TE TARI TIAKI PŪNGAO
ENERGY EFFICIENCY & CONSERVATION AUTHORITY

Electric Vehicle Charging Technology

New Zealand residential charging perspective

For the Energy Efficiency and Conservation Authority by KPMG

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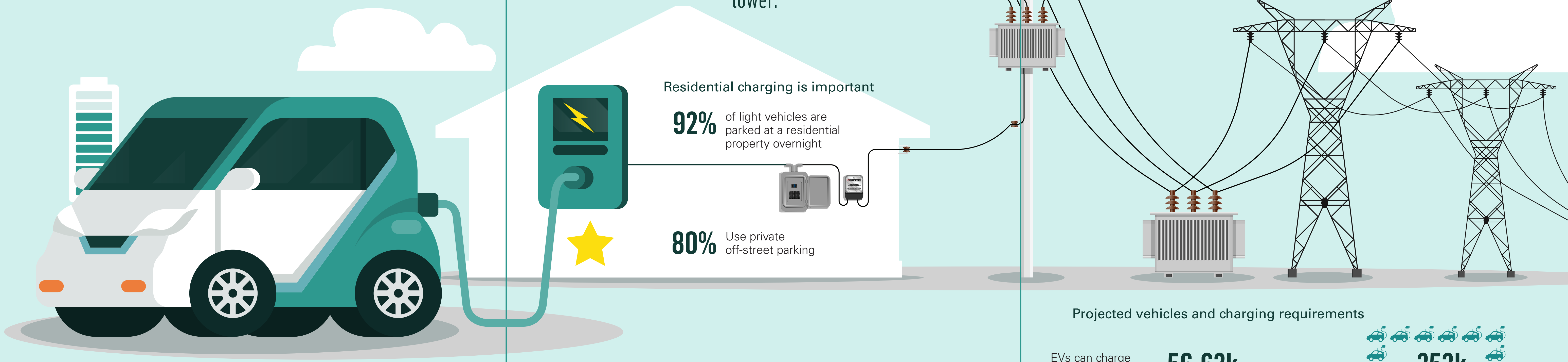


EVs

The majority of the New Zealand EV fleet can be charged with the unused mains capacity of a typical home.

Number of EVs in New Zealand

13,659 EV fleet (Apr 2019)

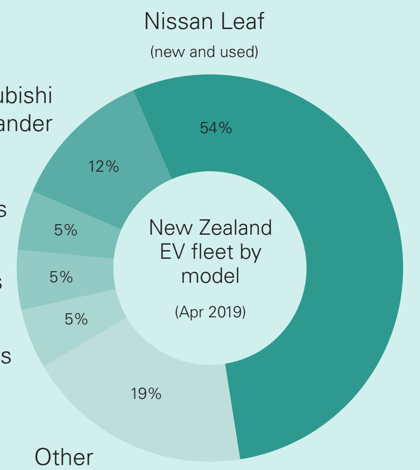
6,027 EV registrations (last 12 month period)

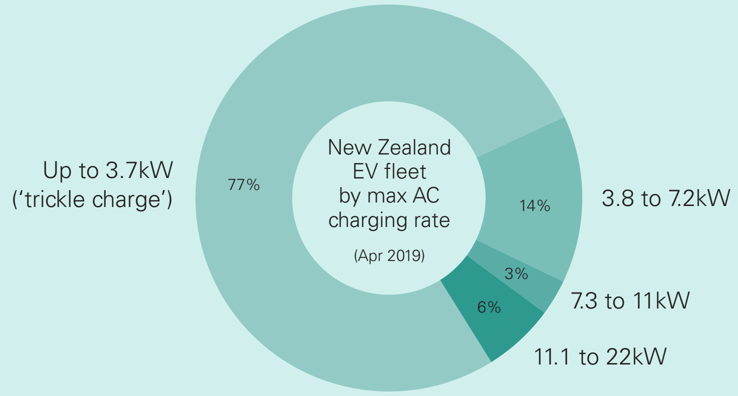
118% 3-year CAGR EV fleet size

0.35% EV as % of light vehicle fleet

2.2% EV as % of light vehicle sales

Composition of current EV fleet





Chargers

A wide range of chargers are available to buy in New Zealand. The cost of faster, wall-mounted chargers is higher, but the additional cost of 'smart' features is lower.

Number and types of chargers currently available in New Zealand

>65 different residential charger models

13 suppliers of chargers available

x12 Charging cables $500-$1,000 — Trickle charge only up to 3.7kW

>80% residential EV charging in New Zealand via charging cables

x27 Basic wall mounted chargers $1,000-$4,000 — Slow/ Medium charge 3.7 to 22kW

$500 to >$5,000 for installation costs (depending on complexity)

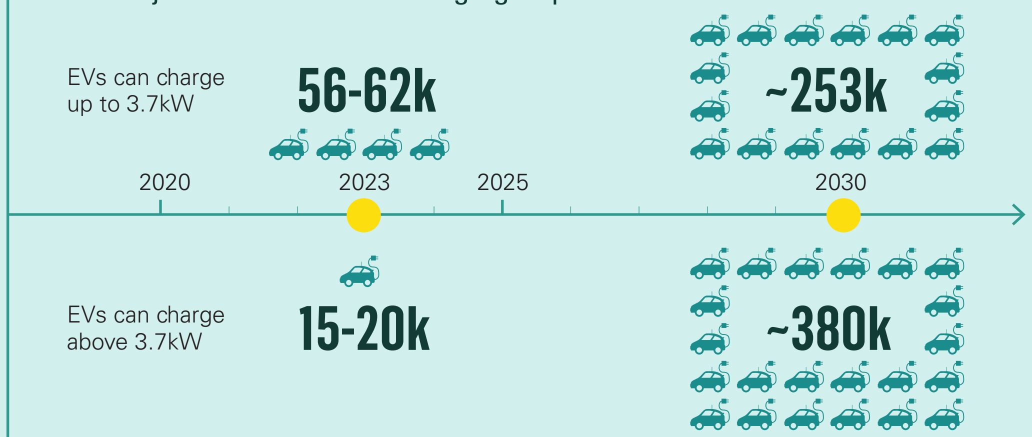
60 amp typical fuse rating for New Zealand houses, charging at >3.7kW may be an issue for most New Zealand houses

x26 'Smart' chargers $1,400-$5,000 — Smart Slow/ Medium charge 3.7 to 22kW

Network impact

EV's impact on networks will increase in the future. 'Smart chargers' can play an important role in managing this impact

Projected vehicles and charging requirements



Until 2023, 70-80% of the EV fleet will consist of vehicles with a maximum AC charging rate less than 3.7kW. In the next decade, the number of EV's is expected to increase above 600,000 and a growing share will support faster charging at home. This may cause electricity load balancing issues at the home and network level.

Managed charging, via smart chargers can reduce the future impact of EV's on the electricity system. Ideally, NZ will take advantage of the next few years to develop and implement systems and policies that incentivise and make effective use of smart charging technology to avoid increasing network peaks and resulting network reinforcement from the uptake of electric vehicles.

Future technologies that underpin managed charging could include:

Next 3-5 years

Manual charging management

Automated network level charging management

>5 years

Co-ordinated charging

Bi directional charging

Introduction (1/2)

Background

The Energy Efficiency and Conservation Authority (EECA) is charged with promoting energy efficiency, energy conservation, and renewable energy.

EECA commissioned this study on residential Electric Vehicle (EV) charging technology as a first step in understanding the wider EV charging landscape. Its purpose is to contribute knowledge, evidence and information to the conversation about the potential impact of home EV charging on the electricity system, including its renewable energy component. This is consistent with EECA's mission to mobilise New Zealanders to be world leaders in clean and clever energy use.

EVs are making up an increasing share of vehicle sales across the world and in New Zealand, albeit from a low base. Widespread EV adoption is expected to have significant opportunities for the economy as it moves toward achieving the government's low-emissions goals, but will also pose challenges for a number of industries, in particular, the energy markets. EV charging will increase electricity demand in New Zealand. Many solutions will be required to meet this demand recognising the different contributions of home charging, public slow charging, and public fast charging.

Surveys suggest the majority of EV owners prefer to charge their EVs at home overnight as it is the simplest, cheapest and most convenient way to charge. It is expected that the growing popularity of EVs and home charging will put increasing pressure on the electricity system, during peak periods. Smart charging can smooth the peak demand profile and reduce the risk of EVs overloading the electricity system. It presents an opportunity to reduce costs to consumers and increase the use of clean, renewable energy.

This study is intended to provide a better understanding of current and near future residential EV charging requirements and technologies in New Zealand, with a particular focus on smart charging technology. It provides industry and government stakeholders with information about the current state of the EV market and residential charging technology. Its aim is to share information and promote discussion on initiatives to reduce pressure on the electricity system during peak demand periods.

Next steps for investigation

Further investigation is required to understand how emerging technologies canvassed in this study can be integrated into our energy system. This will require a broader perspective and discussion on business models, regulatory frameworks and market settings, as well as seeking the views of consumer and industry stakeholders. These will be crucial to integrate renewable energy sources while avoiding impacts on the electricity system.

EECA considers further investigations relevant to EV charging should include:

I) The value of 'smart charging' in New Zealand

II) Impacts on the low voltage electricity network

III) Household and consumer perspectives

IV) Future charging infrastructure requirements

V) Addressing barriers and challenges

VI) Standards, regulation and market design options

The EECA Low Emissions Vehicles Contestable Fund (LEVCF) supports projects that encourage innovation and investment in electric and other low emissions technologies. This includes technologies such as V2X/bi-directional and smart charging that results in reductions to peak electricity demand.

Introduction (2/2)

Approach

This paper was prepared by KPMG based on:

I) Secondary research, using public information, of EV charging technologies globally, and the size, composition and charging requirements of the New Zealand EV fleet, and current availability of chargers in New Zealand;

II) Primary research, using a survey and follow up interviews with EV charger makers, and EV manufacturers and distributors about available products and key market trends; and

III) Projections of the size, composition and charging requirements of the New Zealand EV fleet.

Acknowledgements

EECA and KPMG thank the organisations that took part in the surveys that informed the findings in this report. EECA also acknowledges and thanks the various government organisations for their contributions to the report.

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Executive summary

Executive summary (1/3)

Decarbonising transport is critical to addressing New Zealand's climate change challenge

The global EV fleet had an estimated 5.4 million vehicles in 2018. Uptake has been growing due to the increasing choice and operating range of vehicles, government subsidies, and the environmental awareness of consumers. Nevertheless, EVs still only account for 2% of sales in the main automotive markets. Battery capacities have been increasing to provide greater operating range. With increased battery size, EV makers have also introduced faster charging facilities. The New Zealand EV fleet has been doubled annually in the last three years, and currently stands at 14,000 vehicles, This is driven partly by the availability of relatively low cost used vehicles, mainly from Japan.

The Interim Climate Change Committee has recently recommended a target for reducing annual transport emissions by at least 6 Mt CO_2e in the year 2035 relative to current levels. EVs are expected to play an important role in achieving this goal, along with other innovations such as hydrogen powered vehicles, increased rail transport and cleaner shipping.

Increasing uptake of light electric vehicles has implications for the electricity system

Current situation: More than 85% of the current New Zealand EV fleet consist of five Battery Electric Vehicle (BEV) models: Nissan Leaf, Nissan eNV-200 vans, BMW i3, Hyundai Ionic and Tesla(s), and two PHEVs (Plug-in Hybrid Electric Vehicles): Mitsubishi Outlander and Toyota Prius. The majority (77%) of the current EV fleet supports up to 3.7 kW AC charging rate. Used Nissan Leafs from Japan (the mainstay of the fleet) have a maximum 3.6 kW charging capacity. PHEVs generally have a maximum 3.7kW AC charging capacity and a small battery size to fit space and cost constraints. This charging load can be accommodated within the unused mains capacity of most homes in New Zealand. Charging up to 3.7 kW rate can be achieved with a Mode 2 charging cable, which is typically supplied with vehicles at purchase. For average daily use, such 'trickle charge' overnight is sufficient for 1-2 days' travel.

Near term outlook: Price parity with traditional vehicles is considered a key driver for EV adoption. With (near) price parity, it is assumed that EVs can reach a significant share of new sales (30%-50%, as in Norway).

Projected New Zealand EV fleet size scenarios

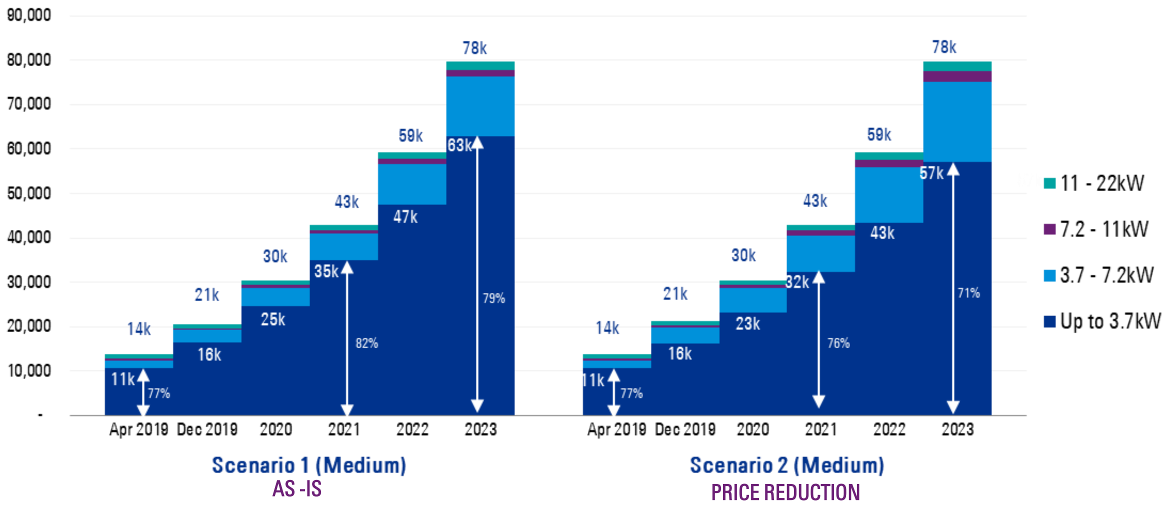
Year	Price Parity by 2035 (Low)	Price Parity by 2030 (Medium)	Price Parity by 2025 (High)
2021	35,668	40,929	62,494
2023	60,096	77,913	135,821
2025	112,699	165,444	310,883
2030	418,236	631,344	1,027,254

Our projections indicate the size of the New Zealand EV fleet to be 60,000 – 136,000 vehicles in 2023. The scenarios vary based on how fast the price of EVs will converge with traditional vehicles. The Medium scenario assumes price parity in 2030, when EVs achieve 33% of light vehicle sales. The Medium case shows 78,000 EVs in 2023, and 165,000 and 631,000 in 2025 and 2030 respectively.

