



Ministry for the
Environment
Manatū Mō Te Taiao



Reducing barriers to electric vehicle uptake

Behavioural insights: Analysis and review

New Zealand Government

Acknowledgements

The Energy Efficiency and Conservation Authority, Ministry of Transport and New Zealand Transport Agency.

A report written by Mahesh Girvan and Edward Hearnshaw on behalf of the Behavioural Insights Group at the Ministry for the Environment

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Executive summary

The New Zealand Government recognises the importance of reducing greenhouse gas (GHG) emissions. To play our part, we need a particular focus on key sectors, including transport which accounts for nearly a fifth of New Zealand's gross GHG emissions. There is scope to reduce the carbon footprint of our light vehicle fleet and improve its energy efficiency more quickly by taking steps to promote electric vehicles (EVs).

New Zealand conditions are ripe for EV uptake, as over 80 per cent of our electricity is generated from renewable sources,¹ the voltage of our electricity system allows every house to charge an EV, and more than 85 per cent of homes can accommodate home charging. However, there are only around 9,500 EVs in New Zealand as of July 2018 – less than 0.2 per cent of the vehicle fleet.

The purpose of this report is to identify barriers to EV uptake in New Zealand, discuss the attitudes and behaviour behind them, and propose ways to overcome them.

The findings highlight that there are significant perceptual and behavioural barriers to increasing light EV uptake by prospective buyers – driving range, publicly available fast charging infrastructure and the upfront purchase price of new vehicles.

We propose interventions to help overcome biases that are holding back EV uptake. Changing how New Zealanders think about EVs will take time and effort, but changing our approach to education, awareness and marketing through behavioural insights may speed this EV transition, which is vital to our low-emissions future.

Driving range

Early model EVs typically have a shorter driving range than equivalent internal combustion engine (ICE) vehicles. As battery technology improves and costs decrease, EV range will increase (without a cost premium). Prospective buyers may fear that they will run out of battery and require vehicle assistance. This fear stems largely from our psychological fear of avoiding losses (ie, loss aversion), which is related to the status quo bias (see box below).

Our analysis indicates that this bias is perceptual and can be addressed by reframing the issue and via direct experience with EVs. Ninety per cent of daily vehicle travel in New Zealand is 90 kilometres or less; the average is only around 30 kilometres. This is well within the single charge range of all available EVs. Likewise, home EV charging is available to most New Zealanders. By emphasising actual driving needs and that charging at home overnight is the simplest, cheapest and most convenient way to charge; we will present EVs as meeting most people's daily requirements with simple charging habits.

¹ Carbon emissions from EV operations are only associated with the carbon intensity of electricity generation systems.

Loss aversion People are averse to losing. They feel the ‘pain’ of a loss at least two times more (and often three or more times) than the equivalent ‘pleasure’ of a gain.

Status quo bias People when evaluating new products, like EVs, compare these products with a reference point, which is often the status quo (in this case, ICE vehicles). As a result, many buyers are unwilling and uncomfortable buying an EV because its driving range, while likely to meet their typical daily driving needs, is still significantly less than that of ICE vehicles.

DRIVING RANGE: SOME SUGGESTIONS FOR IMPROVING EV UPTAKE

For dealerships

- Use prompting questions to help buyers assess their actual driving habits. This will help them realise EVs can meet their daily driving needs.
- Emphasise that buyers can use an EV as the main vehicle for daily driving.
- If driving range is an issue, recommend purchasing a hybrid-EV or, renting a car for occasional long distance travel:
 - Purchasing an EV over an equivalent ICE vehicle equates to roughly 18 to 36 car rental days a year through reduced fuel costs ²
- However, those in the market for new models should be able to satisfy longer trips.
- Integrate trial drives into people’s daily routines through ride-and-drive activities and establishing partnerships with car rental companies to offer a discount to customers who purchase after a four to seven day rental.

For Government

- Continue funding ride and drive experiences:
- EECA, through the Better New Zealand Trust, has supported more than 1200 EV test drive or ride experiences at community events around New Zealand in the last year.
- The Low Emission Vehicles Contestable Fund (LEVCF) has also co-funded projects which increase the visibility of EVs and provide opportunities for the public to experience an EV – such as car sharing scheme.

Charging infrastructure

New Zealanders are not widely familiar with EV charging infrastructure (including the public network of charging stations, home charging units and charging time) and are used to having simple access to petrol stations. For this reason, they think charging stations should be as prevalent as petrol stations and that charging time should be less than five minutes – this reflects the status quo bias. However, we suggest it also stems from the selective attention bias, described below.

² 18 car rental days assumed for peak periods at \$100 a day and 36 days assumed at an off-peak rate of \$50

Our findings show this barrier is largely perceptual and can be addressed by:

- highlighting the option of home charging
- framing new charging habits (especially home charging) as a convenience.

After all, the vast majority of charging occurs at home and EV owners prefer recharging to refuelling an ICE vehicle at a petrol station.³

Selective attention bias: People do not devote equal cognitive processing to all objects in the environment at any given moment, and are often oblivious to perceptual cues for objects they are not familiar with. Charging stations and signage fall into this category. People are unlikely to see or recall them during daily activities or after seeing them on a map. Studies show that prospective buyers can overcome this bias by:

- actively finding charging stations during daily practices
- experience or active engagement with EVs.

CHARGING INFRASTRUCTURE: SUGGESTIONS FOR IMPROVED EV UPTAKE

For dealerships and electricity retailers

- Train dealerships to simplify messages about charging stations and tools wherever possible, to limit complexity in the purchase.
- Show buyers maps of the national infrastructure network.
- Inform them that most EVs owners charge up at home, overnight using largely renewable electricity, often at discounted rates.
- Promote and advertise EVs with discounted rates for overnight and 'smart charging'.

For Government

- Continue to educate buyers about charging, as EVs can be charged from home, and can meet most daily driving needs.⁴
- Improve visibility of charging stations.

High purchase price

New EVs are significantly more expensive than equivalent ICE vehicles at present. Our findings indicate this is the biggest barrier to EV uptake globally and in New Zealand. However, a total cost of ownership or five-year running cost approach shows that new EVs are the same price or cheaper than equivalent ICE vehicles.

Used EVs, such as the 2016 Nissan Leaf, are roughly the same price as equivalent ICE vehicles, such as the Ford Focus and Mazda 3. The 2016 Nissan Leaf reaches price parity with the

³ Franke & Krems, 2013b; Bunce et al (2014); Graham-Rowe et al, 2012; Flip the Fleet, 2017.

⁴ <https://www.energywise.govt.nz/on-the-road/electric-vehicles/ev-charging/>

popular Toyota Corolla in roughly two and a half years through reduced fuel and maintenance costs.

We highlight that hyperbolic discounting (below) can cause people to discount the total financial benefits of EV ownership, despite fuel being six to seven times cheaper. Our findings show that salient and effective product labelling can lessen the influence of this bias and help prospective buyers make better, more informed long-term purchasing decisions. It will require dealers and vehicle comparison websites to change how they present costs to buyers, and emphasise the losses involved when buying an equivalent ICE vehicle.

Hyperbolic discounting: People tend to focus on the upfront (short-term) costs of a product and often discount lower running (medium to long-term) costs. They give disproportionate weighting to upfront costs over the lifetime costs of vehicles.

HIGH PURCHASE PRICE: SOME SUGGESTIONS FOR IMPROVED EV UPTAKE

For dealerships

- Evidence shows effective label design can overcome myopia and hyperbolic discounting. Dealership and vehicle comparison websites should display the five-year running costs of a vehicle in bold, alongside the upfront price.
- Use loss aversion to highlight costs rather than savings. Tell prospective buyers that on average they will lose, for example, \$1,460 per year and \$6,140 over five years (through higher running costs), if they delay switching from an ICE vehicle to an EV.

For Government

- Consider label design and the placement of five year total cost of ownership information upfront on vehicle comparison websites such as Fuel Saver, RightCar, and EECA's vehicle total cost of ownership tool.

Chapter 1: Introduction

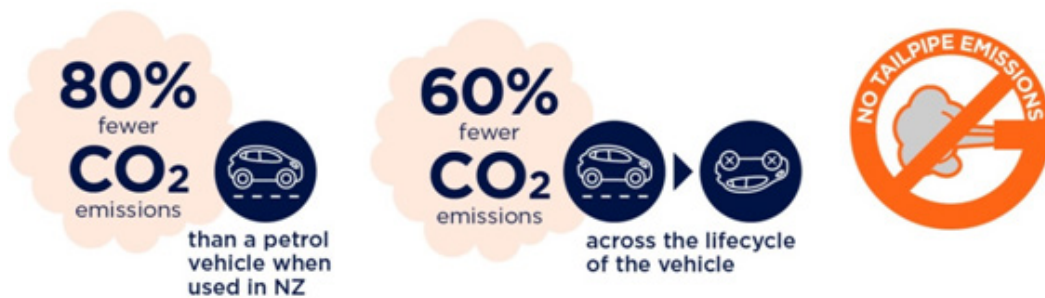
Reducing transport emissions

Currently, the transport sector accounts for about 18.5 per cent of New Zealand’s gross emissions. Projections indicate that by 2020, transport emissions will be 58 per cent above 1990 levels. This is a much higher increase than in any other sector.

Almost 90 per cent of New Zealand’s transport emissions are caused by road transport, with light passenger vehicles accounting for the majority. Presently, New Zealand has the second highest private vehicle ownership rate of OECD countries and the average age of the light vehicle fleet is significantly older than other developed countries.

There is scope to improve the energy efficiency of light passenger transport more quickly by taking steps to promote EVs.⁵ The Ministry of Transport (2017) highlights that New Zealand is one of the most EV-ready countries in the world for many reasons, including that:

- over 80 per cent of electricity is generated from renewable sources, with increasing efforts to improve this percentage



- the 230-volt electricity system means every home could easily charge an EV from existing outlets
- more than 85 per cent of homes have off-street parking, allowing for simple home charging



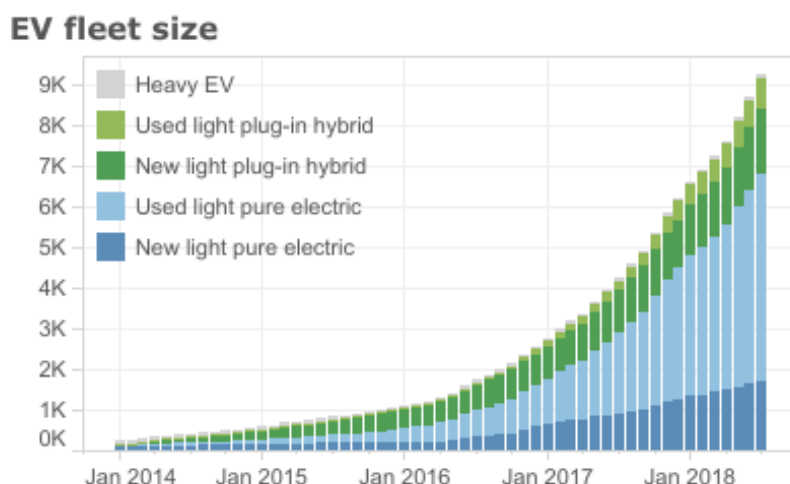
- lower maintenance costs – an EV has a fraction of the moving parts in a typical ICE vehicle.

⁵ There are two main types of EV. Battery EVs are fuelled only by the battery that is charged by plugging it into an electric power point (eg, Nissan Leaf, Tesla S). Plug-in hybrid EVs have two engines – one driven by a battery that is charged by plugging it into an electric power point, and the other fuelled from a tank that generally uses petrol or diesel (eg, Mitsubishi Outlander PHEV, Audi e-tron). Plug-in hybrid EVs should not be confused with hybrid vehicles, which do not charge by plugging in, even though they use many of the same technological elements to recapture energy efficiencies in the operation of their conventional ICE vehicle (eg, standard Toyota Prius, Honda Civic Hybrid).

