cannot be charged by their owners at home, they must be charged in the depot. Vans are loaded in the depot several times each day, adding up to a few hours of idle time in total. This is sufficient time to recharge, provided charging facilities are located in the loading areas. Recharging a 3.6T BEV van enough to add 120km of range (120km/day for deliveries plus 35km/day for commuting) in 2 hours would require a 22kW charger. Providing these for a fleet of vans is likely to exceed the electrical capacity available at depots. Overnight charging in the depot would require less electrical capacity (because recharging could be done over eight hours instead of two) and therefore be significantly cheaper, but this is a major change from the present model of vehicle management – courier drivers would need to commute to work by some other means and would not have as much access to their van. Similar to taxis, couriers using public fast charging is also at odds with their profitability in terms of operating costs and/or income as jobs would be forgone while the vehicle recharges. Overnight home charging (at 7kW/32A) would be the best option if it can be achieved.

In London, LoCity is an industry led group set up to help commercial vehicle operators switch to alternative fuelled vehicles including EVs to go beyond the requirements of London's new Ultra-Low Emissions Zone, which will start in 2020.

LoCity sees the lack of a clear policy framework beyond 2020 to drive change as the key issue. NZ also lacks a policy framework for this sector– there are EV targets for the country but no obligation on commercial fleet operators to do anything.

#### 2.12.1 Summary of findings

LoCity's recommendations that are relevant to the Wellington/NZ context are:

- Industry stakeholders should engage with policymakers to help define targets, timescales and measures that will support market development and reduce emissions
- Fleet operators and infrastructure providers should work together to align timings and locations of EV adoption and charging infrastructure deployment.
- Fleet operators and infrastructure providers should engage with and participate in trials of innovative technologies to demonstrate real-world applicability and provide evidence of cost and emissions savings[47].

## 2.13 Case study: City of Sacramento, California, USA

In 1994, Sacramento City Council adopted a policy that first established the City's EV Parking Program, providing free or discounted parking and charging to EV drivers. The original charging infrastructure supporting this effort was installed in both the City parking garages. This was the City's first program to specifically encourage EVs. The City continues to operate the program, providing free or reduced-cost parking for 316 participants as of August 2017. Participants receive free parking until EV parking transactions exceed 5% of overall parking transactions in any one garage, at which point all EV program participants for that garage will be charged 50% of regular parking fees for the garage[48].

In early 2017, the Sacramento 'air quality district' launched the Our Community CarShare program, a low-income ZEV car share program. The city council is supporting the program with construction of two EV chargers dedicated for the program. Funded by the California Greenhouse Gas Reduction Fund and operated by Zipcar, 300 free memberships are available to residents of three affordable housing developments in Sacramento. Many residents at these locations do not own vehicles, and personal transportation can be a challenge. With the program, residents now have up to nine free hours weekly to use an all-electric Kia Soul.

As part of the Sacramento Area Plug-in Electric Vehicle (PEV) Collaborative, a partnership of local and regional agencies including the electric utility and community partners, the City recently participated in developing the county-wide Electric Vehicle Readiness and Infrastructure Plan (2017)[49]. The primary focus of the plan was to identify the number and types of chargers to meet public needs while avoiding an excess of chargers, and they did a detailed forecasting exercise of charging need in 2036 to support this. The plan informs the City's 2017 EV Strategy and includes a number of recommendations for its member organisations including:

- Setting targets for EV adoption into their own fleets
- Priority parking for EVs at partner facilities (e.g. municipal car parks)
- Adding EV charging requirements to building codes and permitting
- Funding incentives for people to replace high emissions vehicles with low emissions vehicles (part of existing air quality improvement programmes)
- Providing EV infrastructure including carshare schemes to disadvantaged communities or the common destinations of people living in those communities,
- Sharing information about the utilisation of EV chargers to identify gaps
- Funding installation of chargers (the electricity utility is offering US$1,500 grants towards the cost of installing charging infrastructure)
- Setting annual targets for fleet and employee EV use for 2018 through 2025 that reflect the county's portion of the state-wide EV targets
- Providing incentives for employees to use EVs.