Under the Medium projection, the expected composition of the EV fleet was analysed by charging requirements in two further scenarios. Scenario 1 assumes that EV demand and supply by price band remains broadly unchanged until 2023. Scenario 2 assumes that supply and demand shifts towards EVs with bigger batteries and faster charging requirements. These assumptions impact the affordability and expected market share of various EV models and the projected composition of the EV fleet by charging requirement, as summarised on the following charts.

Executive summary (2/3)

Projected New Zealand EV fleet size by charging requirements



Accordingly, about 70% - 80% of the EV fleet in 2019 - 2023 will consist of vehicles with a peak AC charging rate up to 3.7kW. This includes a mix of older BEVs, and PHEVs that tend to have smaller batteries due to size and cost constraints. At that charging rate EV owners are less likely to face charging constraints due to existing home wiring and appliance loading or due to distribution network constraints. However 15,000 – 21,000 EVs will have the ability to charge above 3.7kW by 2023, which may cause electricity network load balancing issues in typical New Zealand homes and require network upgrades or a controllable charger. This number is forecast to increase to 66,000 in 2025 and 378,000 in 2030 (assuming EVs with faster chargers represent 40% and 60% of the EV fleet in those periods respectively).

The charging power level, time and location may have a significant impact on the electricity system. EV charging during peak hours is expected to become a key issue for network companies in areas with high EV concentration. Growing EV numbers and clustering in particular suburbs mean that residential EV charging will impact low voltage distribution networks over time.

A managed approach to EV charging may be required to reduce the additional network capacity needed in peak periods and the associated cost of network upgrades. 'Managed charging' allows external control to adjust the EV's power draw based on factors such as grid capacity, utility incentives and EV owner needs. Charging equipment that supports managed charging is referred to as a 'smart charger'.

New Zealand EV owners can choose from more than 65 charger models and fully installed charger costs range from $1,000 to over $10,000

EV owners have a choice of about 65 residential chargers to purchase in New Zealand with varying feature sets, including more than 25 smart chargers. The majority of current EV buyers are understood to be satisfied with the basic charging cables supplied with EVs. Some early adopters and EV enthusiasts have bought higher-end chargers. Nevertheless the trend is to use simpler products in the absence of any requirement or incentive to purchase higher capacity, feature rich smart-chargers.

The price of chargers generally range from about $475 (for basic charging cables) to $5,000 (for fully featured, wall-fitted smart chargers). The difference in equipment prices is mainly due to the higher cost of the faster wall chargers compared to the basic charging cables. The price premium for smart charging features is relatively low. Additional installation costs for wall chargers varies from about $750 to over $6,000 depending on location, distance from the switch board, any wiring upgrades required.

Executive summary (3/3)

Clean and clever charging can avoid network problems and capture benefits for the electricity system and consumers

Faster EV chargers draw a relatively large electrical load, above 3.7kW to 22 kW. These additional loads can exceed the design capacity of the distribution networks and the electrical network in the home during peak periods. Overseas studies highlight the impact of EV clustering in a few suburbs, and time-of-use electricity rates which encourage EV users to begin charging at the start of the lower price period. EV charging coinciding with peak demand would increase the need for 'peaking' generation, which is more likely to be supplied from gas and coal-fired power plants in New Zealand.

Managed charging allows the vehicle owner, or another party such as the electricity utility, to remotely influence vehicle charging, much like traditional demand response programs. Controllable smart chargers may play a part in managing household and network loads. They allow EV charging demand to become more elastic over time, which can lead to market price and carbon emission reductions. However, a fully managed EV charging ecosystem relies on broader electricity market development as discussed later in this paper.

The potential use of EVs as distributed energy resources is also expected to shape future charging technologies. Depending on the model, current EVs can store between 5-40 kWh of energy. This energy can be used not only to power the car but also other appliances, for example providing energy for homes (Vehicle to Home or V2H) or supply ancillary services to the distribution network (Vehicle to Grid or V2G). Managed charging is expected to evolve through increased automation and co-ordination between various network devices. Ultimately it will enable a V2G model where EV charging systems interact with the power grid to manage their EV charging rate or return electricity to the grid.

EV owners may need incentives to use smart chargers and allow an external party to influence the charging of their vehicle. This could be achieved through offering subsidised chargers, tailored electricity tariffs or sharing electricity load management revenues. The evolution of this market will depend on the direction taken by utilities, retailers and regulators to manage the electricity system.

The main barriers to the adoption of smart chargers include their higher up-front cost and the lack of an industry-wide managed charging system that would incentivise their take up

'Smart' features are incorporated in wall-fitted chargers that also allow faster charging than basic charging cables. Although additional charging control features do not cost significantly more, a typical wall charger itself is relatively expensive compared to the purchase price of an average EV.

Currently, EV owners tend to use smart chargers as a monitoring tool (e.g. for power consumption and range estimation) rather than for charging management. Some users of EVs that allow faster charging, above 3.7kW, can benefit from smart chargers managing the electrical load at the home level. However the majority of EV users currently cannot take advantage of dynamic charging management, and have little incentive to upgrade their charger.

Various managed charging service propositions are evolving in New Zealand and overseas, led by charger manufacturers and network companies. Governments and regulators have begun considering how to enable and incentivise their use. We expect that coordinated industry-wide steps are needed to allow the integration and control of smart chargers within the national power grid. A brief overview of key enablers is discussed later in this paper.

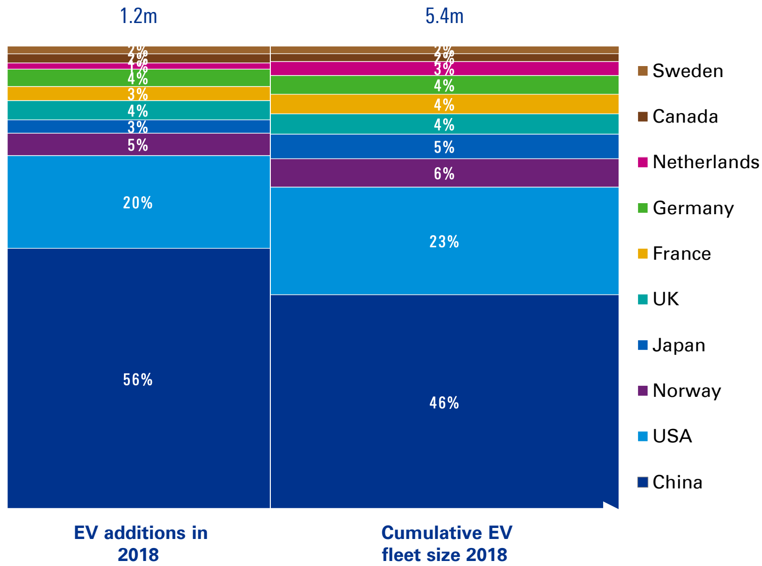
2

Introduction to EV charging

The global EV fleet has exceeded 5 million vehicles, but EVs still account for only about 2% of car sales in key EV markets

The first modern commercial EVs appeared in 2008. Their global adoption has accelerated in recent years and reached 5.4 million units by the end of 2018. Over 2 million[1] were sold in 2018 alone, mainly in China, the US and Northern Europe. EV sales have been growing due to the increasing choice and operating range of vehicles, government subsidies and the environmental awareness of consumers. Nevertheless while EVs account for ~40%[1] of vehicle sales in Norway and more than 7%[1] in Iceland and Sweden, the overall sales of EVs account for only 2% of sales in major automotive markets.

Global EV statistics



Source: IEA Global EV outlook, 2019

Types of electric vehicles

Vehicles with electric engines fall broadly into three groups as per the table below. In this paper, the term EV refers only to plug-in hybrid vehicles and battery electric vehicles, which require an external electrical charging source.

	Hybrid Electric Vehicles (HEVs)	Plug-in Hybrid Electric Vehicles (PHEVs)	Battery Electric Vehicles (BEVs)
Overview	HEVs are powered by a main petrol engine with a small electric engine and battery contributing to fuel economy. The battery is charged by regenerative braking and the engine. HEVs start off using the electric engine, and the petrol engine cuts in if required to support the load or acceleration. The two engines are controlled by an internal computer to ensure the best economy for the driving conditions.	PHEVs have both a petrol and electric engine and they can run autonomously on either. PHEVs can recharge their battery internally in a similar way as an HEV and by 'plugging-in' to an external electrical power outlet. In certain vehicle types, the petrol engine extends the range of the car by recharging the battery as it gets low.	BEVs are fully electric vehicles, with only electric motors. They use an external electrical outlet to charge the battery. BEVs can also recharge their batteries through regenerative braking.
Pros and Cons	✓ Better fuel economy than internal combustion engines, particularly in stop-and-start city driving. ✓ Similar range compared to traditional cars and ability to use existing fuelling infrastructure × Not using the electric engine to full potential to reduce fuel consumption and air pollution	✓ Larger battery than hybrids; enabling longer range on electric mode alone, to improve fuel economy ✓ Not dependent on electric charging infrastructure as it can run on the petrol engine × Higher purchase price compared to HEVs	✓ No fuel consumption and air pollution ✓ Increasing range – can cover a typical daily commute on a single charge × Range is not yet comparable to traditional vehicles × Cannot use existing (petrol) fuelling infrastructure
Examples	Toyota Prius, Nissan Altima HEV, Lexus 450h, Toyota Camry Hybrid, Honda Civic Hybrid	Toyota Prius Prime, Mitsubishi PHEV, Hyundai Ioniq, Kia Niro	Nissan Leaf, Kia soul EV, Hyundai Ionic electric, Tesla Model S, BMW i3

Typically referred as electric vehicles

1. http://www.ev-volumes.com/country/total-world-plug-in-vehicle-volumes/

The New Zealand EV fleet has doubled annually in the last three years, driven by the availability of lower cost used EVs from overseas.

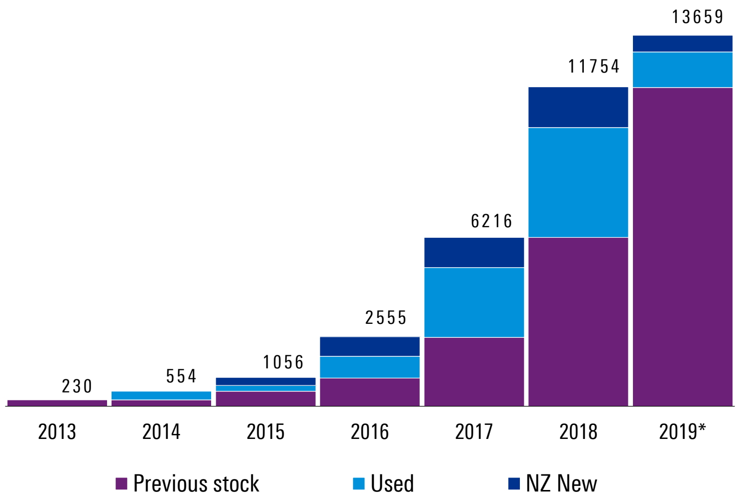
New Zealand is well positioned to benefit from an increased uptake in EVs. This is because more than 80% of electricity is generated from renewable sources, and sufficient renewable energy supply is available to support the widespread adoption of EVs. Therefore the emission reduction benefits of EVs are greater in New Zealand than other countries that generate less renewable energy. Additionally, the average daily commute is relatively short (<40km) and the majority of households has access to off-street parking with an electrical outlet to charge EVs.

New Zealand EV overview

13,659	6,027	118%	0.35%
EV fleet (Apr 2019)	EV registrations (Last 12 month period)	3 Year CAGR EV fleet size	EV as % of light vehicle fleet

New Zealand has joined the Electric Vehicles Initiative (EVI), a multi-government forum of the world's top EV markets dedicated to accelerating the uptake of EVs. Several EVI members have endorsed its EV30@30 campaign to have EVs reach 30% of global car sales by 2030 (although New Zealand has not officially joined this particular campaign).

New Zealand EV growth



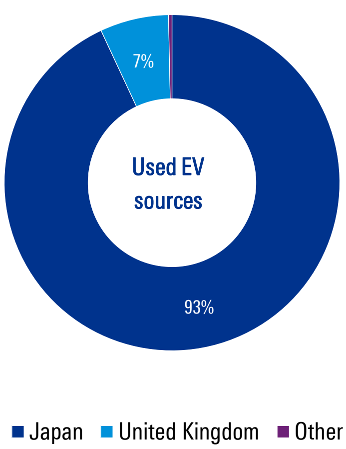
Source: MoT Vehicle Fleet Statistics, May 2019

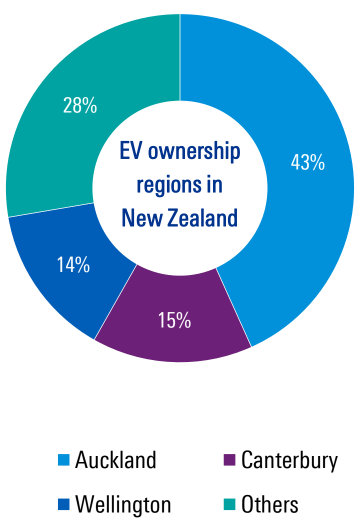
Meaningful growth in the uptake of electric vehicles in New Zealand started in 2014, driven by the sale of used Nissan Leafs from Japan and increasing public awareness of EVs in general. The penetration of EVs has grown from 0.13% of all light vehicle sales in 2014 to ~2% in the first four months of 2019. New Zealand does not provide extensive subsidies for EVs, unlike leading markets such as Norway. Growth in New Zealand has been supported mainly by lower operating costs and sustainability considerations. New Zealand EVs are currently exempt from Road User Charges (until fleet penetration reaches 2%, applies till end of 2021) which offers EV users ~$600 per annum saving. The government has recently announced a proposal to support the cost of newly registered EVs by up to $8,000, starting in 2021.