With these advantages, the widespread uptake of EVs offers New Zealand one of the greatest opportunities to reduce transport emissions. For example, the Royal Society of New Zealand (2016) indicate emissions from the road transport sector could decline from 2013 levels by at least 60 per cent by 2050 if there is large-scale uptake of EVs and the introduction of other measures such as fuel efficiency standards.

Some of these advantages are now being realised, with a greater use of EVs (see figure 1). However, EVs still form less than one per cent of the light passenger vehicle fleet.

Figure 1: Number of EV registrations, 2014–2018



Source: Ministry of Transport, 2018

Barriers to EV uptake

In spite of the considerable opportunity that EVs offer for reducing our GHG emissions, a number of barriers still limit uptake. From the international and New Zealand transport literature, especially that based on empirical analysis and evidence (ie, Ford et al, 2015; Zhu, 2016; Ipsos, 2017), key barriers have been widely identified including: driving range, charging time, prevalence of charging stations, purchase price, and the unknown running and maintenance costs. These issues are investigated further in this report.

Other barriers include low top speed and limited trunk size (Li et al, 2017). Both of these barriers are not discussed further as they are relatively minor. However, two barriers that could be considered to be major barriers not analysed further in this report is the length of battery life and the limited variety of battery EV models available in New Zealand.

The length of battery life, while briefly discussed, is not extensively analysed at length in this report. This is, in part, because EVs have not been in circulation long enough to gather comprehensive information and understanding on the lifetime of EV batteries.

The limited variety of fully battery EV models available in New Zealand is not analysed further because this barrier is out of scope of this report, as it depends largely on the supply-side decisions of vehicle manufacturers rather than dealers or buyers. Nonetheless, currently there are approximately 11 battery EV models available, and nearly all of these EV models are small or mid-size vehicles, so prospective buyers wanting larger utility vehicles have, at best, limited choice. Importantly, various vehicle manufacturers have announced plans to produce more EV models. Volvo has announced that its entire fleet of models will be either battery electric or hybrid electric by 2019.

Behavioural insights


In May 2016, the Government introduced the EV programme with the aim of overcoming barriers and increasing uptake. As part of the EV programme, the Energy Efficiency and Conservation Authority (EECA) is running a multi-year information campaign using key messages to convey the benefits of EVs and overcome the identified barriers. It aims first to raise awareness and familiarise New Zealanders with EVs, and then focus on increasing the number of buyers.

The need for EECA's campaign is evident, as many studies (eg, Zhu, 2016; Ipsos, 2017) show that New Zealanders have limited awareness and misperceptions about EVs. The Royal Society of New Zealand (2016) indicated that in order to transition, knowledge gaps about transport need to be filled. One such gap is an analysis of behavioural insights into New Zealanders' decisions that may be limiting a transition to a low-emissions economy in the transport sector. The Ministry for the Environment's Behavioural Insights Group (the Group), motivated by the opportunity to fill this gap and support EECA's campaign, has undertaken this extensive literature review and analysis.

▶▶ Insights from behavioural sciences – behavioural insights – can help policy-makers to:

- understand why people make environmentally harmful choices
- develop more effective policies to address environmental problems.

Behavioural insights can be used to make existing policies more effective, and to devise new ones. They are another arrow in the policy-maker's quiver to prompt more environmentally sustainable behaviour (OECD, 2017) ◀◀

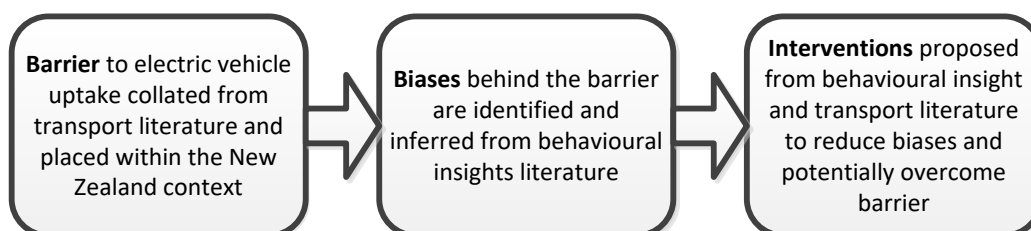


Source: Marketing for Change

Analytical structure

Figure 2 shows the analytical structure of this report. First, we outline the key barriers to EV uptake (eg, driving range, purchase price) identified in the literature, and place them in the New Zealand context. Second, we identify and infer biases from behavioural insights literature that reflect the reasons behind the barrier. Finally, we propose interventions to reduce or overcome the barrier.

Figure 2: Analytical structure of this report



After collating relevant interventions, the report makes suggestions and highlights the potential of specific empirical trials and evaluations to further understand the New Zealand context.

Chapter 2: Driving range

Barriers

Driving range, or the distance a vehicle can travel on a full tank or full charge, is recognised overseas as a major barrier to the uptake of EVs. For example, Giffi et al (2010; 2011) found that limited driving range was a major reason why prospective buyers defer from an EV purchase in 18 countries.

Driving range is considered a barrier because EVs typically have a smaller range than equivalent ICE vehicles. This increases fears of reaching a critical range and being left stranded and needing help (Tannahill et al, 2015). It may also mean that drivers must plan their trips more carefully, and may not have the option of making last-minute decisions to take long-distance trips.

One international study found that the shorter driving range is a significant barrier, unless buyers are offered EVs at a purchase price around US\$17,000 (approximately NZ\$25,000) less than their longer-range ICE counterparts (Dimitropoulos et al, 2013). Another study found that buyers were willing to pay 44 per cent more to extend an EV's driving range from around 240 kilometres to 320 kilometres (Hidrue et al, 2011). These findings highlight the magnitude of driving range as a barrier.

New Zealand studies

In New Zealand studies, driving range is also widely considered a major barrier (eg, Lemon & Miller, 2013; Barton & Schutte, 2015; Metcalfe & Kuschel, 2015; Business NZ Energy Council, 2016). However, they largely extrapolate their findings from overseas findings.

The three New Zealand empirical studies broadly support driving range as a major barrier. For example, Ipsos (2017) surveyed 1000 New Zealand households and found that only 39 per cent of respondents considered that EVs could satisfy their day-to-day driving needs. Furthermore, only 13 per cent of these same respondents considered that EVs could meet their long-distance driving needs.

While the empirical findings of Zhu (2016) also found driving range to be a major barrier, he moderated his conclusion, largely because exactly 50 per cent of 122 respondents considered driving range to be a major barrier. Hence, 50 per cent of respondents did not share this view. Respondents who considered driving range not to be a concern claimed that they either already owned an ICE vehicle or knew that they could simply rent one for longer trips. This reasoning corroborates overseas research where buyers' intentions for EVs increase with the number of vehicles the household owns.

Technological developments

A smaller number of respondents in Zhu's (2016) survey also noted optimism about technological advances increasing the driving range in the near future. This attitude is well founded. Since 2013, the estimated driving range for many EVs has increased significantly. For example, base models of the Nissan Leaf and Tesla Model S grew from a minimum of 120 kilometres and a maximum of 335 kilometres per charge in 2013 to about 172 kilometres

and up to 400 kilometres in 2017. That increase of about 20-40 per cent is mainly due to larger battery packs. Nissan also claim the new 2018 Leaf has a driving range of, at a minimum, 240 kilometres per charge.

More sophisticated range estimation systems may also increase driving range. These systems are giving drivers more accurate information, and therefore greater confidence about how much battery charge remains before they need to recharge (Tannahill et al, 2015).

However, prospective buyers are not accounting for these improvements as they are not aware of them. Zhu (2016) found that 81 per cent of respondents concerned about driving range were not aware of the latest technological advances. Ipsos (2017) also found prospective buyers have limited knowledge about the actual driving range of EVs.

Respondents in Zhu's (2016) survey who considered driving range a major barrier, maintained that a vehicle needs to travel at least 350 kilometres before being refuelled or recharged. Research, however, shows that drivers' preferred range wildly exceeds their actual, practical needs (Franke & Krems, 2013a).

Actual driving needs

In a US survey Giffi et al (2010) highlighted the disparity between the actual performance of drivers, and what they expected from a vehicle. For example, while 85 per cent of respondents stated that they travelled less than 160 kilometres per day, almost 70 per cent expected a driving range of over 450 kilometres before they would consider buying an EV. Similar gaps between expectations and actual driving needs are found in the UK (Element Energy, 2013). One overseas study found that if drivers were willing to alter their driving behaviour for no more than ten days per year, well over 95 per cent of their driving needs could be met by most EVs (Pearce et al, 2011).

In New Zealand, over 90 per cent of daily vehicle travel is 90 kilometres or less – easily within the single-charge range of all available EVs without sipping (ie, opportunistic slow-rate charging when there is a charger available) or a top-up during the day. Further, the average daily commuting distance is around 30 kilometres, and only 22 kilometres for residents in urban centres (Ministry of Transport, 2014). This evidence is corroborated by AA New Zealand (2017), which found that 97 per cent of its 1.6 million members travel over 50 kilometres from home only a few times each year.

It appears that EVs meet nearly all travel requirements of New Zealand drivers for a single day of use. There appears to be a gap between perceived and real driving needs in New Zealand, which is consistent with overseas findings (McKinsey & Co., 2017).

Some authors claim that buyers are using driving range as a way to avoid considering any change in their purchasing behaviour (Kirsch, 2000). That is, driving range may be a "post-hoc excuse to reject EVs in order to avoid [people] changing their behaviour" (Noel & Sovacool, 2016, p. 382).

Overall, available EVs can satisfy most drivers' daily driving needs, which suggests that these concerns are mostly psychologically driven. They appear to arise largely from misperceptions and misinformation about daily driving practices and the technical capabilities of an EV (Jensen et al, 2013). People who consider driving range a major barrier may misperceive not only how far an EV can travel on a single charge, but how far they typically travel in a single day.

Biases

Status quo bias and loss aversion

The fear or anxiety created from the reduced driving range of EVs compared with ICE vehicles appears to be psychologically driven. One bias that appears strongly linked to driving range seen as a barrier to EV uptake is the status quo bias. This bias results in people comparing new products, like EVs, to a reference point (status quo) – in this case, the greater driving range of an ICE vehicle.

Reflecting a lifetime of driving ICE vehicles, many buyers appear unwilling and uncomfortable buying an EV, as its range, while likely to meet their typical daily driving needs, is still significantly less.

This tendency is shaped by a number of complex factors including: regret avoidance, economic costs of making a change, and an aversion to losing what one presently 'owns' (Samuelson, & Zeckhauser, 1988; Johnson & Goldstein, 2003; De Martino et al, 2009). This is known as loss aversion.

Psychological studies note that people evaluate equivalent gains and losses very differently. People are averse to losing because they feel the 'pain' of a loss at least two to three times more than the equivalent 'pleasure' of a gain (Kahneman & Tversky, 1992).

Analysis suggests that the anxiety and misperceptions about driving range will remain an issue for buyers as long as there is a mismatch between the expectation to travel long distances on a single tank or charge, and the ability of EVs to do so. As the current benchmark for prospective buyers compares the EV range with that of an ICE vehicle, it may be inevitable that some will see the shorter EV range as a significant 'loss' and, therefore, a major barrier. The perceived losses are likely to have a far greater psychological impact than the perceived gains (eg, no fuel costs, exemption from road user charges).

Anchoring effect

A factor related to the status quo bias is the anchoring effect. This reflects the disproportionate influence, when people are making decisions, of the first piece of information (the anchor) presented to them (Kahneman & Tversky, 1974; Strack & Mussweiler, 1997). People can be strongly influenced by first impressions, to the point that they are unable to adjust these later, despite more accurate, information.

This bias affects everyone, but especially those with a lack of information or knowledge of a concept or product. Wilson et al (1996) found that knowledgeable people are far less influenced by anchors. However, experts still show some anchoring effects. For example vehicle experts, such as mechanics and dealers, with all the necessary information, were still influenced by the anchors they received when evaluating the value of a vehicle (Mussweiler et al, 2000).