## 2.14 Car share schemes

Car share schemes can offer a way for organisations and individuals to use EVs without buying them. The higher levels of utilisation a car-share scheme typically achieves (over 20%, compared to 3% for a privately-owned vehicle) means the advantage in operating costs with an EV can compensate the scheme operator for the presently-higher purchase cost. For every shared-car added to a city, 9 to 13 vehicles are taken off the road[50], so they help address parking and congestion issues as well. Christchurch City Council was able to shed 54 light petrol vehicles from its fleet immediately when it joined YooGo Share, an all-electric car-share scheme.

MEVO operates a car-share scheme in Wellington using plug-in hybrid Audi E-Trons at present. Their goal is to eventually transition to a fully battery electric fleet, but the convenience of access to charging points for users is a constraint. They have been focussing on establishing charging points (32A/7kW AC) on private land, because of the greater ease of implementation compared to in the road reserve. The hosts of these chargers do not pass on the cost of the electricity to MEVO as it is not expensive enough to warrant it. Other EV owners can use these charging points. Car-share users can be incentivised to plug the vehicles into chargers by receiving a credit or some other financial advantage from doing so[51].

MEVO has a free-floating parking arrangement with Wellington City Council, which is convenient for users as they do not need to make a separate payment to WCC for this: The cost of parking is recovered as part of the car-share usage fee.

## 2.15 Workplace AC charging

The US Department of Energy EV Project found that BEVs that had access to workplace charging only got 2% of their energy from public charging facilities – the rest was from home and workplace charging. For comparison, the EVs without workplace charging got 14% of their energy from public facilities[23]. A separate study in the US found workplaces that provided EV charging increased the ownership of EVs amongst their staff by 20%[52]. While employers have an important role to play in encouraging their staff to use non-car modes to get to work, there are some locations and circumstances where car-use for commuting is unavoidable.

Furthermore, as EVs age, their batteries cannot hold as much charge and their range reduces. While the batteries can be replaced, it may be that many potential owners cannot afford to do this. If workplace charging is provided, these low-range vehicles could be a viable and low-cost way for some staff to commute. It would also reduce the demands on public charging facilities.

## 2.16 Battery reuse and recycling

When an EV's battery pack has degraded to the point that the vehicle is not useful due to reduced range, the pack can be replaced. The old battery pack is not useless however – it will still retain a large portion of its original energy storage capacity. Furthermore, many of the individual cells making up the battery pack may be in good condition. Combined with other 'good' cells from other packs, these can be used to make a reconditioned pack that may be reinstalled in a vehicle. The cells can also be used to build a pack for stationary applications, such as off-grid power, back-up power for data centres, to store solar energy or to stabilise electricity networks and manage peaks in demand for electricity. This is already occurring. For example, Nissan subsidiary the 4R Energy Group sells stationary battery packs made from repurposed Leaf batteries, ranging from very small to utility scale. Repurposed EV batteries could even be used to reduce the electrical capacity needed for DC fast charging stations.

However, eventually batteries will have no further use in their original form. They contain a mixture of valuable elements, some of them potentially hazardous, which means they should not be put into landfill. It is possible to recycle the batteries by crushing and smelting them, and there are companies in larger countries such as the USA that already do this[53].

To ensure the full potential of used EV batteries is realised, and that they do not add to the e-waste problem, regulation requiring product stewardship is required to encourage industry to develop systems to deal with the issue. Such regulations need to apply to second-hand vehicle importers as well as New Zealand new vehicles. Local authorities, as part of their advocacy efforts to central government relating to waste and recycling generally, can call for such regulation. Electricity network companies may also be able to help by using repurposed EV batteries for network management purposes.


*"To ensure the full potential of used EV batteries is realised...regulation requiring product stewardship is required"*

# Recommended Strategy


# Section 3

# Section 3: Recommended Strategy

## 3.1 Vision

A Wellington Region where use of fossil fuels for road transport have been eliminated and replaced with vehicles powered with renewable energy. This decarbonisation will be achieved on a timescale consistent with the road transport sector playing its part in limiting global warming to within 1.5 degrees C.