New Zealand's EV fleet consists of mainly imported used vehicles from Japan. Used Nissan Leafs contribute to 53% of the EV fleet in New Zealand. EVs are currently purchased in greater proportion in the used car market than the new car market, partly due to the higher initial cost of new EVs.

Only 24% of the current EV fleet is company owned, while 71% is registered to individuals, with the remaining owned by government agencies. Home charging is the predominant way of charging EVs.

About 40% of EVs are registered in the Auckland region. The per capita EV ownership is similar across the Wellington, Auckland, Otago and Canterbury regions.





Source: MoT Vehicle Fleet Statistics, Dated May 2019

The majority of EV owners prefer to charge at home and use trickle charging (~3kW rate).

EVs can be charged at home overnight, or at public charging stations and at workplaces. The most convenient place to charge may depend on battery status, battery size, charging cost and upcoming travel distance to cover.

According to the Ministry of Transport (MOT)[2], 92% of light vehicles are parked at a residential property overnight and over 80% use private off-street parking. On average New Zealand EV drivers travel 41km per day, and 95% of day journeys are less than 125km. Recharging to cover this distance can be done at home with basic, trickle chargers (see below) that add 15-18 km of charge per hour. The Global EV Outlook by IEA recently observed that 92% of all chargers (globally) are slow/trickle chargers and EV owners surveyed preferred to charge their vehicles at home.

Speed of charging

Speed is a key feature of EV changing – i.e. how fast can a charger 'fill' an EV. The following table summarises the terminology used to describe charging speed.

Charging speed	Typical location	Illustrative metrics
Trickle charging	Home	– 3kW (15-18km/hr of charging) – 13 hours for 80% of full charge[3]
Slow charging	Home, Work	– ~7kW (30-40 km/ hr of charging) – 6 hours for 80% of full charge[3]
Medium charging	Home, Work	– ~22kW (70-80 km/ hr of charging) – 3 hours for 80% of full charge[3]
Fast charging	Work, Public	– ~43kW (140-160km/ hr of charging) – 1.5 hours 80% of full charge[3]
Rapid charging	Public, Corridor	– 50 - 75kW (200-250 km/hr of charging) – <1 hour for 80% of full charge[3]
High power charging	Typically corridors only	– 145+ kW (300-500 km/hr of charging) – <30 min for 80% of full charge[3]

For EV owners with access to off-street parking with a power point, charging at home overnight is expected to be the simplest way to charge.

Assuming a residential off-peak electricity rate of 24c implies EV charging costs are equivalent to approximately 61c a litre of fuel[4]. The cheapest way to charge an EV is by charging during off-peak hours, typically between the hours of 11pm and 7am

Faster chargers are expected to be more useful if the EVs are away from home for longer trips or with limited access to off-street parking.

Charging at fast public charging stations can potentially cost upto $10 per 100km (equivalent to $1.4 a litre of fuel)[4]. The network of fast public chargers is growing in New Zealand.

Vehicles may limit the rate of charging, e.g. older Nissan Leafs can only charge up to 3.6kW and a new BMW i3 can charge up to 11kW. While a 22kW charger can be connected to these vehicles, it will charge only as fast as the car allows.

2. NZ Vehicle Fleet Statistics (2018), Ministry of Transport, and Ministry of Transport research New Zealand; https://www.transport.govt.nz/assets/Uploads/Research/Documents/393c3d5a9d/25yrs-of-how-NZers-Travel.pdf
3. Assuming 2018 Nissan Leaf with 40 kWh battery with range of 243 km, charging typically slows down after 80% charge is achieved to preserve the health of the battery
4. Assuming 2018 Nissan Leaf with 40 kWh battery with range of 243 km, and a Toyota Corolla using 7.0l/ 100km of fuel , fuel price of $2.3 per litre, 50kW fast charger, with pricing of $0.25 per kWh and $0.25 per min

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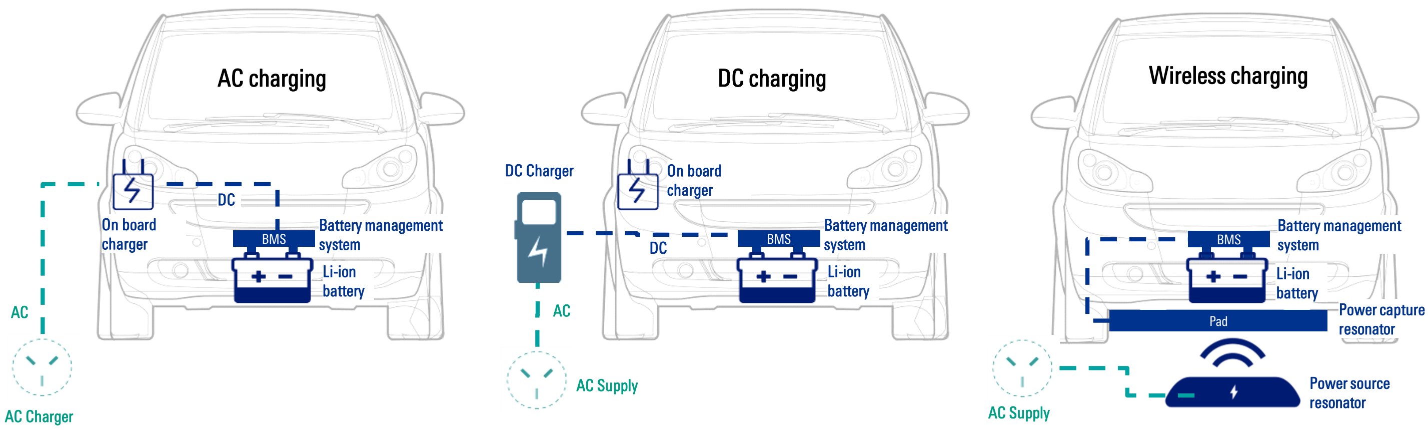
Predominantly AC charging is used for residential charging in New Zealand.

Charging EV batteries is predominantly done through chargers connected to the electric power grid. The power grid delivers alternating current (AC) but an EV battery needs direct current (DC) to charge. The conversion of AC to DC can take place in the vehicle or in the charger, depending on the technology used.

The following table describes three broad categories of EV charging infrastructure.

AC Charging	DC Charging	Wireless Charging
The conversion of AC (from the grid) to DC is done in-car via a built-in inverter. The capacity of the AC-DC converter unit determines how much of the available charging capacity of the charging station can be utilised. The maximum charging capacity currently possible via AC charging at home is 22kW on a three phase connection, or 11kW on a single phase connection. This type of charging is typically used in a residential / low voltage setting (2.3 - 22kW range).	The conversion of AC (from the grid) to DC is done outside the vehicle in an external charger. Direct current (DC) enables the charging point to charge at high power (typically in excess of 50kW). The charging point has direct contact with the car battery. This type of charging is typically used for public fast charging.	This system uses electromagnetic waves to charge batteries. It usually employs a charging pad connected to a wall socket and a plate attached to the vehicle. Currently available wireless chargers can provide up to 11kW power (for residential use) and up to 75kW (for public chargers). Suited for residential use, for garaged vehicles (3-11 kW range).

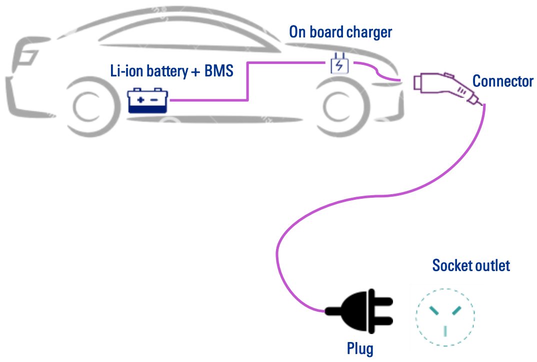
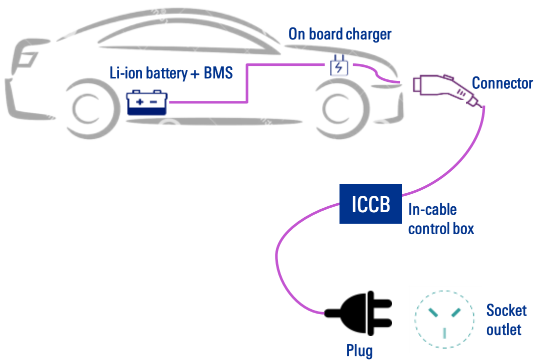
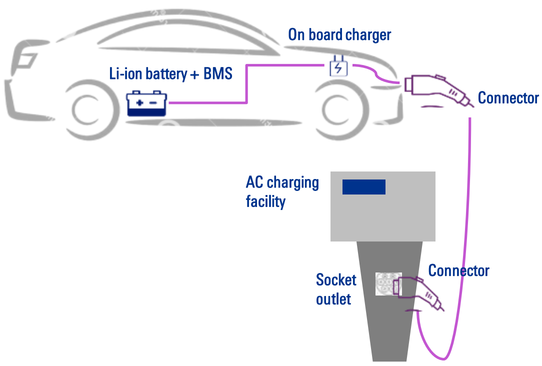
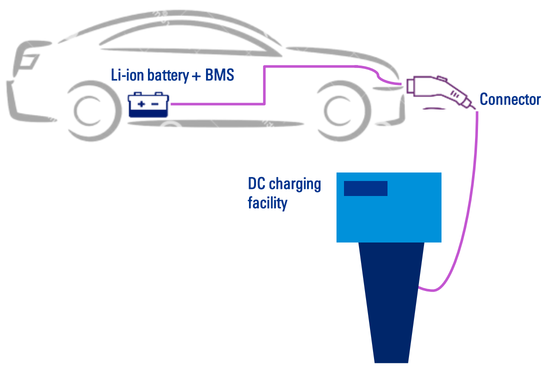


AC Charging	DC Charging	Wireless Charging
✓ Significantly lower cost of installation and operation ✓ Charging speed can be varied ✓ Lower output better for battery life × Typically slower than DC chargers	✓ Faster than other charging methods × Higher costs compared to AC chargers × Unsuitable for most residential applications given high power demand	✓ More convenient for EV users than compared to other charging methods × Slower than other charging methods × More expensive than AC chargers

Charging modes

Of the four standard charging modes, Modes 1, 2 and 3 are the most relevant for low voltage, residential charging.

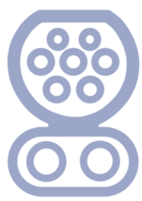
The concept of 'mode' refers to the charging technique, and considers capacity, communication and electrical safety. There are four key modes for EV charging, as defined in the standard EN 61851-1, summarised below.

Mode	Description	Overview
Mode 1	*Non-dedicated charging circuit using socket-outlet for charging. Charging cable does not incorporate Residual Current Device (RCD) protection.* This charging method lacks communication and added safety protection. Therefore in Mode 1 the charging capacity is limited to maximum 2.3 kW (Single phase, 10A) (per IEC 61851-1). Mode 1 should only be used for charging an electric vehicle (in the residential charging context) where the supply is protected by a Type A RCD per WorkSafe guidelines[5]. This type of charging should work on most home circuits / fuse.	
Mode 2	*Non-dedicated charging circuit using socket-outlet for charging. Mode 2 cables are provided with an in-cable control box (ICCB) (including RCD), set and adjusted to a specific charging power, that provides RCD protection during charging.* Mode 2 can be used for charging an electric vehicle in locations where there is no dedicated charging installation or for using old vehicles which no longer have the current commonly used connectors. Mode 2 charging can provide charging capacity up to 7.4 kW with a single phase, max 32A (per WorkSafe guidelines) connection, as the charging levels are controlled by the ICCB. (Mode 2, 3 phase charging is available overseas). In most New Zealand homes, circuits are rated at 10amps.	
Mode 3	*Fixed and dedicated socket-outlet. Mode 3 chargers are defined in two configurations, either with a tethered cable or a dedicated socket-outlet. The Mode 3 charger equipment has built in RCD protection and control functions.* Mode 3 can deliver single or three phase AC fast charging up to 22kW. These chargers are hard wired into the home or building wiring. In Mode 3 the adequate charging capacity (AC) is determined by communication between charging station and vehicle.	
Mode 4	*Dedicated rapid charging, DC supply* Mode 4 is a necessary service function for rapid charging, for use as roadside assistance and service station charging on long journeys. The cable is inseparably linked to / is a integral part of the charging point. The charging capacity delivered varies mostly from 50 kW to 175 kW (higher capacities are currently undergoing trials).	

5. WorkSafe charging safety guidelines May 2019

New Zealand EVs tend to use Type 1 or Type 2 connectors

The connector (charging inlet) on a car is designed to be durable for continuous, safe use. There are multiple standards based on manufacturer, country and charging speed. The following are the typical connectors used on electric vehicles in New Zealand.