The anchoring effect helps explain the large number of respondents, surveyed by Zhu (2016) who continued to use out-of-date information or misinformation about EVs and their driving range, and who failed to update these with new information including technological advances.

Choice-supportive bias

The choice-supportive bias is people's tendency to ascribe and remember positive attributes about a product they have purchased, and ascribe and remember negative attributes about a product that they rejected (Mather et al, 2000; 2003; Henkel & Mather, 2007). This accounts for the position that "I chose this one, therefore it must have been the better option".

The choice-supportive bias could explain several findings (eg, Noel & Sovacool, 2016) that driving range may be a post-hoc excuse to reject EVs. Given that many more drivers own ICE vehicles, the bias would explain why some drivers find negative attributes like driving range and use them to justify their preference for an ICE vehicle, even when EVs would meet most of their driving needs.

▶▶ Driving range may be a "post-hoc excuse to reject EVs in order to avoid [people] changing their behaviour" (Noel & Sovacool, 2016) ◀◀



Interventions

It has been argued that a range of biases (status quo bias, loss aversion, anchoring effect, choice supportive bias) explain why prospective buyers cite driving range as a major barrier (Franke & Krems, 2013b; Pakratz et al, 2017). To ease these anxieties, we must address the biases that are believed to underpin them.

Think like a trader

Psychological research shows that 'perspective-taking', where decisions are placed in a wider context 'as if creating a portfolio' rather than a single decision made in isolation, can reduce aversion to losses (Thaler et al, 1997; Sokol-Hessner et al, 2009). It appears that 'thinking like a trader' may reduce the subjective impact of losses.

Possible interventions include:

- indicating the perceived gains from EVs outweigh the perceived losses by a factor of two or three (eg, significant advances in battery technology)
- changing the perceptions and context about the losses from a reduced driving range.

To reduce the driving range barrier, thinking like a trader could mean considering the wider transport options and types of EVs available. For example, people who own an ICE could be reminded that they can use this vehicle for longer trips, and use the EV for most daily trips.

Reframe reference point

Instead of widening the perspective, another intervention is to change the context of the reference point. This can be critical because people often treat the status quo as a *prima facie* case for 'correctness' or 'goodness'. Various approaches can achieve this, including actively evaluating the status quo itself and not just comparing with it (Bostrom & Ord, 2006).

Because prospective buyers typically make ICE vehicles their reference point, they will automatically complete an evaluative assessment for change from the reference point and therefore EVs, but they inevitably neglect to do an assessment for the status quo itself (ie, ICE vehicles). Therefore, reframing the reference point could ease concerns about driving range.

One example is to make the reference point, where possible, relate to the actual driving needs of New Zealanders, to enable a fair assessment of both vehicle types. If the driving needs of prospective buyers are typical of most New Zealanders, then both vehicle types would be considered more than sufficient to meet their actual needs.

Dealerships could ask simple prompt questions such as: "How far do you drive on an average day?" and "How often do you drive out of town?" Alternatively, questions that invoke descriptive norms could be asked, such as: "Do you know that most New Zealanders only drive around 30 kilometres per day?" and "Do you know that 90 per cent of New Zealanders make less than five long distance trips per year?"

Daily driving practice

Daily EV driving practice can help people reassess their actual driving needs. Evidence suggests that it dramatically reduces concerns about driving range within four to seven days; to the point where this is no longer a major barrier after three to six weeks of practice (Nilsson, 2011; Bühler et al, 2014; Ryghaug & Toftaker, 2014). Other studies indicate that driving EVs can reduce a driver's preferred range safety buffer after three months (Franke et al, 2012), and after six months drivers increase travelled distance between charging (Burgess et al, 2013).

Rauh et al (2015) conducted a field experiment with 12 experienced and 12 first-time EV drivers to study their anxiety levels on a 60-kilometre test drive with a half-charged EV. Experienced EV drivers had substantially less negative driving range appraisal and a higher driving range buffer after the test drive than first-time drivers. McKinsey and Co. (2017) similarly found that EV owners are much more satisfied with the overall range of the EV than prospective buyers, indicating that driving experience is critical to alleviating these concerns.

The National Research Council (2013) found that buyers often do not want to go to a dealership to view vehicles. An alternative approach to actively promote EVs and encourage daily EV driving practice is through 'ride-and-drives' at highly visible locations (see figure 3).

These events can also help raise awareness of the latest EV technological advances such as improved battery capacity and drive range estimation systems. The raising of awareness from 'ride-and-drive' events may be grounded in behavioural insights literature, and in particular, by the 'mere-repeated-exposure paradigm' (Zajonc, 2011). This paradigm promotes that as a person is repeatedly exposed to a specific object (ie, EVs through ride-and-drive' events) they develop an emerging preference for that object.

Evidence also shows that practical experience with EVs is likely to be more influential than information alone (Li et al, 2017). Therefore, finding ways to actively promote daily driving appears to be an effective way to reduce misperceptions and concerns about driving range.

Figure 3: Ride-and-drive events offer EV driving practice (Source: EECA)



Partnerships between dealerships and rental companies can promote these driving experiences. For example, rental company Blue Cars currently offers a special deal for a four- or seven-day rental of a Nissan Leaf, and a lesson on EV driving and charging. If the buyer decides to buy a Nissan Leaf after the rental, Blue Cars will negotiate a \$500 discount off the purchase price.

Another interesting partnership is that of Mercury NZ Limited who have partnered with Snap Rentals to launch an EV subscription service offering vehicles from \$100 a week as a way of enticing drivers to try out electric transport. The scheme intends to insulate drivers from depreciation shocks and take away the hassle and extra costs of the traditional vehicle ownership model.

Play games

Electronic games can introduce people to EVs and allows them to drive them in a safe, cheap and risk-free environment. Studies have shown that games can be useful for addressing behavioural barriers and can also reduce anxiety and cognitive ‘self-defences’ (Horne-Meyer et al, 2014). In this way, games could help those with concerns about driving range.

In New Zealand, Apperley et al (2015) developed a game-like application to track how drivers would function in an EV environment, including how the level of battery affected behaviour. Although only a pilot study, this work provided important evidence of improving attitudes towards buying EVs. Another example is ‘Electric Car Taxi Simulator 3D’ (Reality Gamified, undated), in which players can overcome the barriers they associate with EV usage, including driving range anxiety.

‘Consider-the-opposite’

Anchoring effects have also been shown to potentially underpin expectations related to driving range. Mussweiler et al (2000) has argued that the ‘consider-the-opposite’ strategy can reduce the anchoring effect, by asking whether there are reasons why a first impression might be incorrect.

In the case of EV driving range, dealers could prompt prospective buyers to look for reasons why their initial judgement might be incorrect regarding EV driving range. For example, the dealer could ask the prospective buyer: “Explain why you feel anxious about the driving range of EVs when...?” This strategy may also be useful in addressing the choice-supportive bias that also appears to underpin driving range concerns.

Make it attractive by highlighting health benefit

The shorter driving range of EVs can be reframed as an opportunity to reduce driver fatigue and road accidents by encouraging more frequent rests when recharging.

In 2015, fatigue was a contributing factor in 43 fatal crashes, 119 serious injury crashes and 450 minor injury crashes. These resulted in 36 deaths, 160 serious injuries and 574 minor injuries. The total social cost of crashes involving driver fatigue was about \$291 million. This is about 7 per cent of the social cost of all injury crashes (Ministry of Transport, 2017).

The New Zealand Transport Agency highlights the importance of regular breaks. Incorporating breaks into long distance journeys provides opportunities for top-up charging to extend the driving range of an EV. For example, with rapid DC chargers a break of 20 minutes could charge a Nissan Leaf from zero to 80 per cent.

DRIVING RANGE: SUGGESTIONS FOR IMPROVING EV UPTAKE

For dealerships

- Inform buyers of the latest advances, including improved battery technology and greater driving range.
- Remind buyers to look at all their transport options. Emphasise that buyers can use an EV as the main vehicle for daily driving. If driving range is an issue, consider purchasing a hybrid-EV or, renting a car for occasional long distance travel:
 - Purchasing an EV over an equivalent ICE vehicle equates to roughly 18 to 36 car rental days a year through reduced fuel costs ⁶
- Reframe the driving range issue to address the actual distances required.
- Use prompting questions to help buyers assess their actual driving habits. This will help most buyers realise EVs can meet their daily driving needs.
- Provide opportunities for experiencing and driving EVs (eg, ride-and-drive, dealership partnerships with rental companies).
- Provide opportunities to test EVs through gaming technology as a low-risk strategy.
- Reframe smaller driving range as a benefit: reducing fatigue and accidents by taking a break when charging.

For Government

- Continue funding ride and drive experiences:
- EECA, through the Better New Zealand Trust, has supported more than 1200 EV test drive or ride experiences at community events around New Zealand in the last year
- The Low Emission Vehicle Contestable Fund (LEVCF) has also co-funded projects which provide more opportunities for the public to experience an EV. For example, co-funding has been provided to car share and rental car companies to procure EVs, as well as a project providing electric courtesy vehicles at mechanics for customers to use while their car is being serviced or repaired (Evincible project). Full list of recipients can be found on EECA's website.

⁶ 18 car rental days assumed for peak periods at \$100 a day and 36 days assumed at an off-peak rate of \$50

Chapter 3: Charging infrastructure

Barriers

Charging time and limited charging infrastructure or stations are two barriers discussed in the international literature (eg, Giffi et al, 2010). Pierre et al (2011) stated that these issues cannot be ignored, and must be addressed to improve EV uptake.

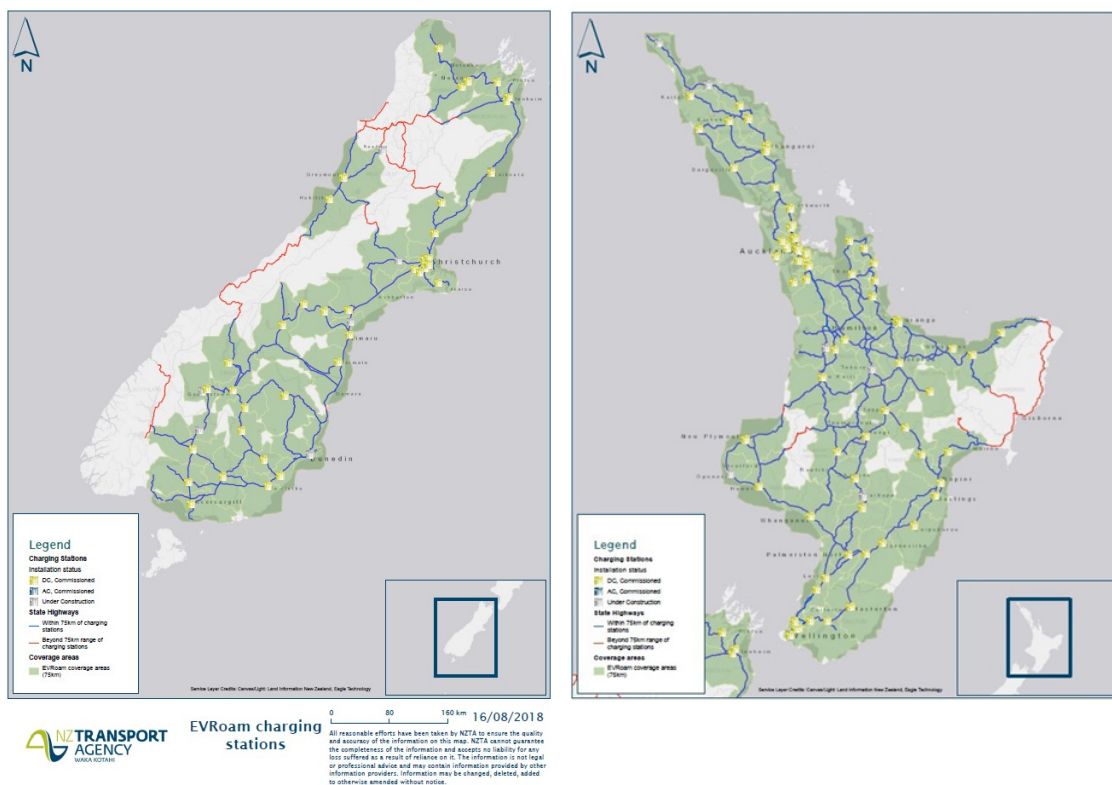
Charging time is closely related to the issue of driving range. With a slow charger, EVs can take up to eight hours to recharge fully. International research indicates that some prospective buyers have a negative perception of how long EVs take to recharge compared to refuelling (eg, Graham-Rowe et al, 2012).