## 3.2 Pathway

Replace (or convert) the existing vehicle fleet in the Wellington Region with electric vehicles, in concert with other low emissions approaches. Namely these are greater use of active modes and public transport and other methods if they present an equal or greater opportunity to reduce emissions. Plug-in hybrid vehicles will be supported in the interim, but this support will be phased out as the range and affordability of battery electric vehicles improves.

## 3.3 Approaches

Our organisation will support the rapid transition of the road vehicle fleet in NZ to battery electric technology using our direct influence and by working with others. Other low emissions vehicle technologies will be also supported provided they present an equal or greater opportunity to reduce emissions.

Wellington Region local government and electricity network companies have key roles in providing **leadership**, supporting the development of **infrastructure** and in **promotion**.

It is recommended that they:

- Incorporate EVs in organisational planning, strategy and operations
  - Prioritise EVs (owned, leased or shared) in fleet procurement decisions
  - Efficiently process applications to establish public EV chargers
  - Work to enable sufficient public charging infrastructure coverage and capacity
- Promote EVs to the public and businesses
- Encourage EV charging facilities in homes, businesses and other key destinations
- Encourage increased use and development of EV car share schemes
- Collaborate with our peers, community, central government and businesses to encourage EV uptake
- Encourage the development of systems to replace, repurpose and recycle EV batteries
- Support requiring for payment for DC fast charging to ensure the resource is used fairly and efficiently
- Monitor and evaluate the effectiveness of any interventions
- Facilitate uptake of battery-electric buses for public transport

## 3.4 Principles

- The transition to an EV fleet is just and sustainable transport including EVs are accessible to disadvantaged communities.
- The 'polluter pays': that cross-subsidy is justified from polluting activities to less polluting activities, in this case from use of fossil-fuelled vehicles to EVs.

- Promotion of EVs must be done in a way that does not significantly affect the objectives of increased use of public transport and active travel i.e. is consistent with the transportation hierarchy for people movement (see Figure 5).
- Any potential negative impacts of increased use of EVs will be mitigated (e.g. battery disposal, depletion of finite resources).

## 3.5 Ambition and Targets

This recommended strategy explicitly acknowledges that the agencies it is for cannot drive overall EV uptake in the Region to a significant degree, but can play an important role in supporting it. Given this, the recommended levels of ambition relating to these overall outcomes are:

- 6% of vehicles in the region will be EV by mid-2024 (Monitored by REV-WG using MoT data)
- An increasing proportion of people in the region view EVs favourably (monitored by EECA)

*(See diagram over page)*

**Supporting Electric Vehicles in the Wellington Region – Recommended Strategy**

## Vision

**Renewable energy replaces fossil fuels in road transport**

Wellington Region plays its part in limiting global warming to 1.5ºC

## Pathways

- Public Transport
- Electric vehicles
- Active Modes

## Approaches

### Leadership

- Include EVs in organisational plans, strategy and operations
- Prioritise EVs for in-house transport and fleet
- Facilitate e-buses for public transport
- Collaborate with our peers, community, government and business

### Infrastructure

- Encourage charging at home and work
- Enable sufficient public charging
- Users pay for public DC fast charging
- Efficiently process applications for public chargers
- Encourage systems to replace, repurpose and recycle EV batteries

### Promotion

- Promote EVs to the public and businesses
- Promote and encourage EV car share schemes

## Ambition

- 6% of vehicles in Region are EVs by 2024
- An increasing number of people view EVs favourably

## Principles

- Priority to active modes and PT
- Polluter pays
- Just and sustainable
- Mitigate any negative impacts

## Target

50% of organisation light fleets (owned, leased or shared) are EVs by end 2024, 100% are by end 2030