Connector	Description	Illustration	Compatible cars in New Zealand	
AC				
Type 1 **SAE J1772 Type 1 AC**	This is the standard Japanese connector for electric vehicle charging in alternating current (also adopted by the North American countries, and accepted by the EU).		– Nissan Leaf (including imports) – Mitsubishi Outlander PHEV – Nissan e-NV 200 – BMW i3 (imported) – Citroen c-Zero	– Kia Soul – Toyota Prius plugin – BMWs sold in New Zealand prior (prior model) – Fiat 500e – Holden Volt
Type 2 **Mennekes**	The connector type for the European Union adopted as the standard for regular (≤ 22 kW) charging of electric vehicles.		– Hyundai Ionic, Kona – Renault Zoe – VW e-golf – Audi A3	– Mercedes B – BMW i3, 330e, i8 – Tesla model S/X
DC				
CHAdeMO	This connector is used for DC charging in Japan and so is the DC inlet supplier with most imported Japanese vehicles. EVs with Type 1 connectors generally have this as the DC connector.		– Nissan Leaf (including imports) – BMW i3 (imported) – Kia Soul – Nissan e-NV 200	– Mitsubishi Outlander – Tesla S/X (with adapter)
Tesla Super-charger	Made exclusively for Tesla.		– Tesla Model 3 – Tesla Model S / X	– Tesla cars imported from UK or Australia have a Type 2 inlet but can use a CHAdeMo connector using a Tesla-supplied accessory.
Combined				
Type 1 CCS	This connector is used in the US for DC charging and was also adopted for some European-origin EVs. Currently fast charging stations in New Zealand are transitioning from CCS Type 1 to CCS Type 2 connectors.		– Old Nissan Leafs	
Type 2 CCS	This connector is the enhanced version of Type 2 with additional power contacts for fast charging. CCS is compatible with AC and DC and CCS is the standard for fast charging in Europe since 2017. Manufacturers such as Audi, BMW, Porsche and Volkswagen use this type of connector		– Hyundai Ionic, Kona – Renault Zoe – VW e-golf – Audi A3	– Mercedes B – BMW i3, 330e, i8

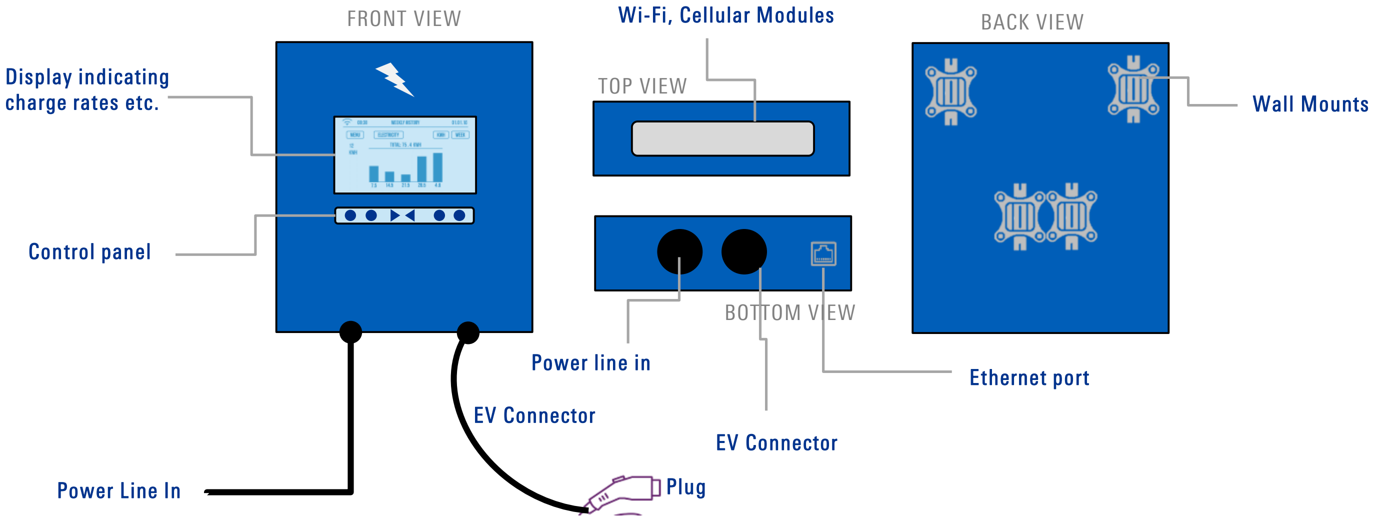
Another notable connector type is the GB/T port, a fast charging stand standard used in China. Currently no vehicles with this port are on sale in New Zealand.

Home EV chargers are typically charging cables, rated up to 3.7kW, or wall chargers between 3.7kW-22kW

Home EV chargers are usually in the form of charging cables or wall mounted charging units.

	Charging cables	Wall mounted charging units
Overview	Charging cables can be used to plug the electric vehicle into a 3 pin home socket without additional equipment. – They are portable and have in-line controls, display/LEDs and protection equipment (e.g. residual current device, overcurrent protection). The higher-end cables may include temperature sensor, auto–restart and timer features. They typically do not have more advanced functions e.g. communication, remote monitoring and load balancing capabilities. – Worksafe guidelines[6] specify that these cables are only permitted to be used in Mode 2 and are limited to charging under 8A-32A (1.8 -7.4kW) loads. However, most charging cables available in New Zealand are rated to 16A (3.7kW). This means that most New Zealand houses can accommodate these cables without any major wiring upgrades based on trickle charging loads.	Wall mounted EV chargers are directly wired into the home network and have their own Type 1 / Type 2 sockets for plugging in electric vehicles. – They require installation by certified professionals and Worksafe guidelines require the installation of Type B - Residual Current Devices (RCDs). – They are permitted to operate up to mode 3 and there are models available for charging between 3.7-11kW (for a single phase connection) and 22kW (for a three phase connection). – Most of these chargers have an LCD display with status information. Features may also include communication functions (e.g. Bluetooth, Wi-Fi, Ethernet, Cellular), remote monitoring and control capabilities (phone app, web interfaces), and load balancing capabilities.
Pros and Cons	✓ Portable ✓ Can be used in most houses without wiring upgrade ✓ Typically provided with the vehicle at the time of purchase × Charges slower than wall mounted chargers × Generally has limited features in terms of monitoring, control and safety	✓ Generally can charge at a faster rate than charging cables ✓ Models available with enhanced value add features including connectivity, monitoring and control × Higher purchase and installation cost compared to charging cables

Wall mounted EV charger illustration



6. Worksafe charging safety guidelines May 2019

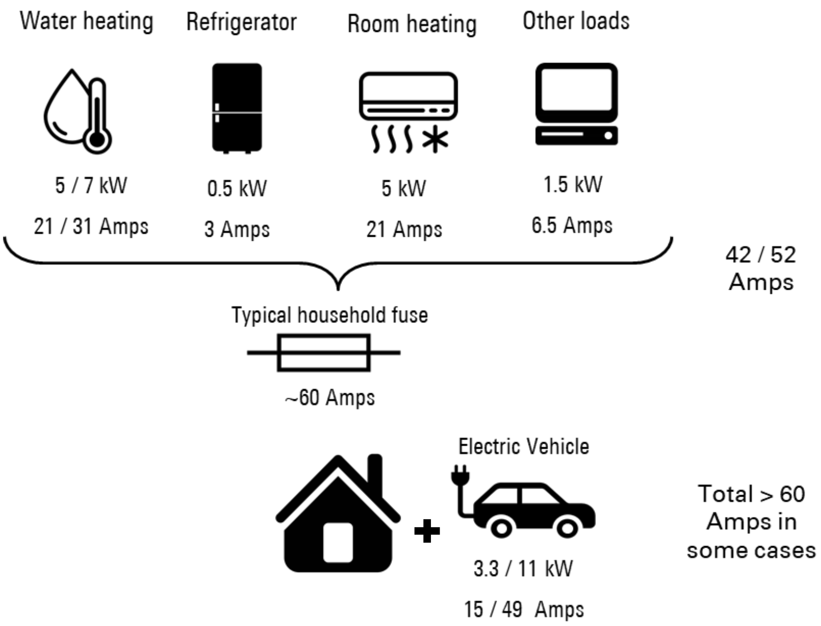
The need for managed charging accelerates with higher EV adoption in order to maintain the stability of the electricity network

EV chargers draw a relatively large electrical load, between 2.2 kW and 22 kW based on current technologies. These additional loads may exceed the design capacities of the electrical networks at home and on the distribution networks.

Home level

Studies in New Zealand and overseas indicate that most EV owners simply plug-in their vehicles to start charging as soon as they get home. This charging approach is called passive charging. In New Zealand, this coincides with the existing peak system demand in the early evening, particularly in the winter.

Impact of EV charging on residential electrical load (Illustration)



The household mains in New Zealand are usually sized at 60 amps[7]. EVs can place a considerable additional load on a household electrical network. Load levels of existing appliances will have an impact on the rate at which an EV can charge without overloading the household fuse. To do this on a real-time basis requires a smart EV charger, which can dynamically vary the charging load based on loading from other appliances or from external market linked signals.

Network level

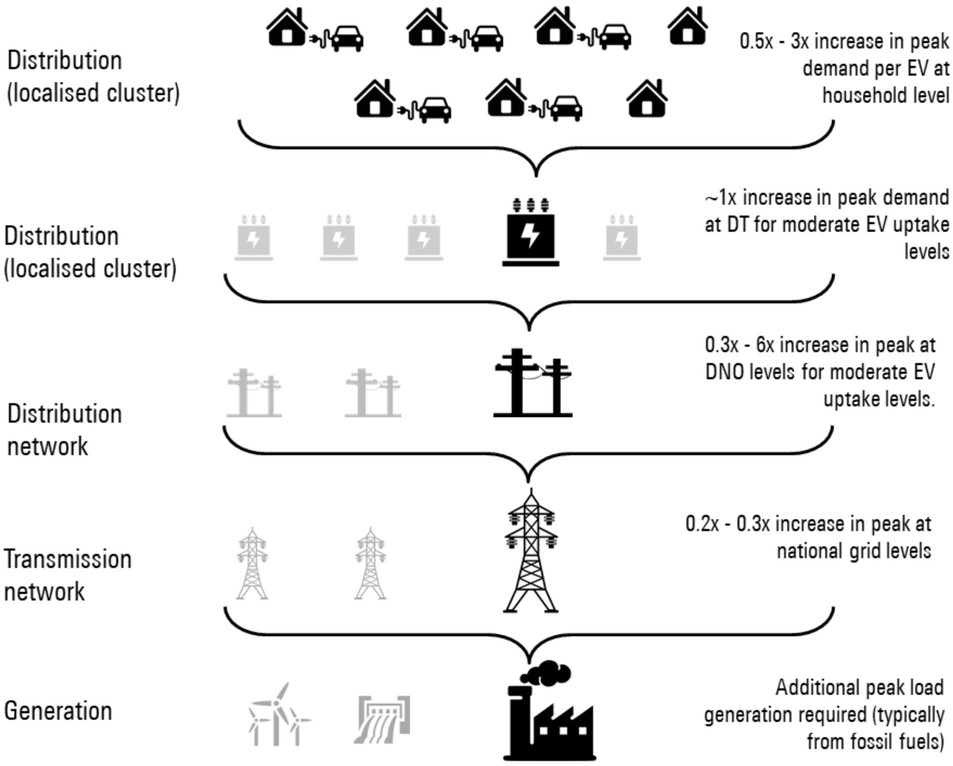
The power level, time and location of EV charging could have significant implications for the electricity system. EV loading on the local grid is a critical issue for network companies, especially in areas with higher EV concentration. Typically peak distribution transformer loading levels are in the range of 60%-80%. Higher uptake of EVs could increase localised demand by more than the acceptable loading limits during peak periods, and drive the need for accelerated network investment.

Growing EV numbers and clustering in particular suburbs mean that EV charging will impact low voltage distribution networks. Vector has assessed multiple scenarios for Auckland and concluded that if customers started using 7kW home chargers, the load will surpass network capacity during evening peak, even at 20% EV penetration level. The relative capacity in the network is higher in the case of slower chargers.

7. Mainpower, capacity increase FAQs

The need for managed charging accelerates with higher EV adoption in order to maintain the stability of the electricity network (continued)

Impact of EV charging on network electrical load (Illustration)



In a report for Orion, PowerCo and Unison, Concept Consulting estimates the growth in transmission and distribution network costs (which are largely driven by peak demand) will be in the range of $160-220/kW/year (an additional $6.1bn cost using passive charging compared to smart charging by 2050). The report estimates the EV linked peak demand increase to be 3,000 MW by 2050 in a passive charging scenario, compared to a lower increase of 500MW in a managed charging scenario. While estimates vary, similar studies also point to material network impact and associated cost under non-managed charging scenarios.

Overseas utilities that have introduced "time of use" rates have observed secondary demand peaks since EV users often schedule their vehicles to begin charging when off-peak rates begin, resulting in sharp load ramps. EV charging which occurs at times of peak demand will increase the need for 'peaking' generation. In New Zealand peaking generation is predominantly from gas and coal-fired power plants, which impacts both power price and carbon emissions.

Managed charging (also referred to as intelligent, adaptive, or smart charging) allows a utility or third-party to remotely control vehicle charging, much like traditional demand response programs. With managed charging, EV users can adapt their charging behaviour in response to market signals (e.g. network loading or price). This means that EV charging demand can become more elastic over time, which will moderate prices and reduce carbon emissions from peaking generation.

Charging equipment that supports managed charging is referred to as a 'smart charger'. In this paper, smart chargers are classified as EV chargers which have built in communication capability and are able to vary charging output based on external signals.

Three levels of charging management have been defined below

Managed charging for EVs is often described as charging which can be externally controlled to allow dynamic changes in the vehicle's charging profile based on factors such as grid conditions, utility incentives and EV owner needs. This is typically enabled by communication signals sent to the vehicle directly or to the charger that controls a charging event. It is also important to note that different EV charging levels offer different potential for managed charging. It is noted that some of the smart features may be built into the vehicle rather than charger than in the charger. Broadly, managed charging schemes have evolved in recent years as described below.