Kodjak (2012) inferred that the expectations for charging time of some prospective buyers are only five minutes. This is roughly the time it takes to refuel an ICE vehicle. Drivers are used to refuelling quickly, and only doing so once or twice a week. Also, longer charging time limits the ability to ‘top up and go’ quickly, or make unexpected trips (Element Energy, 2013; Hosseinpour et al, 2015). Importantly, since most New Zealanders do not drive even close to 100 kilometres per day, an overnight home charge every day is completely adequate.

Figure 4 highlights the available public charging stations across the country. As of August 2018 there were 152 rapid and 46 slow charger stations across New Zealand.

See also appendix 1 for details about charging basics.

Figure 4: Public charging stations (NZTA)



New Zealand studies

A number of New Zealand studies (Lemon & Miller, 2013; Metcalfe & Kuschel, 2015; Ford et al, 2015; Ipsos, 2018) conclude charging time is a major barrier to the uptake of EVs in New Zealand. However, Zhu (2016) in his New Zealand survey found 64 per cent of respondents indicated that charging time was not a barrier because they knew that EVs can be charged overnight at home. However, international studies have found that some people were unaware of the ability to charge at home (Hidrué et al, 2011; WWF, 2014).

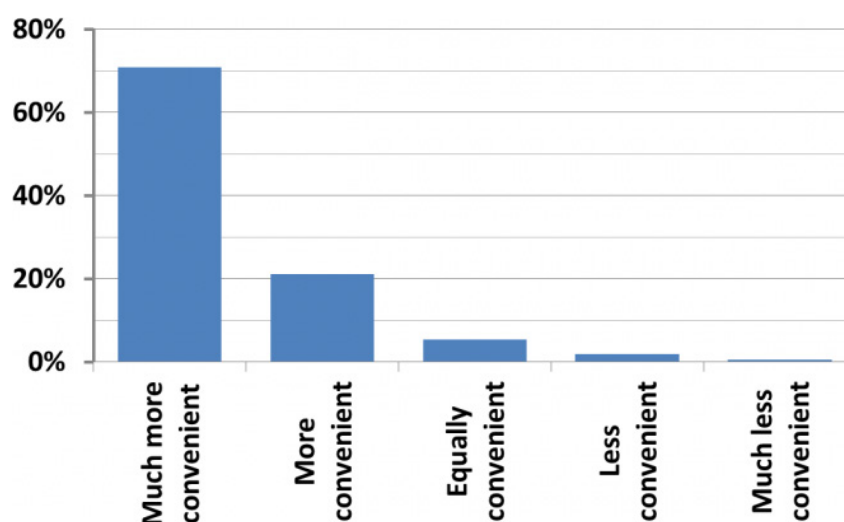
Barton and Schutte (2015) highlight that 85 per cent of New Zealand households have access to garages or off-street parking. This makes it relatively easy to undertake overnight charging. This is a higher rate than in other OECD countries.

It is reasonable to conclude that charging time may not be a major barrier in New Zealand compared to other countries, especially with greater awareness of the ability of home EV charging. The option of home charging may be beneficial for EV uptake. Buhler et al (2014) note that if there is enough opportunity for home charging, current EVs can meet daily driving demands from home charging alone.

In a UK trial, 40 drivers were interviewed after they had driven an EV for one week. They reported that home charging was advantageous compared to refuelling ICE vehicles (Graham-Rowe et al, 2012). Bunce et al (2014) also found in a three-month UK trial that EV drivers found home charging not only easy and convenient, but gave them independence and saved time. Studies in other locations corroborate this evidence. For example, in a six-month trial of 80 MINI E drivers in Berlin, 71 per cent preferred recharging to refuelling an ICE vehicle, and 87 per cent agreed that charging was easy (Franke & Krems, 2013b).

In New Zealand, a survey of over 270 EV owners found that 92 per cent of the *Flip the Fleet* members find home charging either 'much more convenient' or at least 'more convenient' than having to go to a petrol station to fill up (figure 5).

Figure 5: "Compared to filling up at a petrol station, charging my EV at home is..."



Source: Flip the Fleet, 2017

Charging time, however, may become an increasingly important barrier over the lifetime of an EV, because capacity loss is likely to shorten driving range and increase the frequency of recharging the battery. To maintain the battery capacity over the lifetime of an EV, charging habits are likely to be important.

A recent analysis found that battery life is a major barrier to EV uptake in New Zealand (Ipsos, 2018). Despite battery life being a potential major barrier, EV manufacturers provide significant battery warranties of five to ten years or more, which is likely to limit concerns regarding battery life.

However, the issue of battery capacity loss could also be more severe in New Zealand compared to other countries because most EVs purchased in New Zealand are second hand. Manufacturers may only guarantee EVs and their batteries that are sold as new (EV Talk, 2017; Myall et al, 2017).

A New Zealand survey of EV owners found that the degradation of battery capacity over time is an issue (Moller, 2017), depending on whether the reduced range still meets the owners' driving needs. Hence, fading battery capacity could largely be resolved through reframing driving range to actual driving needs, unless battery capacity degrades so severely as to constrain actual driving requirements.

Technological developments

Technological advances in fast charging (using DC rapid chargers) have reduced charging times significantly. For example, Tesla's 'supercharger' can add an 80 kilometre driving range within six minutes of charging, and achieves 80 per cent of its full charge within 45 minutes. However, fast chargers are typically not available at home and there are concerns about the availability of charging stations when far from home.

The perceived limited number of charging stations can be a significant barrier if not addressed (eg, Lemon & Miller, 2013; Metcalfe & Kuschel, 2015; Ipsos, 2017; Moller et al, 2018). Moller et al (2018) found in a choice experiment survey of 108 New Zealand EV owners that the availability and high visibility of fast charging stations were of critical importance.

In another New Zealand study, Zhu (2016) found that 64 per cent of respondents considered it a major barrier. Limited awareness of existing stations among prospective buyers exacerbates this barrier. For example, Zhu (2016) found that many respondents changed their position once they were made aware of maps showing locations of fast charging stations.⁷ However, despite the evidence of maps, 45 per cent of respondents held to their original position (Zhu, 2016). They reiterated that the coverage was insufficient, as presumably they compare it with the wide availability of petrol stations. This comparison was also made in Ipsos' (2017) research, with one respondent stating, "I mean I want them to be as commonplace as petrol stations".

⁷ See <https://driveelectric.org.nz/chargers-map/>

» “I mean I want them [charging stations] to be as commonplace as petrol stations.” «



Although there are some charging stations in New Zealand, until prospective buyers actually see them as regularly as petrol stations, they may perceive themselves as early adopters and believe they are taking an undue risk. A wider availability and visibility of charging stations may be a signal that EVs are a viable economic proposition and a more commonplace choice among their peers. Furthermore, the perceived limited availability of charging stations is likely to further exacerbate anxieties around driving range for prospective buyers (Moller et al, 2018).

International trials have found that after EV driving experiences, prospective buyers' concerns related to charging stations lessened, as did their concerns about range (eg, Turrentine et al, 2011; Vilimek et al, 2012; Franke & Krems, 2013b; Bunce et al, 2014). This is also observed in the McKinsey and Co. (2017) study, which found that EV owners were 39 per cent less concerned about charging infrastructure than prospective buyers.

Home charging

This difference in perception between prospective buyers and EV owners can largely be attributed to home charging and EV owners changing their refuelling/recharging habits. EV drivers do not demand charging stations in the public domain, as they mostly charge their vehicles at home (see Skippon & Garwood, 2011; Plotz et al, 2014). For example, in a six month MINI E trial in Belgium, 83.7 per cent of charging took place at home and only 4.8 per cent at public facilities (Franke & Krems, 2013b).

Evidence strongly indicates there is limited actual need for a wide public charging infrastructure network. This conclusion supports Element Energy's (2013) position that widespread availability of publicly accessible charging stations is not a prerequisite for the emergence and uptake of EVs.

Home charging tools add complexity to purchasing decisions. Buying an ICE vehicle does not require the consideration of refuelling options, whereas EV buyers must learn about, and weigh options for, home and public charging options (National Research Council, 2013).

Li et al (2017) recommend putting more effort into educating people about domestic charging tools. The National Research Council (2015) found that public charging and the variety in types of public charging units adds a burden to prospective buyers. It notes that streamlining charging options and decision making, to the point that it is perceived to be as easy as filling up at a petrol station, will reduce barriers to EV uptake.

This section illustrates that building a lot more charging stations is not a prerequisite for the emergence of EVs. There is a mismatch between perceived and actual need for public stations.

As with the issue of driving range, this barrier could be viewed as psychologically-driven (Carroll, 2010; Turrentine et al, 2011; Bunce et al, 2014). Although more charging stations may help promote EVs, there may be less expensive options, such as raising awareness of the existing charging network and the ability to charge EVs at home.

Biases

It can be argued that charging time is not a major barrier in New Zealand if buyers know they can charge EVs at home. Although the availability of public charging stations and points is a major barrier, it is largely one of perception. Prospective EV buyers typically assume there should be as many charging stations as petrol stations.

Status quo bias

Biases about charging time are similar to those related to driving range. For example, some buyers expect the charging time to be five minutes – the same as for refuelling. On this issue buyers continue to use ICE vehicles as their reference point (Harris et al, 2016).

The status quo bias is also evident in perceptions about the limited number of charging units. The assumption that these should be ‘as commonplace as petrol stations’ shows that the reference point is based in accordance with ICE vehicles rather than the actual requirements for driving an EV.

Selective attention bias

The selective attention bias refers to the fact that people do not devote equal cognitive (mental) processing to all objects in the environment at any given moment, and often are oblivious to perceptual cues for objects they are not familiar with (Marois & Ivanoff, 2005).

Memory formation requires the perception of external stimuli, and internal reflection on them. This is inherently ‘selective’ and dependent on mechanisms of ‘attention’ that modulate, sustain and manipulate information that is most relevant for current or future use (Chun et al, 2011).

Perceptual cues for petrol stations and ICE vehicles are nearly universally understood in New Zealand, whereas those for charging stations and EVs are not. People are less likely to see and recall EV charging stations and signage during daily activities, or after seeing them on a map. These instances would fall into the category of things that are ‘seen’ in the immediate sense, but not actively processed, and therefore not remembered (Craik & Lockhart, 1972).

The selective attention bias is linked to heuristics – mental strategies or shortcuts to solve problems and make judgements quickly and efficiently (Dale, 2015). Heuristics can speed up our problem-solving and decision-making, but they can introduce errors and biases.

For example, the availability heuristic refers to people’s tendency to determine the likelihood of an event according to how easy it is to recall similar examples. People also tend to give more weight to information or perceptual cues they are familiar with (eg, petrol stations) rather than processing all relevant information or perceptual cues they are unfamiliar with (EV charging stations and signage) (Tversky & Kahneman; 1973; Kliger & Kudryavtsev, 2010).



Source: Hyman et al, 2014.

» The significance of selective attention is reflected in a recent study (Hyman et al, 2014), in which dollar bills were noticeably clipped to low-hanging tree branches so that pedestrians had to move to avoid them.

Less than 20 per cent of people walking alone and not using mobile devices noticed the bills, and only 6 per cent of those using mobile devices noticed them (Hyman et al, 2014).