## 3.6 Suggested measures

- It is recommended that the Wellington Region local authorities and electricity network companies consider the following measures and implement those they wish to implement in support of the recommended strategy and its aims. •
- Undertake a fleet audit and optimisation review to identify opportunities for EVs and use of corporate car-share schemes by 2020.
- Implement an EV first policy (i.e. purchase or lease EVs for fleet renewals unless not fit for purpose), by 2021.
- Rapidly transition fleet to EV by means of direct purchase, lease and/or use of a shared fleet. 50% EV fleet by end 2024, 100% EV fleet by 2030.
- Update procurement requirements to reward the use of EVs (by 2020), and require the use of EVs by contractors as part of procurement policies and processes (50% by 2024, and 100% by 2030).
- Co-ordinate with other organisations in the Regional EV Working Group to advocate to central government and others for stronger policies to help drive the uptake of EVs, increase supplies of renewable electricity to power EVs and address potential issues with the reuse and recycling of EV batteries.
- Develop and introduce organisational policies and systems for the efficient processing of requests to install EV chargers on public land in collaborationwith other agencies to ensure there is a consistent approach across the regionby 2020.
- Support further work through the Regional EV Working Group to plan the deployment of charging infrastructure and co-ordinate its development.
- Undertake regular promotional activities related to EVs – for example helping facilitate EV test-drive events.
- Provide EV charging facilities for our own organisations' employees at their place of work, where parking is provided.
- Undertake pilot projects to gain familiarity with new EV related technologies of strategic significance, for example grid management involving repurposed EV batteries, vehicle to grid, neighbourhood charging management and/or new EV types and classes (e.g. utility vehicles including trucks).
- (Councils) Support e-mobility in planning requirements for all new development, including medium density and apartment dwellings, commercial, retail and in upgrades to inner-city streets. This means requiring AC charging points with a proportion of any new car parks provided in any development and/or requiring electric car sharing in certain cases.
- (Councils) Help provide EV infrastructure that is useful to disadvantaged communities – e.g. help facilitate car share schemes in those communities and AC charging at common destinations.
- (Councils) Provide priority parking for EVs (not necessarily with charging facilities) at public parking facilities.
- (Councils) Waive resident parking permit application fees for households with EVs.
- (Councils) Provide EV charging facilities at council housing where parking is already provided. Installation may be demand-led.
- (Councils) Encourage workplace charging infrastructure with large employers to help ensure older EVs with less range are still viable.
- (Councils) Encourage private businesses to provide EV charging to customers.
- (Councils) Where possible, provide land for the establishment of DC fast charging and EV car sharing schemes.
- (Network companies) Review peak pricing approaches and consider changes to avoid unnecessarily discouraging the roll-out of DC fast charging infrastructure – such pricing may be transitional.


# Document references


# Sources

## 3.7 References

[1] https://www.transport.govt.nz/multi-modal/climatechange/electric-vehicles/

[2] http://www.gw.govt.nz/electric-vehicles

[3] Energy Efficiency and Conservation Authority (2018). Driving a Low Emissions Economy – How Local Authorities can support and promote electric vehicles. https://www.eeca.govt.nz/assets/Resources-EECA/research-publications-resources/electric-vehicles-local-government-guide.pdf

[4] http://electricheaven.nz

[5] https://www.transport.govt.nz/multi-modal/climatechange/electric-vehicles/

[6] Vivid Economics (2017) Net-zero in New Zealand - Scenarios to achieve domestic emissions neutrality in thesecond half of the century. Report prepared for GLOBE-NZ March 2017. http://www.vivideconomics.com/publications/net-zero-in-new-zealand

[7] New Zealand Productivity Commission. (2018). Low-emissions economy: final report. https://www.productivity.govt.nz/sites/default/files/Productivity%20Commission_Low-emissions%20economy_Final%20Report_FINAL.pdf

[8] http://www.lgnz.co.nz/assets/Uploads/Climate-Change-Declaration-updated-17-November-2017.pdf