Features	Progressively greater levels of managed charging (1-3)		
	1. Manual charging management	**2. Actively managed with limited integration**	**3. Fully managed**
Overview	– Charging starts when plugged in or when the timer kicks in – Charging continues at rated speed	– (1)+ Dynamic variation in charging rate based on home level load, controlled by the charger	– (1)+ Fully integrated load control based on home and utility/ community level load
Type of charger	– Charging cables (typically supplied with all EVs) (up to 16 amps) – Lower priced wall mounted units (~3.3 -7.4kW)	– Wall mounted units, sometimes with optional peripherals	– Feature-rich wall-mounted units with external communication interfaces and optional peripherals
Communication interface	– LCD screen, LED lights only for cables – Limited charging statistics via phone app (e.g. through Wi-Fi) for some wall mounted units	– Same as (1) + Phone app / web interface – Wifi / Cellular / Ethernet / PLC Communications – Optional Cloud IT interface	– Same as (2)
Charging Protocol	– None	– Direct OCPP (or similar) – In many cases, access to standard protocols enabled via cloud or integrated device.	– Same as (2) – Communication with AMI meter via interface equipment
Charge management	– Some units allow manual switching between 2 types of charge	– Same as (1) + Charge management directly via online interface, automated scheduling, or algorithmic scheduling – Automated load management based on circuit loading	– Same as (2) – Third party control – Coordinated charging of EVs – Bi-directional flow e.g. battery - solar integration (Third party control, coordinated charging and bi-directional flow: **Medium / long term focus**)
Charging security	– RFID – Manual lock/key	– Phone app/ digital key – RFID – Manual lock/key	– Phone app/ digital key – RFID – Manual lock/key
Other new/optional features	– Auto restart after power surge – Temperature sensors – Integrated RCD – High IP ratings	– (1) typically standard – Car features integration	– Same as (2)

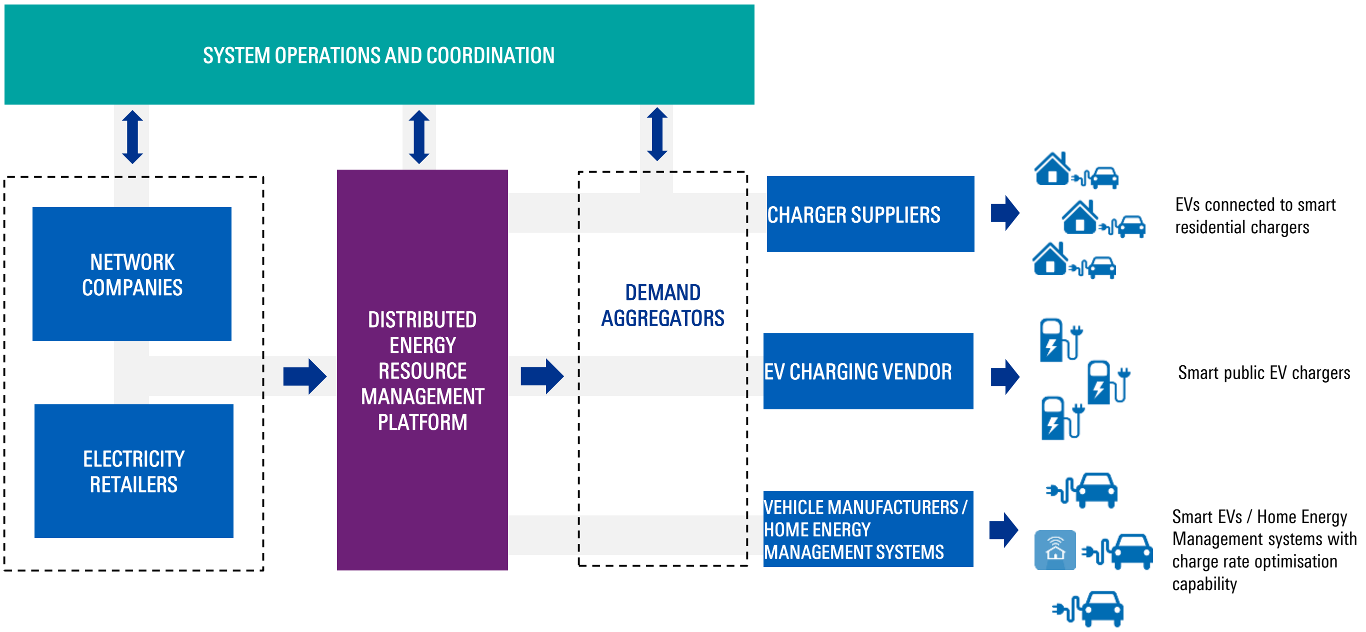
Manual charging management is currently the most common in New Zealand, as basic charging cables are supplied with the vehicle and overnight trickle charging is sufficient to charge most vehicles for 1-2 days of use.

Moving from option (1) to (2) is relatively simple e.g. by installing a smarter charger, but moving from (2) to (3) is more challenging and relies on broader market development as explained on the next page. Unidirectional managed charging (where utilities influence EV charging) is typically known as V1G and is likely to dominate the fully managed charging applications over the next 4-5 years. A V2G (bidirectional managed charging) system is one in which EV systems communicate with the power grid to manage the charging rate or return electricity to the grid.

Broader market development is needed to enable a fully managed charging system.

Fully managed charging is one of the multiple technologies that can support a more reliable and efficient electrical grid. However, it requires several key elements to be in place, as illustrated below.

Managed charging framework



Consumers **(Demand aggregation – EV Users)**	– Multiple chargers are available in New Zealand that allow third party control of EV charging. Many of these rely on proprietary software platforms operated by the charger developer. Other chargers have connectivity hardware, but need to connect to independent energy management systems for external control. Also many current EVs allow settings for charging rates and timers and in the future the capability for managed charging may be embedded in the vehicle rather than in the charger equipment. – Nevertheless, the majority of current EV owners use basic charging cables with no dynamic charge rate control capability. EV users may need to be incentivised to use more expensive controllable chargers and allow an external party to influence the charging of their vehicle. This could be achieved through offering subsidised chargers, tailored electricity tariffs or sharing load management revenues, depending on the market structure. – Demand aggregators may sign up multiple EV users and may require to facilitate external control systems to utilise the chargers they control.
Network companies	– To understand and control local loads in real time, network companies will need more granular information on network load status. For example, the communication functions of distribution transformers may need upgrading to enable access to real-time load and temperature data.
System operations	– To enable a commercially viable managed charging model, a Distributed Energy Resource Management (DERM) platform will be required to integrate various EVs and chargers under a common node for utilities to access. – Examples of these platforms include the Open Vehicle-Grid Integration Platform being developed by EPRI in the US or commercially available platforms such as the Mercury DERM platform.
Regulators	– An open market would need to allow multiple parties (network, retailer, demand aggregator) to access controllable EV chargers on an open, non-discriminatory basis. Regulators are expected to provide the regulatory settings for a managed charging program, particularly if (part of) the infrastructure is included in the regulatory asset base.

Standardised protocols are emerging for EV chargers to communicate with a central monitoring or control entity

EV charging infrastructure available today has been developed by private operators and manufacturers independently. Several chargers and charging networks use closed communication systems. The control of these chargers are through proprietary network servers and cloud-based systems.

The lack of commonly agreed communication standards can hinder the integration of charging stations into the energy infrastructure to leverage the latest grid-edge technologies. Interoperable and open networks would allow access and sharing of data to improve charging services and plan for infrastructure development.

Standardised protocols are emerging for EV chargers to communicate their status and activity with a central monitoring or control entity. Three of these are profiled below.

Open Charge Point Protocol (OCPP)

OCPP was developed to standardise the communications between an EV charge point and a separate control system, which may be used for operating and managing charge points. The communication protocol is open and free to use, in order to ensure the possibility to upgrade a charging network without necessarily replacing all the charging stations or incurring significant programming costs. The protocol is intended to exchange information related to charging transactions and for operating a charge point including maintenance.

Open Automated Demand Response standard (Open ADR)

The Open ADR protocol is aimed at automating demand response communication, which supports a system (or device) to change power consumption or production (if applicable) based on grid requirements. The communication protocol is open and free to use.

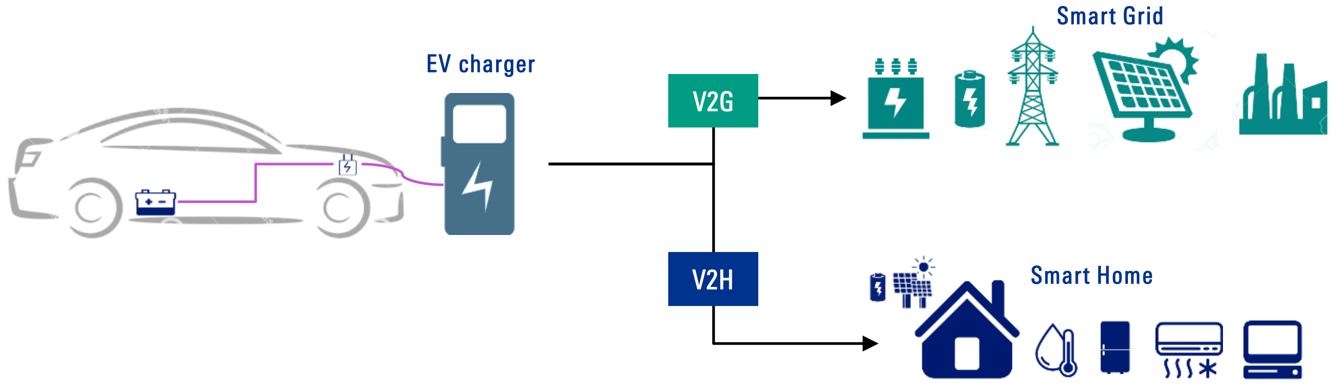
Open Smart Charging Protocol (OSCP)

The OSCP communicates the available capacity of the electricity grid to other systems. The protocol is based on a budgetary system where client systems can indicate their needs to a central system, which guards against overuse of the grid by handing out limited budgets to client systems. If a system requires more it can request more, if it requires less it can hand back part of its budget, to be available for other systems. The communication protocol is open and available for free.

These constitute the major protocols relevant for residential EV charging. However, there are additional protocols which are relevant for public charging facilities, for example OCPI (independent EV roaming protocol), OCHP (for exchanging authorisation data, charge transaction and charge point information data), eMIP (eMobility Interoperation Protocol for open access to vehicle charging stations), OICP (roaming protocol to communicate with Hubject B2B service platforms).

The use of EVs as distributed energy resources is expected to shape future charging technologies

Current EVs can store between 5-40 kWh of energy. This energy can be used not only to power the car but also other appliances, for example providing energy for homes (V2H) or supply ancillary services to distribution network (V2G).



Vehicle to home (V2H)	Vehicle to grid (V2G)
V2H is the integration of an electric vehicle into a 'smart energy' home. The electric vehicle battery stores energy and intelligently feeds it back to the home to power appliances Basic V2H technology is already in the marketplace. The Mitsubishi Outlander PHEV, Nissan Leaf (or other CHAdeMO based vehicles) can supply electrical power to a home and can act as an emergency power source, using electricity stored in the vehicle's battery to run appliances in a power outage, at an emergency evacuation site, or at outdoor events.	V2G is the integration of an electric vehicle into the public power grid. By integrating many electric vehicles, the overall stability of the grid can be increased. The vehicle owner would receive some form of compensation for these services. A key factor which will drive V2G technology in New Zealand is that it will improve the grid's capability to handle intermittent sources of renewable power (e.g. solar, wind), and make further investments in renewable sources of generation capacity more feasible.

Vehicles

As at any given time about 95% of cars are parked, the batteries in 'gridable' vehicles could be used to let electricity flow from the car to the electric distribution network and back. V2H/V2G can be used with vehicles, which include:

- A hybrid or fuel cell vehicle, which generate power from storable fuel, and can use its generator to produce power for a utility at peak electricity usage times. These include vehicles powered with conventional fuels, biofuels or hydrogen.
- A battery-powered or plug-in hybrid vehicle that can use its excess rechargeable battery capacity to provide power to the electric grid in response to peak load demands. They are typically then recharged during off peak hours.
- A solar-powered vehicle that can use its excess charging capacity to provide power to the electric grid when the battery is fully charged.

For example, Nissan in Japan operates a V2H system. It shifts vehicle charging to low demand times (demand management) and feeds power to the home in the event of a grid failure.

Key barriers to adoption

- While bidirectional V2G/V2H chargers are increasingly available globally (e.g. 10kW PRE power developers model[8]), at this stage they are significantly more expensive and would need to take into account direct solar charging benefits and a favourable regulatory environment to make the economics work.
- The two main DC EV charging systems (CHAdeMO and CCS) communicate with the vehicle in different ways. While this may not be a major concern in a V2H scenario, a standard communication system will be required for large scale V2G uptake.
- EV batteries have a limited number of charge/discharge cycles before they start to degrade. This could therefore impact the long term usable life of EV batteries, and potentially the warranties that EV makers are prepared to provide.

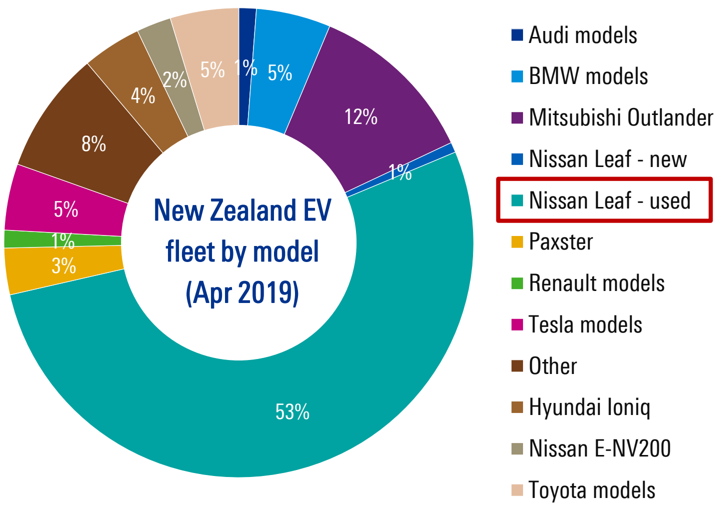
8. http://www.pr-electronics.nl/nl/nieuws/59/pre-power-developers-leader-in-v2g-charger-modules/

3

Residential EV charging in New Zealand today

A majority of the current EV fleet supports up to 3.7kW charging, which is achievable through the unused mains capacity of most New Zealand homes

13,659	10,216	3,309	134
EV fleet (Apr 2019)	Pure EVs Light	Plug in hybrids Light	Heavy EVs



Source: KPMG Analysis, MoT

Vehicle type	Model Year	Battery size (kWh)	Max AC charging rate (kW)	% of existing fleet
Nissan Leaf (Japanese Imports)	2011-12	24	3.6	56%
	2013	24	3.6	
	2014-15	24	3.6	
	2016	24	3.6	
	2016	30	3.6	
Nissan leaf (British Imports)	2011-15	24	6.6	
	2017	40	6.6	
Mitsubishi Outlander PHEV	2015-18	12	3.7	11%
	2019	13.8	3.7	
Hyundai Ioniq PHEV	2016-19	8.9	3.3	1%
Hyundai Ioniq BEV	2016-19	28	6.6	4%
BMW i3	2014-16	22	7.4	4%
	2017-18	33	11	
Nissan E-NV200	2014-18	24	3.3	3%
	2018	40	6.6	
Toyota Prius PHEVs	2012-16	4.4	2.2	4%
	2017	8.8	3.3	
Hyndai Kona	2018-19	64	7.2	2%
Tesla model S, X	2016-19	100	22	4%
	201-19	75	22	

Source: KPMG Analysis, MoT

The New Zealand EV fleet

The current EV fleet (at Apr 2019) includes c.14,000 BEVs and PHEVs.