The results highlight that even with familiar objects of inherent value and interest, selective attention is divided: people are oblivious to something that might be otherwise 'obvious' to an observer, given the context. «

People are distracted by sights and sounds, which is certainly the case anywhere they would physically encounter charging stations or advertising. Cognitive effort is divided among a variety of tasks. Object recognition focuses on things of immediate relevance such as obstacles, barriers and threats. The 'deeper' perceptual processing that guides behaviour and helps form memories is frequently focused on specific tasks at hand or engaged in 'mind-wandering' (Hyman et al, 2014).

We cannot expect that people will take notice of, or remember, charging stations or signs they may come across, except in specific circumstances. These could include instances where: they were actively seeking out a charging station (Baddeley & Hitch, 1974); they had very recently been primed to direct their attention to charging stations (Schupp et al, 2016); or they physically encountered with a station or something signifying it (Treisman & Gelade, 1980).

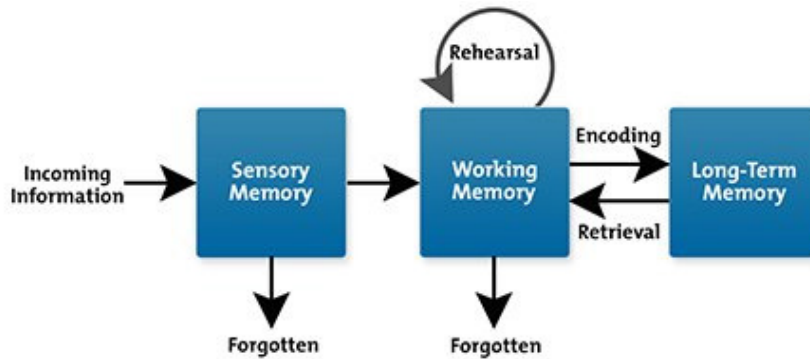
Cognitive load theory and bounded rationality

Cognitive load is an idea based on a number of widely accepted theories about how our brains process and store information (Gerjets et al, 2009). These theories include that:

- memory can be divided into working memory and long-term memory
- information is stored in the long-term memory in the form of cognitive frameworks or concepts that help organise and interpret information (schemas)
- processing new information results in 'cognitive load' on working memory, which can affect learning outcomes (Atkinson & Shiffrin 1968; Anderson, 2003; Baddeley, 1983).

Figure 6 illustrates the aspects of memory relevant to cognitive load theory.

Figure 6: Memory – a proposed system and its control processes



Source: Adapted from Atkinson & Shiffrin, 1968

Cognitive load theory is premised on the fact that people have limited mental processing ability. Too much information or increased complexity of information (ie, heavy cognitive load), can lead to risk-averse behaviour, and poor decision-making, for instance about purchases (Deck & Jahedi, 2015).

Electric vehicle charging adds complexity to buying decisions, as it requires buyers to consider not only the vehicle, but also the installation, the use of a charging unit for home charging, and the use of public charging stations. Supporting this, Ipsos (2017) found that buyers have many questions about charging infrastructure.

Tversky and Shafir (1992) showed that simply adding further options to a decision (eg, choice of charging unit as well as the vehicle itself) increases the likelihood of delay or of avoidance entirely. They also showed that when the decision was cognitively burdensome, people were biased towards the default option (eg, ICE vehicles).

When people are overloaded with information, they tend to settle for 'good enough' or 'satisficing' solutions rather than optimal solutions (Kahneman, 2003). This is described as being 'boundedly rational' (Simon, 1955): the idea that people tend to avoid cognitively burdensome decisions and opt for a course that requires less cognitive effort, even if it is not in their long-term best interests (Kool et al, 2010).

This tendency is reflected in everyday buyer decision-making. Some studies show that buyers deciding between many possible goods are less satisfied with their purchase, more frustrated about the decision context, and less likely to purchase the goods compared to settings with fewer options (Scheibehenne et al, 2010).

Interventions

Reframe reference point

The status quo bias is likely an underlying bias behind the barriers of charging time and the perceived scarcity of charging stations. One way to counter this is to encourage an evaluation of the status quo, reframing the reference points of refuelling times and the availability of petrol stations.

Reference points can include:

- Number of potential EV charging stations (public and private) vs number of gas stations
- Reduced number of visits to refuel for users that have access to charging facility at home.

Every prospective buyer needs to be aware that EVs can be charged at home, and therefore unlike ICE vehicles, do not need a widespread public charging infrastructure network, nor trips specifically to refuel at petrol stations (Hidrué et al, 2011). When buyers know this they will understand that EVs can save them time, as found in studies (eg, Bunce et al, 2014). This fact should be well-disseminated wherever EVs are sold.

Visible placement of charging stations

Selective attention bias is said to prevent people from seeing widespread EV uptake around them, whether the vehicles or the charging stations. Buyers may therefore consider themselves as early adopters, and buying an EV as too risky – despite an adequate charging infrastructure network, given the option of home charging.

The bankruptcy of EV charging companies such as Better Place and ECOtality, resulting in the loss of hundreds of millions dollars, showed that charging infrastructure needs to be well planned and account for shifting charging habits (predominantly home charging). Charging stations should not be built simply to overcome buyers' selective attention bias.

Maps or information alone are unlikely to change perceptions about charging time and the charging infrastructure network. In Zhu's (2016) New Zealand survey, many respondents' concerns did not reduce, even after viewing maps showing the current coverage. However, trials have shown that anxieties lessen after EV driving experiences (Turrentine et al, 2011). Similarly, Gebauer et al (2016) recently found that these concerns significantly reduced after experiencing fast charging first-hand. None of these effects were seen when buyers received the same information in written form.

A more suitable intervention is to improve the visibility of existing charging stations (Bunce et al, 2014). The recent adoption of standard NZTA signage supports this objective, as do mobile applications that show in real time the location of charging points and whether they are in use, such as EVRoam developed by the New Zealand Transport Agency (NZTA). EVRoam is a live cloud based database built from real-time information from EV public charging stations around New Zealand, which pushes data out to a wide range of customer-facing websites, apps and maps.⁸

A range of strategies exist to improve the placement and visibility of charging stations, including selling EVs next to charging stations, and placing charging units with EVs at the front of a dealership lot (Rushlow et al, 2015; Lunetta & Coplton-Newfield, 2016). Research also shows that placing EVs under a solar canopy for vehicle charging can greatly increase buyer interest (Carney, 2016).

Evidence from market research also suggests that placing physical advertisements for EVs near a charging point can prime the audience to notice its presence, location and features of interest (Taylor et al, 2006). This is logical given the role of spatial location and awareness in memory formation (eg, Miller et al, 2013). Advances in location-based advertising, especially via social media, may also be effective in targeted campaigns to reach prospective buyers who fit demographic and geographic profiles (Lee et al, 2015).

⁸ See EVRoam on the New Zealand Transport Agency's website here: <https://www.nzta.govt.nz/planning-and-investment/planning/transport-planning/planning-for-electric-vehicles/evroam>

We have highlighted that EV driving experiences can be critical in addressing the perceived scarcity of charging stations. For example, about 15 per cent of the participants in the 2015 Best Ride Ever ride-and-drive series in California bought or leased an EV three to six months after attending an event (Paauwe, 2016). At these events charging stations and EV charging practice were also available. Driving experiences force prospective buyers to actively seek out charging stations. The need to find a particular object in the environment can be a critical way of reducing selective attention (eg, Baddeley & Hitch, 1974).

Simplify information about charging

Cognitive load and bounded rationality may prevent people from buying an EV because of the added issues of public charging stations, and installing and using home charging units. Suitable interventions typically involve either giving people more information to help them make a decision, or simplifying communications as much as possible (OECD, 2017) – for example, ‘Did you know that EV owners mostly charge their vehicles at home?’

Keeping things short and simple is essential for effective communication. It is best not to overload buyers with many options at one time. Instead, offer smaller amounts of the most important information (Fredericks et al, 2015). Showing a full range of home charging units is unhelpful in most situations, except where customers already know about their features. Recent studies indicate that the average person can only process three or four items or chunks of new information (Shiffrin & Nosofsky, 1994; Kane & Engle, 2003; Farrington, 2011). Keeping to three to four items should help buyers make better decisions.

For vehicle dealers to communicate effectively in easy-to-understand terms, various studies recommend that they have adequate training (eg, McCutcheon-Schour et al, 2012; National Automobile Dealers Association, 2016). Training may be especially important, as evidence suggests that buyers are not adequately informed about EV charging requirements before they visit dealerships (McCutcheon-Schour et al, 2012).

A survey of dealerships in the US indicated that many dealers are not adequately prepared to explain and educate people on the charging infrastructure required for EVs (McCutcheon-Schour et al, 2012), let alone explaining only the most important aspects. Effective training can be critical to improving EV uptake from the dealer’s perspective.

Given the comparatively high cost of training and preparing dealership staff, EV showcases have been found to increase overall awareness of EVs and charging infrastructure. Drive Oregon (2016), for example, has developed a permanent ‘storefront’, where experts can help with any questions about charging. Public events also offer first-hand experience with the technology, to demonstrate the simplicity of EV charging, and in turn increase the likelihood of purchasing an EV.

Adopt universal standards

A final intervention to reduce complexity is promoting universal standards for charging tools. During the early 1990s the need to simplify connectivity and charging of electronic devices was well recognised. The result was the USB, which is now the clear industry standard for connectivity and charging.

A similar approach should also be investigated for EVs in New Zealand. Where industry cannot set universal charging standards, policy-makers may wish to intervene.

CHARGING INFRASTRUCTURE: SUGGESTIONS FOR IMPROVED EV UPTAKE

For dealerships

- Advance location-based advertising to reach out to buyers.
- Simplify messages (preferably no more than three or four items of new information) about charging stations and tools, to help buyers make a decision.

For Government

- Train dealerships to readily educate people about EV charging.
 - EECA are developing a 'Dealer's' guide to help both the seller and consumer make well informed purchasing decisions. The Buyers guide is published and available here: www.energywise.govt.nz/evbuyersguide
- Educate consumers that they can charge EVs at home, and that this can meet most daily driving needs.
 - By emphasising actual driving needs and that charging at home overnight is the simplest, cheapest and most convenient way to charge, EVs can be presented as meeting most people's daily requirements with simple charging habits. EECA has information available about charging here: <https://www.energywise.govt.nz/on-the-road/electric-vehicles/ev-charging/>
- Improve visibility of existing public charging stations.
 - The New Zealand Transport Agency (NZTA) recent adoption of standard EV signage and mobile applications which display the location of charging stations and whether they are in use, supports this objective.
- Advance location-based advertising as a way to reach out to prospective buyers.
 - EECA's online ads are geo-targeted to within 100 metres of a car yard that sells EVs.
- Consider universal standards for charging tools for home charging.
 - NZTA has developed and agreed upon charging standards for New Zealand.⁹

⁹ <https://www.nzta.govt.nz/planning-and-investment/planning/transport-planning/planning-for-electric-vehicles/national-guidance-for-public-electric-vehicle-charging-infrastructure/>

Chapter 4: Upfront purchase price

Barriers

The upfront purchase price of an EV is the most significant and consistently identified barrier to uptake (Giffi et al, 2010; Element Energy, 2013; Adeptu & Keshar, 2015). An international study by Giffi et al (2011) found that the higher price compared to ICE vehicles was the most significant barrier to uptake across 17 countries including Australia, Canada and the UK. It found that 69 per cent of Australian respondents, 66 per cent of Canadian respondents, and 71 per cent of UK respondents would only be willing to buy an EV if it had the same price or less than an ICE vehicle.

New Zealand studies

The price barrier has been observed in three empirical New Zealand studies (Ford et al, 2015; Zhu, 2016; Ipsos, 2017). For example, Zhu (2016) found that 64 per cent of respondents considered it a major barrier.

Concept Consulting (2016) estimated the price difference between a new mid-range EV over an equivalent new ICE vehicle was around \$12,000 in New Zealand. Concept Consulting noted there is significant uncertainty about price estimates due to differing pricing approaches and market positioning for the models currently available in New Zealand.