[9] https://www.ipcc.ch/sr15/chapter/summary-for-policy-makers/

[10] Pearce, et. Al. (2017) Climate change and variability - Wellington Region National Institute of Water & Atmospheric Research Ltd. http://www.gw.govt.nz/assets/Climate-change/Climate-Change-and-Variability-report-Wlgtn-Regn-High-Res-with-Appendix.pdf

[11] Email communication, Willy Trolove, NZTA, 12 February 2019

[12] Kuschel, G., Metcalfe, J. et al (2012) Updated Health and Air Pollution in New Zealand Study - Volume 1: Summary Report. Emission Impossible Ltd Suite 1-6, D72 Building, 72 Dominion Road, Mt Eden, Auckland. http://www.hapinz.org.nz/HAPINZ%20Update_Vol%201%20Summary%20Report.pdf

[13] https://www.transport.govt.nz/mot-resources/vehicle-fleet-statistics/monthly-electric-and-hybrid-light-vehicle-registrations-2/

[14] https://www.electricvehicles.govt.nz/

[15] https://en.wikipedia.org/wiki/List_of_countries_banning_fossil_fuel_vehicles

[16] International Energy Agency (2017) Global EV Outlook 2017 – Two Million and Counting. https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf

[17] Bu, Christina (2018) The Norwegian EV Success. Presentation for Drive Electric, Wellington, November 29, 2018. https://driveelectric.org.nz/wp-content/uploads/2018/12/Christina-Bu-Fleet-EV-Presentation.pdf

[18] Lorentzen, E., Haugneland, P., Bu, C., & Hauge, E. (2017) Charging infrastructure experiences in Norway - the worlds most advanced EV market' Conference paper for the EVS30 Symposium Stuttgart, Germany, October 9 - 11, 2017. https://

wpstatic.idium.no/elbil.no/2016/08/EVS30-Charging-infrastrucure-experiences-in-Norway-paper.pdf

[19] https://www.transport.govt.nz/multi-modal/climatechange/electric-vehicles/

[20] https://insideevs.com/examine-electric-car-pre-orders-norway/

[21] http://www.scoop.co.nz/stories/BU1610/S00454/commitment-will-boost-nz-ev-numbers-by-more-than-75.htm

[22] Wellington Electricity (2018) Report on Electric Vehicle Charging Trial. https://www.welectricity.co.nz/disclosures/pricing/evtrial

[23] Francfort, James 2014 - EV Project Data & Analytic Results. DOE Vehicle Technologies Office Review (presentation), Idaho National Laboratory June 20, 2014. Project ID: VSS137

[24] Information taken from New Zealand Household Travel Survey July 2011-June 2014 data. Data sent by Jennifer McSaveney, Ministry of Transport, 31.10.2017
For additional information/further queries, please contact Jennifer McSaveney (j.mcsaveney@transport.govt.nz) or more generally: travelsurvey@transport.govt.nz. More information on the survey is available from: http://www.transport.govt.nz/research/travelsurvey/

[25] Summary report – My Electric Avenue http://myelectricavenue.info/sites/default/files/Summary%20report.pdf

[26] Schey, S., Scoffield, D., Smart, J. (2012) A First Look at the Impact of Electric Vehicle Charging on the Electric Grid in The EV Project. Conference paper for EVS26 Symposium, Los Angeles, USA, May 6-9 2012. https://www.energy.gov/sites/prod/files/2014/02/f8/evs26_charging_demand_manuscript.pdf

[27] http://www.nichicon.co.jp/english/product_news/new124.html

[28] https://www.vector.co.nz/articles/vector-set-to-unleash-power-of-evs-via-two-way-cha

[29] Croucher,M., Higgs, G., Bevis, K. (2015) Electric Vehicle Charging Study Final Report - A review of options for charging at homes without off-street parking. Report by Parsons Brinckerhoff Ltd for a consortium of London boroughs and Transport for London, July 2015. http://content.tfl.gov.uk/ev-charging-options-for-homes-without-offstreet-parking.pdf

[30] Pers Comm – Liz Yeaman with Rosemary Knight and Matthew Eastwood, Energy Saving Trust (UK), 4 Jan 2019.