- More than 85% of the fleet consist of five BEV models (Nissan Leaf, Nissan eNV-200 vans, BMW i3, Hyundai Ionic and Tesla), and two PHEVs (Mitsubishi Outlander, Toyota Prius)
- The share of used vehicles in EV sales has been growing steadily and reached 72% in 2018. This is mainly due to the high initial price of EVs compared to similar traditional cars, and the increased availability of more affordable used EVs from Japan. Sales in Japan continue to be led by the Nissan Leaf (57% in 2018), Prius (26%), Outlander PHEV (13%).
- Around 90% of used EVs are bought under $35,000 and most of these are used Nissan Leafs. These are mostly used as a secondary car. Users that purchase EVs as their primary vehicle are typically more inclined to opt for PHEVs such as the Mitsubishi Outlander.
- The more expensive end of the market (above $70,000) includes the Tesla model S and X, and premium PHEV SUVs. As the line up of new vehicles available in New Zealand is expanding, e.g. with the arrival of the Hyundai Kona, Ionic, Renault Zoe, sales at the premium end is expected to become more diverse.

Charging requirements

The majority (77%) of the current EV fleet supports up to 3.7 kW AC charging rate.

- Used Nissan Leafs from Japan (the mainstay of the fleet) have a maximum 3.6 kW charging capacity.
- PHEVs generally have a maximum AC charging capacity of 3.7kW given their limited battery sizes and to reduce costs.
- Only Tesla models are capable of 22kW AC charging, most other mainstream cars including new models only have a maximum charging rate of 6.6 to 7.2 kW on AC.
- Charging up to 3.7 kW rate can be achieved by a Mode 2 charging cable, which is typically supplied with vehicles at purchase. For average daily use, overnight trickle charge is expected to be sufficient if charged every 1-2 days. Current estimates indicate that most New Zealand homes would not require a wiring upgrade to accommodate this charging rate.
- EV owners who want to charge faster at home, and their car supports this, will need a higher rate charger which may also require changes to home wiring. Alternatively these EV users can periodically charge their EVs at public fast charging stations or before longer trips as the situation may require.

New Zealand EV owners can choose from 65 charger models and fully installed charger costs range from $1,000 to over $10,000

New Zealand EV users have a choice of about 65 charger models across a range of price points, manufacturers and features. Costs can range from about $500 to over $10,000 including installation. An overview of available products and costs is shown below.

13	65	27	26
Number of companies selling EV chargers in New Zealand	Charger models available for purchase in New Zealand	"Smart" Charger Models	Wall mounted Mode 3 chargers available

Overview of the New Zealand charger market

	Charging cables	3.7-7.4 kW wall mounted chargers	11 – 22 kW wall mounted chargers
Number of models available	– 12 base models with variations	– 31 base models with variations	– 22 base models with variations
New Zealand suppliers, distributors	– OEM Audio, Blue Cars, Chargesmart., Transnet	– Chargemaster, Chargenet, Echarge, Juicenet, Plugndrive New Zealand, Schider Electric, Blue cars, Transnet, YHI, Embrium, Evnex,	– Blue cars, Chargemaster, Chargenet, Echarge, Juicenet, Schider Electric, Transnet, YHI, OEM Audio, Embrium, EVnex
Key differences	– Pricing variations with cable length, on in-cable control features (delay, screen) and place of manufacture	– Aesthetics and design, built in RCD type, charge level, manual variation in charging limit, smart features and cable length	

EV charger pricing (NZD)

	Charging cables	3.7-7.4 kW wall mounted chargers	11 – 22 kW wall mounted chargers
Base product price*	475 – 1000	1,000 - 1,800	1,500 - 4,000
Additional price for installation and home wiring **	NA	+ 750 - 1,500	+ 1000 - 5,000
Total price of basic charger	475 – 1000	1,750 - 3,300	2,500 - 9,000
Additional price for communication and control features	NA	+ 500 – 1,000	+ 500 - 1,500
Total Price for a "smart charger"***	NA	2,250 - 4,300	3,000 - 10,500

* Excluding outliers ** Installation dependent *** Currently no subscription charges

Charger suppliers stated that some early adopters and EV enthusiasts have bought higher end chargers, but expect the trend to move towards commoditised, basic products in the absence of any requirement or incentive to purchase 'smarter' chargers.

The majority of EV chargers used in New Zealand are charging cables, which have low charging speeds and limited additional features

Discussions with charger suppliers and EV dealers indicated that the majority of EV buyers were satisfied with the basic charging cables (8 amp) supplied with their EVs. The type and cost of additional chargers purchased correlated with the purchase price of the vehicle. (Refer Appendix 1 for further details).

While one supplier (OEM Audio) has indicated sales of more than 9000 portable charging cables, other major respondents indicated sales of 800-1200 units each in New Zealand (YHI - 1,200 units, Schneider electric ~800 units, Juicepoint – 1,000 units including both cables and smart wall mounted chargers). Other manufacturers who responded have smaller sales or have recently started selling.

Suppliers also indicated that connectivity (for remote monitoring) was a key requirement for customers buying higher end chargers.

Sales mix by charger type and functionality, based on the manufacturers who responded

By charger type	%
EV charging cable (plug into home outlet)	78%
1-phase AC charger (Mode 3)	17%
3-phase AC charger (Mode 3)	5%
Total	**100%**

By charger functionality	%
Basic chargers only (no 'smarts') / or delay timer only	74%
With additional features but no connectivity	10%
With full internet connectivity	16%
Total	**100%**

Source: Responses to KPMG & EECA survey

As described earlier, smart chargers in this paper are defined as chargers which have built in communication capability, and are able to vary their EV charging output based on external signals. The connectivity hardware on smart chargers available in New Zealand include standalone Ethernet, Wi-Fi or 3G options, or a combination of these. Some smart chargers may not have charge management capabilities out of the box, but it can be enabled through firmware updates or third party software. The external connectivity to some smart chargers may be via their respective platforms/cloud systems rather than directly via the charger.

Key points from Worksafe's EV charging safety guidelines

- It is not permitted to install a socket-outlet with the intention to provide Mode 1 charging for an electric vehicle.
- The maximum current for Mode 2 charging is 32 A
- All AC charging stations should be Mode 3 and conform with IEC 61851-1:2017.
- RCDs should be Type B and comply with IEC 62423, have a residual operating current of not greater than 30 mA and operate to interrupt all live conductors, including the neutral (applicable for Mode 3 chargers).
- Socket-outlets installed for Mode 2 charging in domestic or similar installations should AS/NZS 3112 and have a rated current not exceeding 20 A (per phase).
- The supply lead for the connection of the EV should be in one piece.

All chargers available in New Zealand must be approved for sale by WorkSafe. Charger suppliers must provide a type testing certificate to WorkSafe in line with New Zealand guidelines for approval. A summary of chargers currently sold in New Zealand is included in Appendix 2 and 3. Interviews with market participants indicated that most EV chargers available in New Zealand comply with regulation, although there is anecdotal evidence of non–compliant equipment used, e.g. modified versions of imported chargers sold with used vehicles.

The requirement of a Type B RCD is not an international standard. The majority of the chargers currently available in New Zealand do not include an integrated RCD Type B device and therefore the installation for these chargers need to account for the additional costs of this equipment (typically $400-500).

Summary observations on current residential charging arrangements

New Zealand EV fleet includes ~14k vehicles, and 65% are imported vehicles from Japan.

More than 85% of the current EV fleet consist of five BEV models (Nissan Leaf, Nissan eNV-200 vans, BMW i3, Hyundai Ionic and Tesla), and two PHEVs (Mitsubishi Outlander, Toyota Prius). Around 90% of used EVs are bought under $35,000 and most of these are used Nissan Leafs. The share of used vehicles in EV sales has been growing steadily and reached 72% in 2018.

A significant majority of the current EV fleet has a maximum charging rate of 3.7kW.

The majority (77%) of the current EV fleet supports up to 3.7 kW AC charging rate. Used Nissan Leafs from Japan (the mainstay of the fleet) have a maximum 3.6 kW charging capacity. PHEVs generally have a maximum AC charging capacity of 3.7kW given their limited battery sizes to reduce costs. This load is typically within the unused mains capacity of most New Zealand homes.

Charging up to 3.7 kW rate is achieved by a Mode 2 charging cable supplied with vehicles at purchase. For average daily use, such trickle charging overnight is expected to be sufficient for 1-2 days' travel.

EV owners who want to charge faster than 3.7kW at home, and their car supports this, will need a higher rate charger which may also require changes to home wiring. Alternatively these EV users can periodically charge at public fast charging stations and before longer trips.

EV owners have a choice of over 65 charger options and fully installed charger costs range from $1,000 to over $10,000. The price difference between an otherwise similar smart and passive chargers is less than $1,500 even at the high end.

New Zealand EV owners have a choice of 65 residential chargers to purchase. Some early adopters and EV enthusiasts have bought higher-end chargers. Nevertheless the trend is to use simpler products in the absence of any requirement or incentive to purchase higher capacity, smart-chargers.

The price of chargers generally range from about $475 (for basic charging cables) to $5,000 (for fully featured wall chargers). The additional installation costs for wall chargers varies from about $750 to over $6,000 depending on location, distance from the switch board, any wiring upgrades required. The incremental cost of smart features is relatively low compared to the overall installed cost of the given charger. For example the price difference between the 22kW SE Evlink Wallbox EVH2S22P04K and the 22kW EVlink Smart Wallbox EVB1A22P4RI (smart) is $800.

Most new vehicles are supplied with their own manufacturers' charging cable and some manufacturers such as BMW and Mercedes offer their own wall chargers.

Key barriers to adopt smart chargers currently include their higher upfront cost and limited benefit for most EV users

'Smart' features are incorporated in wall-fitted chargers that also allow faster charging than basic charging cables. Although additional charging control features do not cost significantly more, a typical wall charger itself is relatively expensive compared to the purchase price of an average EV.

Currently, EV owners tend to use smart chargers as a monitoring tool (e.g. for power consumption and range estimation) rather than for charging management. Some users of EVs that allow faster charging, above 3.7kW, can benefit from smart chargers managing the electrical load at the home level. However the majority of EV users currently cannot take advantage of dynamic charging management, and have little incentive to upgrade their charger.

4

The outlook for residential EV charging in New Zealand

The New Zealand EV fleet is projected to grow to 60k-135k vehicles by 2023

Future EV charging requirements and their impact on electricity networks is linked to the future size and composition of the EV fleet, and the charging behaviours of EV owners. The following approach was used to estimate the size and future composition of the EV fleet.

A. Estimate the size of the EV fleet over the next 5 years (under three growth rate scenarios) → B Estimate new vehicle registrations by price band (using historical price evidence) → C. Estimate new EV registrations and charging requirements by price band

A. Estimate the size of the EV fleet over the next 5 years

Purchase price parity with traditional vehicles is considered a key driver for EV adoption. With (near) purchase price parity, it is assumed that EVs can reach a material share of new sales (30%-40% as in Norway). This could be achieved by lower EV prices or government incentives. Independent studies have indicated overall price parity to be achieved between 2022-2030 (Bloomberg, Morgan Stanley) considering initial purchase costs and operating costs, including government incentives. Bloomberg is expecting EVs to account for 54% of global sales by 2040.

In its November 2017 projection, MoT estimated that EVs will make up 40% of the New Zealand fleet by 2040. Transpower, in its Energy Futures report, estimates EVs to reach 40% market share of sales by 2030 and 85 percent by 2050, which is broadly in line with MoT's projections.

Projected size of the EV light vehicle fleet

Year	Price Parity by 2035 (Low)	Price Parity by 2030 (Medium)	Price Parity by 2025 (High)
2021	35,668	40,929	62,494
2023	60,096	77,913	135,821
2025	112,699	165,444	310,883
2030	418,236	631,344	1,027,254

Source: KPMG analysis

Our projections assume EVs achieving purchase price parity, and 33% market share of light vehicle sales, by 2025 (High), 2030 (Medium) and 2035 (Low) respectively.

These projections assume no significant disruption in supply. Japan is New Zealand's main source of imports. It has about 200,000 EVs in use and sales have fluctuated in the past. New Zealand is no longer a key destination for used Japanese vehicles, therefore imports could be impacted by competition, foreign exchange changes and production constraints.

B. Estimate new vehicle registrations by price band

861,000 light vehicles were added to the fleet between Jan 2016 – Jun 2019, across 138 makes and 1,633 models. About 60% of these additions have been imported, used vehicles. The allocation of vehicles to their respective price bands was based on the vehicle's price when new, and price depreciation by their age.