Prices are projected to fall, with many vehicle manufacturers committing to reduced EV prices. For example, by 2022 Skoda intends to produce an EV with a 480-kilometre driving range and 15-minute charging time that is cheaper than most comparable ICE vehicles. But despite falling prices and the growing second-hand import market in New Zealand (Zhu, 2016), the perception remains that EVs are expensive.

On the other hand, the running and maintenance costs are typically lower than for equivalent ICE vehicles, making the total ownership cost reasonably similar (Element Energy, 2013; Raustad, 2017). Electric vehicles are fundamentally more energy efficient, resulting in low running and maintenance costs. Also EVs have no fuel requirements, produce no GHG emissions, and have fewer mechanical and moving parts. On average, New Zealanders could lose about \$1,460 per year and \$6,140 over five years on fuel costs if they did not replace their ICE vehicle with an EV.¹⁰

While, new EVs are notably more expensive than equivalent new ICE vehicles; the economics differ for a buyer deciding between a used EV (ie Nissan Leaf) and a comparable ICE vehicle (ie Toyota Corolla). On the second-hand market the 2011 Nissan Leaf is on average available for roughly \$13,700 and the 2011 Toyota Corolla for roughly \$13,200. While, the EV is marginally more expensive to purchase, the price differential would approximately be recovered through

¹⁰ New Zealanders on average drove 11,500 km in 2016 and as of 2016 the average fuel efficiency of the light vehicle fleet was 9.25 litres per 100 kilometres. Petrol was assumed at a fixed rate of \$2.20 per litre. Price of electricity is assumed at 0.18 c/kwh at 0.2 efficiency rate. Using this calculation we can estimate that the average New Zealander driving an EV would pay \$414 on fuel per year.

lower EV charging costs (compared to petrol) within three to four months with average usage.¹¹

On average, a buyer could lose around \$1,460 per and \$6,140 over five years on fuel costs if they purchased the 2011 Toyota Corolla over the 2011 Nissan Leaf (table 1). It is important to note that EVs are exempt from road user charges until 31 December 2021, and fuel costs will likely increase when the road user charges exemption ends (but EV charging will still be considerably cheaper than petrol).¹²

Table 1: 2011 second-hand vehicle comparison

	Toyota Corolla	Nissan Leaf
Upfront price	\$13,230	\$13,663
Fuel cost	\$1,872	\$414
Five year total cost of ownership	\$20,370	\$15,730
Five year fuel cost	\$7,866	\$1,743

As previously noted, Ipsos (2018) found that battery life is one of the largest barriers to EV uptake in New Zealand. Although, nearly all vehicles used to calculate the average price of the 2011 Nissan Leaf had 10 out of 12 bars of battery health, battery life may still be a concern for buyers. Buyers may be more comfortable purchasing a later model such as the 2016 Nissan Leaf.

The 2016 Nissan Leaf, Mazda 3 and Ford Focus are almost identical in upfront price and have no payback period (table 2). Purchasing one of these ICE models over the Nissan Leaf would cost the owner over \$1000 extra per year in fuel costs and roughly \$5000 over five years. While, the 2016 Toyota Corolla can be purchased for slightly cheaper, if the Leaf was purchased the upfront price difference would be recovered through lower fuel costs within two and a half years. Over five years, Nissan Leaf owners would forego losing over \$3000 in fuel costs over a five year period.

Table 2: 2016 second-hand vehicles.

2016	Nissan Leaf	Toyota Corolla	Mazda 3	Ford Focus
Vehicle type	EV	ICE VEHICLE		
Upfront price	\$23,650	\$20,943	\$23,664	\$23,269
Fuel cost	\$414	\$1,543	\$1,467	\$1,695
Five year fuel cost	\$1,743	\$7,716	\$7,337	\$8,476
Five year total cost of ownership	\$25,720	\$28,660	\$31,000	\$31,744

However, Lemon and Miller's (2013) analysis indicates that lower annual running and maintenance costs of EVs are not enough to offset the higher price for most consumers. A

¹¹ New Zealanders on average drove 11,500 km in 2016 and the 2011 Toyota Corolla has a stated fuel efficiency of 7.4 litres per 100 kilometres. Fuel costs for both vehicles over 5 years were calculated using a net present value with a discount rate of six percent. Toyota Corolla 5 year fuel costs: \$7,886; Nissan Leaf 5 year fuel costs \$1743.

¹² <https://www.transport.govt.nz/multi-modal/climatechange/electric-vehicles/>

study by Element Energy (2013) also concludes that people place significantly more 'value' on purchase price than on running and maintenance costs.

International EV running and maintenance costs are typically 20–40 per cent lower than for comparable ICE vehicles (Loveday, 2012; Tsang et al, 2012), but this information is not widely known by prospective buyers (McKinsey & Co., 2017). Similarly, a New Zealand study showed that 51 per cent of participants did not know how EV and ICE running and maintenance costs compared (Ipsos, 2017).

Zhu's (2016) New Zealand study showed similar results: 68 per cent of respondents perceived running and maintenance costs as a barrier. Zhu's (2016) study asked these particular respondents if they would change their minds with further information. They received information about running and maintenance costs, including that:

- EVs have no fluids to change
- EVs do not suffer the same wear that typically occurs in an ICE
- manufacturers like Nissan offer an eight-year, 160,000-kilometre warranty for their batteries and if the battery degrades below 75 per cent of its capacity the manufacturer will replace it.

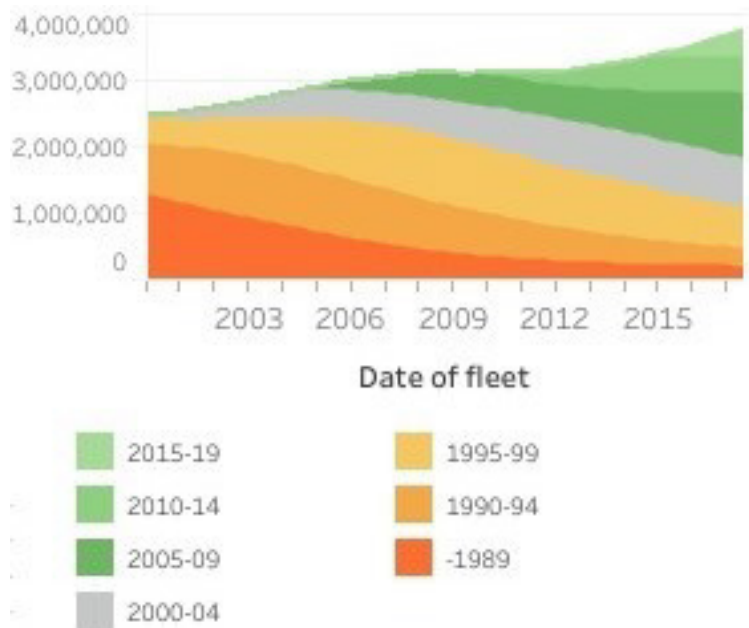
With this additional information, 62 per cent of respondents who previously considered unknown running and maintenance costs a barrier agreed it changed their perception.

Many New Zealanders have low knowledge and almost no experience of EVs. Surveys indicate that they ask many questions, including "How much will EVs add to my home electricity bill?" (Kurani et al, 2009; Turrentine et al, 2011). The lack of EV familiarity is not surprising given there are relatively few EVs on New Zealand roads. Lemon & Miller (2014) note the lack of familiarity with the vehicles, their operation and maintenance creates a substantial barrier to widespread uptake.

Long vehicle life

New Zealanders hold on to vehicles for a long time. The average age of the light passenger vehicle fleet, as noted, is around 14 years. Figure 7 shows how New Zealander's tend to purchase older vehicles and hold onto them for significant periods of time.

Figure 7: Light fleet year of manufacture for the fleets from 2000 onwards



Source: Ministry of Transport, 2018

It is sometimes inferred that the character of New Zealand’s vehicle market will act as another barrier to EV uptake until there is an adequate supply of second-hand EVs (Ford et al, 2015). However, in Zhu’s (2016) analysis, there is no conclusive evidence that buyers prefer new or second-hand EVs. He notes that this assumption is not technically correct.

Rather, the underlying issue remains that EVs exceed what New Zealanders are willing or able to spend on a vehicle. In a recent New Zealand survey, it was found that less than 16 per cent of respondents spent more than \$30,000 on their last vehicle (Ipsos, 2017). Furthermore, 61 per cent of respondents spent less than \$15,000 on their last vehicle. This budget currently limits the purchase of most EVs to used, low-mileage Nissan Leafs and Mitsubishi I-MiEVs. The average price of a used 2011 Nissan Leaf is about \$13,700.¹³

Buyers appear not to fully account for the total ownership costs of a vehicle in their purchase decisions. It appears that they ignore, do not know or substantially miscalculate the long-term costs and benefits of their decisions when considering an EV against an ICE vehicle. Many of these miscalculations will be psychologically driven.

Biases

Many New Zealanders have low knowledge and almost no experience of EVs. Surveys indicate that they ask many questions, including “How much will EVs add to my home electricity bill?” (Kurani et al, 2009; Turrentine et al, 2011). The lack of EV familiarity is not surprising given there are relatively few EVs on New Zealand roads. Lemon & Miller (2014) note that the lack of familiarity with the vehicles, their operation and maintenance creates a substantial barrier to widespread uptake.

¹³ Market research on range of NZ used-car websites.

Hyperbolic discounting

One bias strongly linked with EVs' high price is myopia or short-sightedness. People tend to focus on short-term costs and benefits, and discount the medium- to long-term benefits more than they should (Thaler, 1981; Loewenstein & Thaler, 1989; Frederick et al, 2015; Harris & Laibson, 2003; Green, 2014; Allcott & Wozny, 2014). The tendency to increasingly choose a smaller-sooner reward over a larger-later one (ie, \$50 today or \$100 in a year) is referred to as hyperbolic discounting (Laibson, 1998).

Hyperbolic discounting may explain why the purchase price of EVs is considered a barrier and why total lifetime costs of a vehicle tend to be ignored in purchasing decisions, which, in turn, could limit EV uptake.

More shrewd buyers, like fleet managers who are responsible for selecting vehicles to keep deliveries on schedule and within budget, may not face this bias. Typically, they will carefully estimate the total cost of ownership.

Sunk cost fallacy

People persist with an endeavour once they invest valued resources such as time, effort and money – a phenomenon known as the sunk cost fallacy or effect (Thaler, 1980; Arkes & Blumer, 1985). This is because people tend to become irrationally fixated on recovering losses already suffered, and discounting future costs and benefits.

For example, imagine a buyer who bought an ICE vehicle three years ago for \$11,000, but due to depreciation the vehicle is worth \$6,755¹⁴ in the current market. The buyer, however, still values the vehicle at \$11,000 because they want to recover the money they initially spent. The vehicle is reliable and still meets their travel needs. The buyer may prefer to hold onto their vehicle until it no longer reliably meets their needs or repair costs exceed its value, rather than accept \$4245 less than they value their vehicle at.

New Zealanders hold onto their vehicles considerably longer than individuals from other developed countries. This may be because of a combination of the sunk cost fallacy, how much time or money they have invested in the vehicle, the already low value of New Zealand vehicles and the endowment effect – where they are overvaluing the vehicle, only because of their ownership of it.

From a purely rational point of view, investments made in the past should have no bearing on those made in the future. If the previous investment does not do a particular task (or do it well enough to meet expected current and future needs), then it is rational to evaluate additional solutions and their return on investments, independent of previous investments.

This reasoning can apply to the purchase of an EV. Some buyers may find it difficult to justify the high upfront price for a number of reasons, including that they:

- have 'sunk' so much into their ICE vehicle
- know their ICE vehicle has always been reliable
- do not have this level of trust with an EV (familiarity bias).

¹⁴ While different cars depreciate at different rates, it's a good rule of thumb to assume that a new car will lose around **20 per cent** of its value in the first year and 15 per cent each year after that until, after 10 years, it's worth around **10 per cent** of its original price.