[31] https://www.zap-map.com/statistics/

[32] https://cleantechnica.com/2017/11/14/amsterdams-electric-vehicle-leadership-cleantechnica-video/

[33] Nygaard, Erik (2015). The Substitution Effects of Electric Vehicles in Norway - Are we subsidising traffic congestion? Masters Thesis, Norwegian University of Life Sciences Faculty of Social Sciences, School of Economics and Business. https://brage.bibsys.no/xmlui/bitstream/handle/11250/2379708/Masteroppgave%20ferdig%20-%20Erik%20Nygaard%202015.pdf?sequence=1

[34] https://www.citylab.com/environment/2018/12/norway-electric-vehicle-models-incentives-car-free-oslo/578932/

[35] Fishbone, A., Shahan, Z., & Badik, P. (2017) Electric Vehicle Charging Infrastructure Guidelines for Cities. CleanTechnica Ltd and Greenway infrastructure Ltd. https://cleantechnica.com/files/2018/04/EV-Charging-Infrastructure-Guidelines-for-Cities.pdf

[36] Moller, H., Myall D. & Ivanov D. (2018). Rapid chargers for battery electric vehicles in New Zealand: current use, access and location preferences. Flip The Fleet Research Report No. 3. 29 + iv pages.https://flipthefleet.org/wp-content/uploads/2018/05/FtF_RapidChargerReport_Final.pdf

[37] Burgstaller, S., Darida, K., Della Vigna, M., Yuzawa, K., Gandolfi, A., Tamberrino, D. (2017) From Pump to Plug - A c.US$6 tn investment to power EVs. Goldman Sachs International, Equity Research, October 19, 2017

[38] https://www.portlandoregon.gov/bps/article/619275

[39] Meeting with Ian Gordon, GM Fleet for NZ Bus, 20 December 2018

[40] Meeting with James Howard, Project Manager, Tranzit Group, 30 October 2018

[41] Element Energy (2018) A Study of the Impact of Electrification of Auckland's Bus Depots on the Local Electricity Grid – Final Report. https://www.c40cff.org/knowledge-library/a-study-of-the-impact-of-electrification-of-aucklands-bus-depots-on-the-local-electricity-grid

[42] https://about.bnef.com/blog/electric-buses-cities-driving-towards-cleaner-air-lower-co2/

[43] https://insideevs.com/boat-electric-byd-buses-arrives-chile/

[44] Meeting with Rob Wheeler, General Manager at Green Cabs 30 October 2018

[45] https://tfl.gov.uk/info-for/taxis-and-private-hire/emissions-standards-for-taxis

[46] Meeting with Sam Bridgman, NZ Post, 28 November 2018

[47] Lyons, S., Chatterji, P. (2016) The road to reducing commercial vehicle emissions: Exploring the technical barriers to uptake of alternatively fuelled commercial vehicles. Element Energy report for Transport for London. https://locity.org.uk/wp-content/uploads/2016/05/LoCITY-Technical-Barriers_Final-Report1.pdf

[48] http://www.cityofsacramento.org/ev

[49] http://www.cityofsacramento.org/-/media/Corporate/Files/Public-Works/Electric-Vehicles/Sac-County-EV-Inf-Plan.pdf?la=en

[50] Martin, E., Shaheen, S. & Lidicker, J. (2010) Impact of carsharing on household vehicle holdings: Results from North American Shared-Use Vehicle Survey. https://journals.sagepub.com/doi/10.3141/2143-19

[51] Meeting with Erik Zydervelt, Chief Executive of MEVO, 7 February 2019

[52] US Department of Energy (2014) Workplace Charging Challenge: Progress Update 2014. https://afdc.energy.gov/files/u/publication/wpc_2014_progress_report.pdf

[53] https://www.cnet.com/roadshow/news/for-dead-ev-batteries-reuse-comes-before-recycle/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ADVISORY REPORT

# Supporting Electric Vehicles in the Wellington Region

**Version 1.5.8**
**2019-09-06**