In line with historical trends, 70% of additions are expected to be vehicles costing less than $36k

Price categorisation of light vehicle fleet (Jan 2016 – Jun 2019)		
Base	70.3%	Price <$36k
Mid - Low	12.6%	$36k- 46k
Mid	11.4%	$46k-70k
High	5.1%	$70k-150k
Ultra high	0.1%	Price > 150k
Classic / Enthusiast	0.5%	Not priced for the analysis

Source: KPMG analysis, MoT

Over 80% of additions have been at a price point below that of the cheapest new EV currently available in New Zealand.

The annual share of used EVs added to the fleet increased to 72% in 2018 (from 42% in 2015). More than 95% of these imported vehicles were priced under $36k, i.e. a similar proportion of EVs additions fall in the base price band as traditional vehicle additions. For future EV additions, it is assumed that this mix by price band will be maintained.

C. Estimate new EV registrations and charging requirements by price band

Based on the above analysis, 70% of EV additions in the next 5 years are assumed to be in the Base price band (<$36k). This category is expected to include imported vehicles from Japan. EV sales in Japan continue to be led by Nissan Leaf (57% in 2018), Prius (26%), Outlander PHEV (13%) and New Zealand imports tend to mirror the delayed sales trends in Japan. The potential for imports from other right hand drive countries like the UK require favourable price and currency conversion, which is currently not the case. New EVs are expected to continue at c.30% of overall EV sales in the next 5 years. These are assumed to be led by the EV/PHEV versions of popular traditional models like the Mitsubishi Outlander, Hyundai Ionic, Hyundai Kona/Kia Niro models, and new Nissan Leaf models.

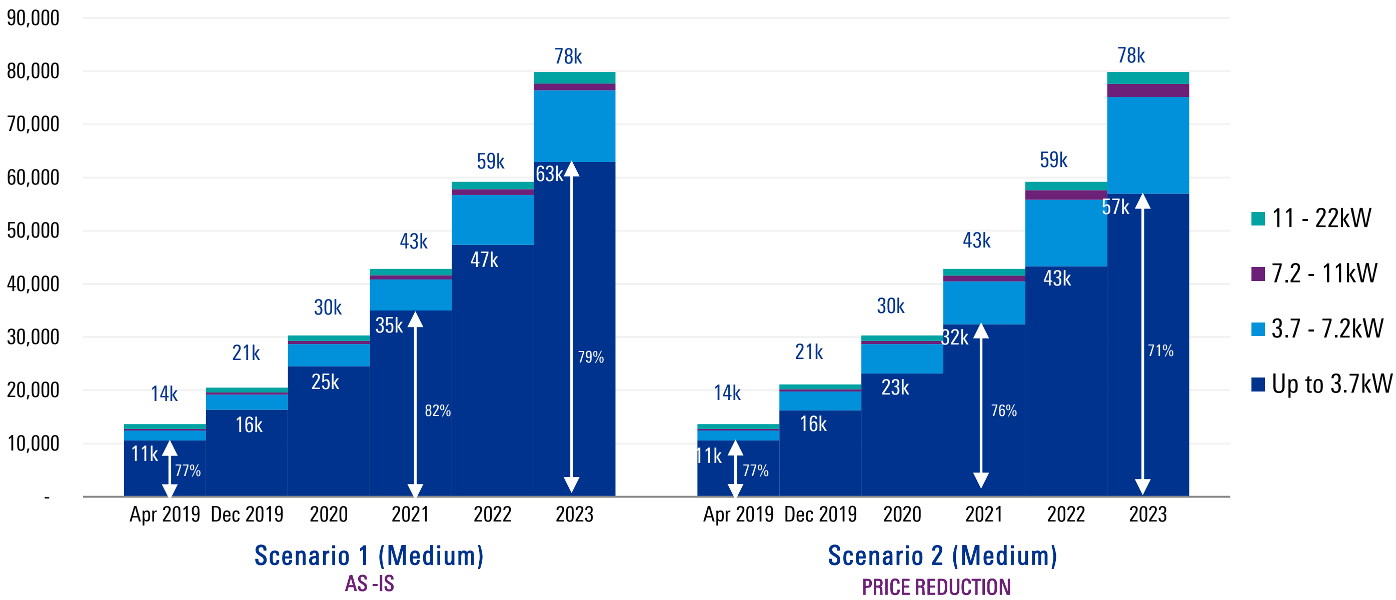
The pricing and market share assumptions for various EV models in 2019-2023 are provided in Appendices 4 and 5. Most vehicles in the Base and Mid-Low price bands have low peak AC charging rates. Vehicles that allow higher rate charging fall in higher price, lower volume bands.

Under the Medium EV fleet projection set out earlier, two further scenarios were considered to assess the impact of upcoming EV models and demand trends on the composition and charging requirements of the EV fleet.

Scenario 1 (As is)	Scenario 2 (Price reduction)
EV demand and supply by price band remains broadly unchanged until 2023.	Supply and demand shifts faster towards EVs with bigger batteries and faster chargers.
Key vehicles such as the 30kWh Nissan Leafs and 2016 Mitsubishi Outlanders enter the Base price band by 2020.	EVs below the High price category (such as Hyundai, Nissan, Renault and entry level BMW and Audi models etc) move down a price band.
40kWh Nissan Leafs, Hyundai Ionic are available in the Mid – Low price segments by 2022.	40kWh Nissan Leafs, Hyundai Ionic are available in the Base price segments by 2022.
Key models in the High price band are the Tesla Model 3, Hyundai Kona, (2019 onwards) and the 62 kWh Nissan Leaf (2021 onwards)	Key models in the Mid category are the Tesla Model 3, Hyundai Kona, (2019 onwards) and the 62 kWh Nissan Leaf (2021 onwards).

Projections indicate that 70%-80% of the New Zealand EV fleet will have a peak AC charging rate of no more than 3.7kW until 2023

For the purposes this analysis, the "Medium" EV uptake projection (with 78,000 EVs in 2023) has been considered further. Based on the assumptions set out previously, the chart below shows the evolution of the EV fleet by charging requirement. Overall, about 70%-80% of EVs are expected to allow only up to 3.7kW charging until 2023.



Source: KPMG Analysis

EVs currently being introduced into New Zealand typically have bigger batteries and have faster charging capabilities compared to the existing fleet. However, given the higher price of these vehicles, their share of new registrations are expected to remain low throughout the projection period.

Accordingly, about 70%-80% of the EV fleet in 2019 - 2023 will consist of vehicles with a peak AC charging rate up to 3.7kW. This includes a mix of older BEVs, and PHEVs that tend to have smaller batteries due to size and cost constraints. At that charging rate,

EV owners are less likely to face charging constraints due to existing home wiring and appliance loading or due to distribution network constraints. However 15,000 – 21,000 EVs will have the ability to charge above 3.7kW by 2023, which may cause electricity network load balancing issues in typical New Zealand homes and require network upgrades or a controllable charger. This number is forecast to increase to 66,000 in 2025 and 378,000 in 2030 (assuming EVs with faster chargers represent 40% and 60% of the EV fleet in those periods respectively).

Mainstream BEVs like the Nissan Leaf and Hyundai Kona have upgraded to charging speeds of 6.6kW and 11kW for their high end models. Most BEV models by premium vehicle makers are expected to be in the range of 11-22kW charging rates within the projection period, but are expected to remain a relatively small part of the fleet.

We expect that the demand from EV charging on the electricity system will increase beyond 2023, led by higher EV numbers, larger batteries and faster charging requirements. However there is time until then to prepare in order to mitigate the potential network impact and optimise the required investment.

New Zealand EV owners already have a wide choice of chargers and new models are expected to be introduced as the EV market develops.

While most New Zealand customers are currently satisfied with using basic the charging cables, discussions with EV suppliers indicated that some of their customers are looking for faster charging and connectivity options. Suppliers indicated that the key feature that customers prioritised while considering upgraded EVSEs was connectivity but mainly for remote energy monitoring. It is however expected that market development for managed charging (both in NZ and overseas) will impact the customer demand for new charger feature sets. It is noted that some of the new features may be available in the EVs themselves rather than in the chargers.

New Zealand EV owners currently have a choice of more than 65 types of chargers. If the demand for chargers increases, additional manufacturers may start supplying chargers in New Zealand.

Chargers available in selected geographies including Australia, UK, USA, some European countries, China and Japan were assessed at a high level to understand potential suppliers and technologies that may be relevant to the New Zealand market in the next 3-4 years. A list of popular overseas charger brands is provided in Appendix 7

Type	Commentary
Charging cables	The market for charging cables appears to be dominated by one supplier in New Zealand (~90% of sales). Most current products are manufactured in China, one product is manufactured in Europe. Charging cables features are similar across brands in the countries surveyed and are broadly in a similar price bracket. The key differences between the more expensive cables and the cheaper ones include aesthetics, place of manufacture minor differences in IP (Ingress Protection) rating.
Wall chargers	A wide range of products are available in New Zealand. At lower price points, models available in New Zealand tend to be the same as in Australia and UK (e.g. EO, Zappi, Halo, Rolec). Popular smart chargers available in leading EV countries such as Juicebox, Evbox, Halo, Keba, Delta, are also available in New Zealand. Some smart chargers such as Aeroviroment, Tritium, Garo, Clippercreek are currently not sold here. Some of these are available in Australia and may be introduced in New Zealand as the EV market develops. Home grown brands e.g. by Embrium and Evnex are also available and have competitive feature sets. The main future advances in smart charging are expected to include i) Software - integration with home automation systems, personal assistants and over-the-air updates, ii) Innovation in hardware design – e.g. split chargers for better load management (home and network) and iii) Automation in charging.
Future technology	Currently there are no wireless EV charging or V2G suppliers in New Zealand. The number of vehicle models that support wireless car charging is very limited. BMW has recently released one model and a compatible wireless charger. This technology may increase in popularity with improved pricing and manufacturer support. Some V2G chargers such as (Nissan, PREpower, WitriCiti) are available in other countries. The supply of V2G chargers in New Zealand will depend on accommodating regulation and increased EV uptake.

Summary observations on future residential charging

The New Zealand EV fleet is expected to reach 60,000-136,0000 vehicles by 2023

Price parity with traditional vehicles is considered a key driver for EV adoption. With (near) price parity, it is assumed that EVs can reach a material share of new sales (30%-50%, as in Norway).

A Medium scenario of 78,000 EVs in 2023 assumes price gap between electric vehicles and comparable traditional models to narrow between 2025 and 2030, and EVs market share of light vehicle sales to reach from 33% by 2030.

70%-80% of the EV fleet in 2019-2023 is expected to have a maximum charging rate of 3.7kW

EVs currently being introduced into New Zealand typically have bigger batteries and have faster charging capabilities. However, given the higher price of these vehicles, their share of new registrations are expected to remain low in the projection period.

Accordingly, about 70%-80% of the EV fleet will be vehicles with a peak AC charging rate of up to 3.7kW. This includes a mix of older, used BEVs and PHEVs, which have smaller batteries due to size and cost constraints. At that charging rate the owners of these vehicles are less likely to face charging constraints due to existing home wiring and appliance load.

The number of EVs allowing faster charging (above 3.7kW) is forecast to be relatively low in 2023 and accelerate thereafter

15k - 21k EVs are forecast to have the ability to charge above 3.7kW in 2023. This number is expected to increase to 66,000 and 378,00 by 2025 and 2030 respectively. Charging at this faster rate may cause load balancing issues in a typical New Zealand home and require wiring upgrade or a controllable charger.

EV owners have a wide choice of chargers in New Zealand and additional charger options are available overseas

EV owners can currently chose from about 65 residential charger models to purchase in New Zealand. Additional options are available overseas (e.g. in the US and Europe) which may be introduced in New Zealand as the market develops.

Many of the currently available charger models are wall-mounted, smart-chargers that support faster EV charging and have control features to manage the timing and the electrical load. Ultimately these chargers could form the basis of a fully managed charging ecosystem where owners and third parties can influence vehicle charging. A key barrier to adoption is price as faster, more feature rich chargers can cost $5,000-10,000 to buy and install.

Government policy and regulation, the evolving electricity market structure, and car industry innovation will be key drivers of the future EV charging market in New Zealand

A range of factors will impact the longer term roadmap for EV charging in New Zealand. These will influence, for example, charging locations and speeds, the standards and protocols adopted, and how managed charging is implemented in New Zealand.

Overseas governments are taking an increasing role in promoting EVs and charging infrastructure. For example the UK government is consulting on requirements related to residential charging points, cybersecurity and smart charging. Such overseas government interventions will impact the types of chargers available in New Zealand.

Local demand aggregation services may develop in response to the proliferation of controllable energy resources (such as EVs). Regulation may also impact the electricity market structure and product design, e.g. through pricing rules. Finally, global car makers will continue to innovate vehicle and charging designs. Overall, the longer term future of EV charging is hard to predict and will be shaped by global innovation, as much as local policy and regulation.