The sunk cost fallacy is unlikely to affect early adopters (buyers who constantly purchase the latest technology, including the 16 per cent of New Zealanders who spent more than \$30,000 on their last vehicles as identified by Ipsos (2017)). However, this fallacy is likely to be a significant factor in slow EV uptake among the 84 per cent of New Zealanders who are not willing or able (constrained capital) to spend \$30,000 on their next vehicle until EVs become considerably cheaper.

Several factors influence decision-making. These include past experiences (Juliussen et al, 2005), cognitive biases like anchoring or the endowment effect (Stanovich & West, 2008), age, socioeconomic status and personal relevance (ie, personal aspirations, interests or cultural experiences) to name a few (Dietrich, 2010).

Recognising and removing a powerful bias will sometimes do more to improve our judgements than accumulating or analysing a large body of facts. For example, Coca Cola released 'new Coke' in 1985 to reverse its declining market share and to match changing preferences for the sweeter taste of Pepsi-Cola (Schindler, 1992). However, Coca Cola executives failed to account for the American public's associations and familiarity with 'old Coke'. People reacted negatively towards 'new Coke', with 'old Coke' outselling it three to one despite blind taste tests showing that consumers preferred the sweeter version by a large margin. Sometimes our past experiences, associations and cognitive biases can overpower significant factors.

Interventions

Labelling

Hyperbolic discounting, which leads to short-sighted purchase decisions, has been argued to be an important bias against upfront price and unknown running and maintenance costs. We have shown that providing pieces of relevant information can reduce the barrier of unknown running and maintenance costs (Zhu, 2016). Indicating the lifetime costs in a salient way could be crucial in showing consumers the dollar advantage of buying an EV.

Demonstrating the lifetime costs upfront has been shown to be effective. A randomised controlled trial in the UK found that placing the total lifetime costs of tumble dryers alongside the upfront price led to consumers buying the energy efficient models resulting in almost a 10 per cent reduction in annual electricity consumption associated with tumble dryers (OECD, 2017).

The behavioural insights literature has demonstrated a number of useful interventions to give relevant information upfront, to influence buying decisions and avoid myopia. For example, to address the significant bias against higher prices among people buying more efficient vehicles, the US Environmental Protection Agency's (EPA) Expert Panel (2010) suggested providing financial information over five years, to demonstrate a larger and more realistic impact.

Prospective buyers go through multiple stages before buying a vehicle, as outlined in the EPA's 'vehicle buying cycle' (see figure 8). The journey consists of considering a purchase (stage one), getting familiar with a range of vehicles and seeking the opinion of their peers (stage two and three), through to final purchase (stage seven).

Figure 8: Vehicle buying cycle



Source: EPA, 2010

When redesigning its fuel economy label, the US EPA ran an online survey. Two-thirds of respondents in the pre-focus group reported that they had researched fuel economy before buying their vehicle. Of these, about half (52 per cent) reported that they started researching about one to three months before the purchase. The research stage is the fourth of seven steps, and there is substantial time before a person buys a vehicle.

Based on this analysis, it makes sense that buyers, who may wish to research fuel efficiency before entering a dealership, should have ready access to fuel efficiency information on dealership and comparative fuel efficiency websites, such as the New Zealand Transport Agency's RightCar website¹⁵ and EECA's vehicle total cost of ownership tool.¹⁶ Displaying five-year fuel would be particularly helpful for EV uptake, given recharging costs are nearly seven times cheaper than fuel costs for ICE vehicles.

The literature demonstrates that translating fuel efficiency indicators into expected fuel costs over several years can be highly effective in prompting people to buy more fuel-efficient vehicles. While buyers research fuel efficiency potentially months before stepping into a dealership, the US EPA (2010) found that the label inside the dealership is still useful for buyers to confirm their findings. Additionally, buyers have the option to buy online without even entering a dealership. It is increasingly important to provide information on a vehicle's fuel efficiency and costs via channels that buyers are comfortable with.

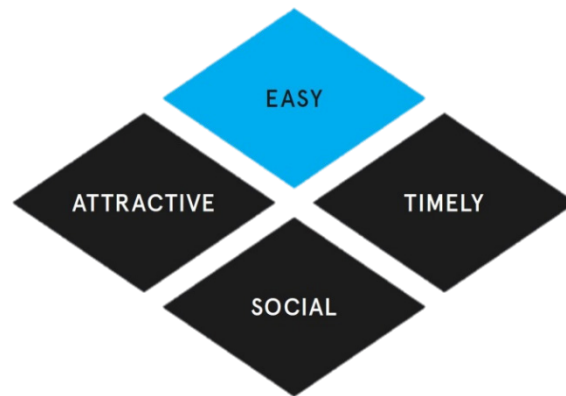
In New Zealand, it's a legal requirement to display fuel economy labels on all light vehicles under 3.5 tonnes being sold by a registered motor vehicle trader. EECA administers the Energy Efficiency (Vehicle Fuel Economy Labelling) Regulations 2007, which make it mandatory to display the fuel economy label on new and used vehicles for sale. Consumers could calculate the five-year fuel costs of a given vehicle using existing labelling, which displays annual fuel costs, but behavioural insights literature promotes making messaging and interventions simple and convenient for people (Mullainathan and Thaler, 2000; Stern et al, 2010; Behavioural Insights Team, 2014).

The Behavioural Insights Team (2014) developed a framework to encourage behaviour change by making interventions easy, attractive, social and timely (EAST), see figure 9. These four simple principles for applying behavioural insights are based on the Behavioural Insights Team's own work and the wider academic literature.

¹⁵ <http://rightcar.govt.nz/>

¹⁶ <https://www.eecabusiness.govt.nz/tools/vehicle-total-cost-of-ownership-tool/#Making>

Figure 9: EAST Framework (Behavioural Insights Team, 2014)



Labelling: Making it easy

Making five-year fuel cost labelling salient by displaying it next to the upfront price in dealerships and on websites will reduce the ‘hassle factor’ and make it simpler for prospective buyers. The Behavioural Insights Team (2014) note that the effort required to perform an action often puts people off and by reducing the effort required can increase uptake or response rates of a targeted behaviour. This finding is in line with a London Economics (2014) report, which found that energy efficiency scales with letters rather than numbers are generally better understood.

Waide and Watson (2013) went even further and assessed buyers’ willingness to pay for more energy-efficient products using an ‘A+++ to D’ scale. They found that on average, respondents were willing to pay €40 more for every higher label class of refrigerator-freezer. Further, they were willing to pay 44 per cent more for an A+++ grade than for an A- grade product.

Labelling: Making it attractive and timely

Five-year fuel costs can be made more salient and attractive by using a different colour and writing the figures in bold. People are more likely to do something that our attention is drawn towards – the use of images, colour, personalisation or prompts when people are likely to be most receptive have been successful in changing behaviour (Kahneman, 2011), such as people paying their taxes (Behavioural Insights, 2012) or power bills on time.

In 2015, the Israeli Ministry of Environmental Protection ran an online trial to test the impact of alternative fuel efficiency labels on vehicle choice. The trial tested the extent to which different labels induce or ‘nudge’ people to make a purchase (OECD, 2017). In the trial, 350 participants were given a choice between two vehicles: one with a lower upfront price but higher estimated fuel costs, and one with a higher price, but lower estimated fuel costs. The vehicles had different labels reflecting this information. Over 75 per cent of participants chose the vehicle that was labelled with the higher price and a lower estimated fuel cost over five years.

▶▶ Over 75 per cent of participants chose the vehicle with a higher upfront purchase price but with a label showing a lower estimated fuel cost over five years. ◀◀



But it is not just simple, salient information that will overcome myopia. Dumortier et al (2015) indicated that buyers account for and value the current expense more than the long-term savings of EVs. For example, a price sensitivity test in Manitoba, Canada showed that buyers were unwilling to pay large premiums for an EV even with information on fuel savings provided. However, of those with experience or exposure to EVs, nearly 25 per cent were willing to pay a premium of up to \$10,000 (Larson et al, 2014).

Among the most conclusive findings of labelling and information experiments, the main points were:

- label design: behaviourally informed interventions drawing on fuel economy indicators (eg, information on foregone fuel savings, vehicle running costs presented in different formats) were more effective than those drawing on emission-reduction indicators
- promotional materials (eg, stand-alone leaflets): the most effective treatments were the graphic illustration indicating five-year running costs and carbon dioxide emissions.

We have noted that loss aversion may play a role in the driving range barrier. The same can be said when providing information about total lifetime costs. With that mind, Gonzales et al (1988) suggested that messages to improve household energy efficiency by installing insulation, for example, should be framed in terms of loss (money lost by inaction), rather than gain (money gained by action). This takes advantage of loss aversion and the fact that people react two to three times more strongly to equal-sized losses than gains.

Taking this logic to EVs, the upfront information about the lifetime of costs of vehicles should emphasise the losses involved. For example, buyers should not be told that by buying an EV they will gain \$1,460 on reduced fuel costs compared to buying an equivalent ICE vehicle, such as the Toyota Corolla. Instead, they should learn that they will lose up to \$1,460 per year and \$6,140 over five years by not switching to an EV.¹⁷ As the research shows above, the labelling and display of reduced fuel costs should be as simple as possible.

We acknowledge that multiple factors outside upfront and fuel costs influence consumers' vehicle purchasing decisions such as colour, brand loyalty, size, safety, and new electronic features. However, it is clear from the literature that short-sightedness is a significant behavioural bias influencing vehicle purchasing in New Zealand. Our findings show that salient and effective product labelling can lessen the influence of this bias and make five-year fuel costs more readily available and convenient to help prospective buyers make better, more informed long-term purchasing decisions.

¹⁷ Refer to footnote 7.

HIGH PURCHASE PRICE: SUGGESTIONS FOR IMPROVED EV UPTAKE

For dealerships

- Evidence shows that effective label design can overcome myopia and hyperbolic discounting. Dealership websites should display the five-year running costs of a vehicle in bold, alongside the upfront price.
- Use loss aversion to highlight costs rather than savings. Tell prospective buyers that on average they will lose, for example, \$600 per year and \$3000 (through higher running costs) over five years, if they delay switching from an ICE vehicle to an EV.
- Consumers may be more likely to buy an EV if dealership training focuses on positive, factual information about safety, reliability, costs, charging times and battery warranty.
- Highlight EV battery warranty information – very important to allay fears about battery replacement costs.

For Government

- Show dealerships the impact of five-year costing and different labelling on purchasing behaviour.
- Consider label design and the placement of five-year total cost of ownership information upfront on vehicle comparison websites such as RightCar.
- Highlight the cost disparity between recharging an EV (30 cents) per litre equivalent and petrol – seven times more expensive (+\$2.30).
 - The 30 cents per litre is key for the government’s information campaign and is prominently featured on EECA’s website: <https://www.energywise.govt.nz/on-the-road/electric-vehicles/advantages-and-challenges-of-evs/>, event promotional material. Companies such as Mercury and Meridian quote this figure in their own advertisements and information campaigns.
- Frame messages to focus on ongoing costs, losses or risks from retaining more inefficient and costly (fuel and running cost) vehicles. Reduce the importance of any costs (eg, money, time and effort) already outlaid for a petrol or diesel-based vehicle.
- Explain that a prospective buyer will on average lose, say, \$1,460 per year and \$6,140 over five years if they delay switching to an EV, rather than that they will save \$1,460 on reduced fuel costs per year (loss aversion).
- Improve knowledge and training for EV salespeople. Government agencies and dealerships should partner to develop better training, to improve knowledge of EVs and supporting programmes.
 - EECA are developing a ‘Dealer’s’ guide to help both the seller and consumer make well informed purchasing decisions. The Buyers guide is published and available here: www.energywise.govt.nz/evbuyersguide

Chapter 5: Conclusions

Fundamentally, New Zealand is ready for EV uptake. This report has proposed avenues to help overcome biases that are holding uptake back. Changing how New Zealanders think about EVs will take time and effort, but changing our approach to education, awareness and marketing through behavioural insights may speed this EV transition, which is vital to New Zealand's low-emissions future.

In particular, this report analysed and discussed the key behavioural barriers limiting EV uptake in New Zealand: driving range, the availability of charging stations and the high upfront price. These concerns are recognised to be largely based on misinformation and misperceptions, and therefore psychologically driven. This underlies the importance of identifying and using behavioural insights to address them.

A range of biases may underpin the barriers that are particularly relevant to the New Zealand context. A wide-ranging set of interventions has been proposed to overcome the biases and, in turn, reduce the barriers. The Group believes that these measures, including EECA's information campaign, could help to improve uptake. The report provides ample evidence to validate and explain the reasons.

A critical finding is that ICE vehicles and their 100-year preponderance have played a key role in shaping buyers' preferences. We suggest that this bias strongly underpins some concerns about EVs, including driving range, charging time and perceived scarcity of charging stations.

To allay these concerns requires reframing information so that EVs are not compared with ICE vehicles and petrol stations, but rather seen in terms of performance, and the actual needs of New Zealand drivers. Another key finding is that passive information alone is unlikely to reduce buyers' concerns. Active information through driving experiences and practice is therefore vital.

We recognise that the report outlines many suggested interventions. As noted, some of these interventions are already been enacted in some way in New Zealand. In order to prioritise the suggested interventions, Government and dealerships would need to consider the cost of the intervention, the priority of addressing the barrier to EV uptake, and whether the intervention can also address other barriers as they share similar underlying biases.

Empirical next steps...

Addressing the barriers is important in accelerating EV uptake in New Zealand towards new transport targets, and in significantly reducing transport emissions. Psychological factors could also be very helpful in improving EV uptake and in encouraging uptake over time. For example, through social networks and social norming effects, EV owners can influence prospective buyers towards buying an EV.

Recent research by Figenbaum (2016) found that after two years of ownership, 67 per cent of EV owners had influenced at least one family member or friend to buy an EV. Such social norming needs to be further understood and could be an important next step in finding cost-effective ways to promote uptake in New Zealand. One interesting area is the influence of social media.

A caveat applies to this work, as it assessed underlying biases rather than definitive experimentation. While the findings are logically deduced they require additional empirical testing in real-world settings.

Behavioural insights literature has long promoted random controlled experiments to test deductions in real-world environments. This approach could be another important next step. The critical finding about the importance of driving experience and practice, while empirically assessed in overseas contexts, needs to be tested further in New Zealand. One way could be to use random control experiments in the development of experiences like EV ride-and-drive events.

Behavioural insights analysis using the structure in this report could apply elsewhere, including other measures to reduce GHG emissions. Measures to focus on are where the lower emissions option is cheaper than the status quo, as represented by negative marginal abatement costs. Examples of these cost-effective measures include water-efficient showerheads and LED lighting.

Appendix 1: Charging basics

Electric car charging: The basics

Charging is as easy and as safe as charging your mobile phone.

Slow charging

With the right charging cable, you can use your regular sockets and power supply to slow charge overnight. Depending on the battery size, from completely empty your battery will take about 12 hours to be fully charged with an ordinary 8 – 10 power outlet.



Slow charging overnight typically costs \$3 per 100 kilometres of range.

Fast charging

There is a growing nation-wide network of rapid chargers at power levels between 22kW and 50 kW – compared with your average 2.2 kW at home. This includes shopping malls, supermarkets and some petrol stations – so you can recharge your EV and do your shopping at the same time.



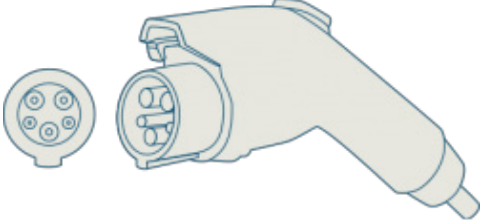
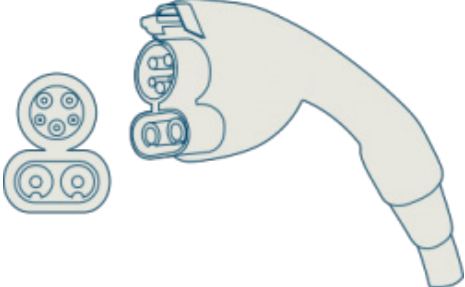
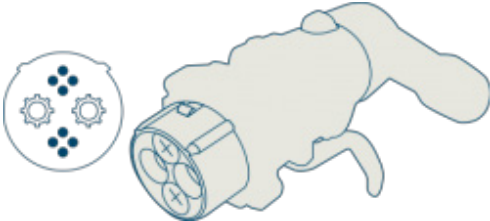
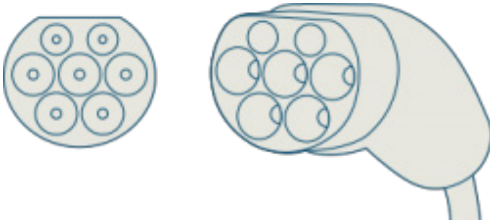
Fast chargers typically cost \$10 per 100 kilometres of range. To recharge your battery to 80 percent takes roughly 20 minutes.

How often do you need to charge?

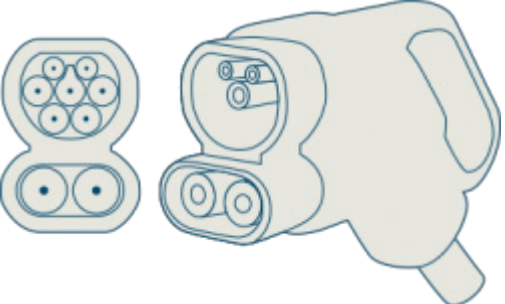
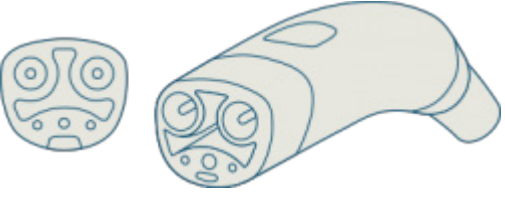
For an average daily drive you won't be using all your battery power, so it could cost \$1.00 to recharge the next night. That's \$15 a fortnight – or less.

Charger types

There are multiple standards based on manufacturer, country and charging speed: The following is based on configuration for cars in New Zealand.¹⁸

Connector	Description
 <p data-bbox="293 636 523 663">SAE J1772 Type 1 AC</p>	<p data-bbox="839 398 944 425">TYPE 1 AC</p> <p data-bbox="839 439 1385 528">This is a standard connector for AC charging. It has origins in the US but is also a standard connector in use in Japan.</p> <p data-bbox="839 551 1362 577">EV models with Type 1 inlets in New Zealand include:</p> <ul data-bbox="839 591 1181 734" style="list-style-type: none"> • Nissan Leaf (including imports) • Mitsubishi Outlander PHEV • Nissan e-NV 200 • Kia Soul EV.
 <p data-bbox="293 1093 746 1120">SAE J1772 DC CCS Combo 1 Connector Type 1</p>	<p data-bbox="839 788 1078 815">TYPE 1 DC CCS Combo 1</p> <p data-bbox="839 828 1398 887">This connector is used in the US for DC charging and was also adopted for some European-origin EVs.</p> <p data-bbox="839 909 1315 999">Currently fast charging stations in New Zealand are transitionally from CCS Type 1 to CCS Type 2 connectors.</p>
 <p data-bbox="293 1406 568 1433">Chademo Yazaki Connector</p>	<p data-bbox="839 1169 976 1196">CHAdEMO DC</p> <p data-bbox="839 1209 1391 1299">This connector is used for DC charging in Japan and is so is the DC inlet supplier with most imported Japanese vehicles.</p> <p data-bbox="839 1321 1372 1348">Models with CHAdEMO inlets in New Zealand include:</p> <ul data-bbox="839 1361 1181 1469" style="list-style-type: none"> • Nissan Leaf (including imports) • Nissan e-NV200 • 2017 Mitsubishi Outlander.
 <p data-bbox="293 1756 466 1783">IEC 62196 Type 2</p>	<p data-bbox="839 1518 1078 1545">TYPE 2 or Mennekes AC</p> <p data-bbox="839 1559 1382 1585">This connector has become widely used across Europe.</p> <p data-bbox="839 1608 1372 1635">Models with Mennekes inlets in New Zealand include:</p> <ul data-bbox="839 1648 1369 1787" style="list-style-type: none"> • used European EVs including BMW, Audi, VW and Mercedes • New Zealand new Renault Zoe and Kangoo Z.E. • Tesla cars imported from UK or Australia.

¹⁸ <https://www.nzta.govt.nz/planning-and-investment/planning/transport-planning/planning-for-electric-vehicles/national-guidance-for-public-electric-vehicle-charging-infrastructure/charging-point-connectors-and-socket-outlets/>

Connector	Description
 <p data-bbox="220 548 598 577">EU DC CCS Combo 2 Connector Type 2</p>	<p data-bbox="762 230 1050 259">EU DC CCS Combo TYPE 2 DC</p> <p data-bbox="762 271 1324 394">This is a fast DC charging connector used extensively across Europe. This is a recommended connector for fast (and possibly slow) DC charging in New Zealand (alongside the CHAdeMo).</p> <p data-bbox="802 405 1289 465">Models with Type 2 Combo inlets in New Zealand include:</p> <ul data-bbox="762 477 949 548" style="list-style-type: none"> <li data-bbox="762 477 885 506">• BMW i3 <li data-bbox="762 517 949 548">• Hyundai Ioniq.
 <p data-bbox="220 831 470 860">Tesla charging connector</p>	<p data-bbox="762 629 821 658">Tesla</p> <p data-bbox="762 669 1324 730">Used on Tesla cars imported from US or Japan. It has fast DC and AC, and slow AC, charging capabilities.</p> <p data-bbox="762 741 1324 842">Note: these proprietary chargers are not installed in New Zealand; however a Tesla supplied accessory can be used to charge from a CHAdeMo or CCS Type 2 connector.</p>

Glossary

Anchoring effect:	The tendency of people to rely too heavily, or 'anchor', on one trait or piece of information when making decisions (usually the first piece of information acquired on that subject).
Availability heuristic:	A mental shortcut or heuristic that relies on immediate examples that come to a given person's mind when evaluating a specific topic, concept, method or decision. People tend to heavily weigh their judgments toward more recent events with greater 'availability', making new opinions biased toward the latest news.
Bounded rationality:	The idea that in decision-making, people are limited by the information they have, the cognitive limitations of their minds, and the finite time. As a result, they seek for a "good enough" decision and tend to make a satisficing (rather than maximizing or optimizing) choice.
Choice supportive bias:	The tendency of people to remember choices made as better than they actually were. In a self-justifying manner retroactively ascribing one's choices to be more informed than they were when they were made.
Cognitive load theory:	A theory indicating people have limited mental processing ability when faced with too much information or increased complexity of information (ie, heavy cognitive load), can lead to risk adverse behaviour, and poor decision-making and purchasing outcomes.
Endowment effect:	The tendency of people once they own something (or have a feeling of ownership) they irrationally overvalue it, regarding of its objective value. People feel the pain of loss twice as strongly as they feel pleasure at an equal gain, and they fall in love with what they already have and prepare to pay more to retain it.
Hyperbolic discounting:	The tendency of people to have a stronger preference for smaller immediate payoffs relative to larger-later payoffs.
Loss aversion:	The tendency of people to prefer avoiding losses to acquiring equivalent gains. People are averse to losses because they feel the 'pain' of a loss at least two-to-three times more than the equivalent 'pleasure' of a gain.
Selective attention bias:	The tendency of people to not devote equal cognitive processing to all objects in the environment at any given moment. They are often oblivious to perceptual cues for objects they are not familiar with.
Status quo bias:	The tendency of people to like things to stay relatively the same. When comparing features of alternative options to those of the status quo, their disadvantages loom larger than the advantages; this leads to inertia.
Sunk cost fallacy:	The tendency of people to irrationally follow through on an activity that is not meeting their expectations because of the time and/or money they have already spent on it.

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