5

Appendices

Overview of survey results (1/2)

Question	Summary of responses received
What are the main reasons for sourcing/developing the products you have included in your line up (e.g. features, price points, manufacturers, EV compatibility – please specify)?	Most charger suppliers indicated that New Zealand compatibility, safety and product quality were the key reasons for choosing to supply products. A key feature highlighted by distributors (of overseas products) or suppliers (with overseas contract manufacturers) was the ability of the overseas companies to ramp up production or adapt to market changes.
Approximately how many EV chargers have you sold so far, and over what period?	The market appears to be dominated by one manufacturer (OEM Audio) that has indicated sales of more than 9000 portable charging cables. YHI has sold more than 1200 units, Schneider electric has sold ~800 units in New Zealand. Juicepoint has sold more than 1000 units, which included charging cables but lately has been selling only smart, wall mounted chargers. Other manufacturers who responded have smaller sales or have recently started selling.
Please provide an approximate breakdown of the type of chargers you have sold?	Sales mix by charger type and functionality, based on the manufacturers who responded:

By charger type	%
EV charging cable (plug into home outlet)	78%
1-phase AC charger (Mode 3)	17%
3-phase AC charger (Mode 3)	5%
Total	**100%**

By charger functionality	%
Basic chargers only (no "smarts")	72%
With delay / timer mode only	2%
With additional features but no connectivity	10%
With full internet connectivity	16%
Total	**100%**

Many EVs have built-in timer functionality and do not need this charger feature

Question	Summary of responses received
What are the key features your customers are looking for in EV chargers? Please rank by importance	The responses for these depended on the charger supplier. For instance, load balancing capability was high on the list of customer requirements for companies like Schneider, Embrium. while YHI that have a solar business had customers interested in solar compatibility. Embrium has also introduced a "split charger" where a part (the "smart" part) of the charger is installed at the switch board, while the charging part is installed in the garage/charging location. Overall connectivity (enabling remote monitoring) was a key requirement for customers of a number of suppliers that responded. For wall chargers, the priority ranked feature was as follows. 1. Connectivity 2. Timer / delay to optimise tariffs 3. Installation size and pricing 4. Energy monitoring 5. IP rating 6. Load balancing 7. Solar integration

Overview of survey results (2/2)

Question	Summary of responses received
In anticipation of demand, what are your relative stock levels for EV charging cables, 1-phase chargers and 3-phase chargers?	Most suppliers indicated that they have stocks to meet 3 months to 1 year of anticipated demand. Discussions also indicated that their contract manufacturers or original equipment manufacturers are able to supply significantly larger quantities if required.
Do you work with or recommend installers to your customers	Most suppliers stated that they do not recommend installers to their customers as many installers are currently not aware / experienced with the updated guidelines. Some companies have been developing a network of electricians but going forward may not need to recommend installers as installation of chargers becomes commonplace.
In your experience what is the approximate installation cost for the customers (above the price of a charger)?	Most respondents indicated that the cost of installation depends on the location. The variables include the distance from the switch board, wiring complexity, structural aspects and upgrades to other parts of the household network.

Charger type	Typical Cost per install (NZD)*
EV charging cable (plug into home outlet)	Typically nil, since socket already available
1 phase AC charger (Mode 2/3)	750 - 1500
3 phase AC charger (Mode 2)	1000 – 5000

* Could be higher if more work is required

Question	Summary of responses received
What are the key challenges for suppliers sourcing, developing, selling EV chargers for home use in New Zealand (e.g. regulation, parallel imports – please specify)?	The key challenges cited were – New Zealand requirements in some areas exceed the requirements of other countries. Following international guidelines may make chargers cheaper and more readily available from overseas. – Small customer base, with low or no incentives for customers to buy smart chargers. Government incentives for EVs sales would help to grow the market. – Customer concerns over battery degradation/replacement. Current EV lifespan is considered lower than traditional vehicles. – Customer concerns over long term electricity supply and costs – Lack of full fledged trials by distribution companies, Transpower for managed charging – (though relatively small concern) Lack of oversight of EV charger parallel imports or use of Japanese OEM units with adapted, changed plugs.
What type of chargers (in terms of output, features, standards, and price) do you expect customers will be most interested in going forward?	Most EV suppliers believe that connected wall mounted EV chargers will become more popular as the market evolves. At this stage, connectivity with EV owners through a phone app is more of an important requirement than connectivity with external parties. As users start using EVs with larger batteries, 7.4kW units are expected to be more popular as it balances installation costs and charging speeds
List of parties who responded	OEM Audio, Juicepoint, Blue Cars, Rolec, Chargesmart, Schneider Electric, YHI, Embrium

Appendix 2

Smart charger platforms for chargers available in New Zealand

Charger Brand	Number of Models	Platform
Keba E, B, X, Solar series	5	KeContact
Juicebox	3	Juicenet
Halo Wallbox	5	Chargeamps cloud
Inch Home	1	Etrel Ocean
Delta Mini	1	Delta Cloud
EVLInk (Schnider)	2	NA
Amtron	1	Menkkes
Embrium	2	Good measure
EV Box Elvi Series	4	EVBOX
EVnex	1	CP Link

– Some chargers such as Keba, Schnieder can only support Ethernet connectivity. Others do not have their own back-end software and would need to be integrated to a common platform such as a home energy management system to enable user or third-party control.

– OCPP, Open ADR protocols may not be embedded into charger device but supported through the respective manufacturer's cloud software platform. These charger manufacturers could play a role as demand aggregators in a managed charging market.

Appendix 3

New Zealand Charger database (further information in excel sheet) (1/3)

Model name	Charging level	Ampere rating	Application type	Network communication interfaces				Smart Filter	NZ Supplier / distributor	Price
	kW	Charger rating (A)		Wifi	Cellular (GSM only)	Ethernet	Other			Cost + cable (NZD)
	Max output	Charger rating	Socket - outlet / AC Supply wiring	Y / N	Y / N	Y / N				
EV Power 8A Typ 1	2.2	8	Plug type	N	N	N	N		OEM Audio, Chargesmart	599
EV Power 8A Typ 2	2.2	8	Plug type	N	N	N	N		OEM Audio, Chargesmart	599
EV Power 8A Typ 1	3.7	16	Plug type	N	N	N	N		OEM Audio	699
EV Power 8A Typ 2	3.7	16	Plug type	N	N	N	N		OEM Audio	699
EV Wallbox 32	3.6 / 7.2	16 / 32	AC supply wiring	N	N	N	N		OEM Audio	1,549
Evbox Elvi 3.7 kW	3.7	16	AC supply wiring	Y	N	N	BT, GPS	Y	Chargemaster , Chargesmart	1,699
Evbox Elvi 7.4 kW	7.4	32	AC supply wiring	Y	N	N	BT, GPS	Y	Chargemaster , Chargesmart	1,799
Evbox Elvi 11 kW	11	32	AC supply wiring	Y	N	N	BT, GPS	Y	Chargemaster , Chargesmart	1,999
Evbox Elvi 22 kW	11	32	AC supply wiring	Y	N	N	BT, GPS	Y	Chargemaster , Chargesmart	2,199
Keba E-series EV charging station 4.6 kW Wallbox	4.6	`10 / 20	AC supply wiring	N	N	Y	USB (mainly for updates)		Chargemaster , Chargesmart	2,649
Keba B-series EV charging station 11 kW Wallbox	11	`10 / 32	AC supply wiring	N	N	Y	Optional Greenphy		Chargemaster , Chargesmart	2,999
Keba B-series EV charging station 22 kW Wallbox	22	32	AC supply wiring	N	N	Y	Optional Greenphy		Chargemaster , Chargesmart	3,749
Keba Smart solar 22 kW Wallbox	22	32	AC supply wiring	N	N	Y	Optional Greenphy, Modbus	Y	Chargemaster , Chargesmart	4,049
Keba X-series EV charging station 22 kW Wallbox	22	32	AC supply wiring		Y (Optional)	Y		Y	Chargemaster , Chargesmart	4,949
EO Basic charger	22	32	AC supply wiring	N	N	N			Chargemaster , Chargesmart	1,749
EO mini	7.4	32	AC supply wiring	N	N	N			Chargemaster , Chargesmart	1,349
Juicebox 32 typ 2	22	32	AC supply wiring	Y	N	N		Y	Juicepoint NZ	2,065
Juicebox 40 T1	7.4	32	AC supply wiring	Y	N	N		Y	Juicepoint NZ	1,461
Juicebox 40 T2	7.4	32	AC supply wiring	Y	N	N		Y	Juicepoint NZ	1,406
RAY EV Charging cable type 1	1.8	16	Plug type	N	N	N	NA		BlueCars	995
RAY EV Charging cable type 2	3.7	16	Plug type	N	N	N	NA		BlueCars	995
Type 1 EV Charger 16 Amp hardwired 5M with delayed start function	3.7	16	Plug type	N	N	N	NA		BlueCars	599

New Zealand Charger database (further information in excel sheet) (2/3)

Model name	Charging level	Ampere rating	Application type	Network communication interfaces				Smart Filter	NZ Supplier / distributor	Price
	kW	Charger rating (A)		Wifi	Cellular (GSM only)	Ethernet	Other			Cost + cable (NZD)
Type 1 EV Charger 8 Amp 10M with delayed start function	1.8	8	Plug type	N	N	N	NA		BlueCars	699
Type 1 EV Charger with 6-8 Amp current	1.8	`6-8	Plug type	N	N	N	NA		BlueCars	599
Type 2 EV Charger 8 Amp 5M with delayed start function	1.8	8	Plug type	N	N	N	NA		BlueCars	599
Halo Wallbox Type 1- 16A	3.68	16	AC supply wiring	Y	N			Y	BlueCars	1,295
Halo Wallbox Type 2- 16A	3.68	16	AC supply wiring	Y				Y	BlueCars	1,295
Halo Wallbox Type 1- 32A	7.36	32	AC supply wiring	Y				Y	BlueCars	1,395
Halo Wallbox Type 2- 32A	7.36	32	AC supply wiring	Y				Y	BlueCars	1,395
Halo Wallbox Type 2- 16A 3p	11	32	AC supply wiring	Y				Y	BlueCars	1,495
Inch Home touchscreen interactive charge station	22	32	AC supply wiring	Y		Y		Y	Ecogeek Co	3,339
Delta AC Mini Electric Vehicle Charge Point	7.4	32	AC supply wiring						YHI , Ecogeek Co	1,749
Delta Mini AC Electric Vehicle Charge Point - wifi	7.4	32	AC supply wiring	Y		Y (Optional)		Y	YHI , Ecogeek Co	2,913
Delta Mini AC Electric Vehicle Charge Point - Networked 3G (Plus)	7.4	32	AC supply wiring		Y	Y (Optional)		Y	YHI , Ecogeek Co	2,914
Evlink Wallbox EVH2S11P04K	11	16	AC supply wiring	N	N	N			Schneider Electric	1,950
Evlink Wallbox EVH2S22P04K	22	32	AC supply wiring	N	N	N			Schneider Electric	2,250
Evlink Wallbox EVH2S3P02K	3.7	16	AC supply wiring	N	N	N			Schneider Electric	1,450
Evlink Wallbox EVH2S11P04K	7.4	32	AC supply wiring	N	N	N			Schneider Electric	1,650
EVlink Smart Wallbox EVB1A22P4EKI	22	~10/32	AC supply wiring			Y	Modbus	Y	Schneider Electric	2,850
EVlink Smart Wallbox EVB1A22P4RI	22	32	AC supply wiring			Y	Modbus	Y	Schneider Electric	3,050
Rolec EV Wallpod 3.6	3.6	16	AC supply wiring	N	N	N	N		YHI	1,650
Rolec EV Wallpod 7.2	7.2	32	AC supply wiring	N	N	N	N		YHI , plugndrive NZ	1,850
Rolec EV Wallpod 22	22	32	AC supply wiring	N	N	N	N		YHI	2,350
Amtron Start E 3,7 C1	3.7	16	AC supply wiring	N	N	N	N		Echarge	1,950

New Zealand Charger database (further information in excel sheet) (2/3)

Model name	Charging level	Ampere rating	Application type	Network communication interfaces				Smart Filter	NZ Supplier / distributor	Price
	kW	Charger rating (A)		Wifi	Cellular (GSM only)	Ethernet	Other			Cost + cable (NZD)
Amtron Start E 3,7 C2	3.7	16	AC supply wiring	N	N	N	N		Echarge	1,950
Amtron Start E 11 T2	11	16	AC supply wiring	N	N	N	N		Echarge	2,150
Amtron Standard E 11/22 T2	~11 / 22	16/32	AC supply wiring	N	N	N	N		Echarge	2,550
Amtron Premium E 22 C2	22	32	AC supply wiring	Y	N	Y	N	Y	Echarge	2,950
Amtron E 11/22	~11 / 22	16/32	AC supply wiring	Y	N	Y	N	Y	Echarge	2,550
Goodmeasure EV0100 7	7.4	32	AC supply wiring	Y	N	Y (Optional)		Y	Embrium	1,550
GoodMeasure EV0201 Split System	7.4	32	AC supply wiring	Y	N	N		Y	Embrium	1,850
Transnet e-mbility t2	2.2	8	Plug type	N	N	N	N		Transnet	748
Transnet e-mbility t1	2.2	8	Plug type	N	N	N	N		Transnet	489
Circontrol e-home charger EVC-EHOME-16T1	3.7	16	AC supply wiring				PLC		Transnet	1,328
Circontrol e-home charger EVC-EHOME-32T1	7.4	32	AC supply wiring				PLC		Transnet	1,495
Circontrol e-home charger EVC-EHOME-16T2	3.7	16	AC supply wiring				PLC		Transnet	1,328
Circontrol e-home charger EVC-EHOME-32T2	7.4	32	AC supply wiring				PLC		Transnet	1,495
Wallbox Pulsar T1	7.4	32	AC supply wiring	N	N	N	Bluetooth		Transnet	1,950
Wallbox Pulsar T2	7.4	32	AC supply wiring	N	N	N	Bluetooth		Transnet	1,950
Zappi T1	7.4	32	AC supply wiring	N	N	N			Plugndrive NZ	1,200
Zappi T2	7.4	32	AC supply wiring	N	N	N			Plugndrive NZ	1,200
EVnex R Series Intelligenct charging station 7	7	32	AC supply wiring	N	Y	Y	Bluetooth	Y	Evnex	1,380
EVnex R Series Intelligenct charging station 7, Type 2 lead or Type 2 lead	7	32	AC supply wiring	N	Y	Y	Bluetooth	Y	Evnex	1,380
EVnex R Series Intelligenct charging station 22	22	32	AC supply wiring	N	Y	Y	Bluetooth	Y	Evnex	1,840
EVnex R Series Intelligenct charging station 22 Type 2 Lead	22	32	AC supply wiring	N	Y	Y	Bluetooth	Y	Evnex	1,840

Note:
Prices and data as provided in the responses to the questionnaire or as available on respective websites. Please note that the prices are subject to change and some have changed during the duration of the research. Prices are quoted inclusive of charger and charging lead (i.e. price of charging lead added in cases where the charger does not come with the cable).

Appendix 4

Current and upcoming electric vehicles and charging requirements (1/3)

Used vehicles

Vehicle type	Model Year	Price Range (NZD)	Battery size (kWh)	Max AC charging rate (kW)	Expected share in NZ EV additions
Nissan Leaf (Imports)	2013	9,000 – 25,000	24	3.6	High
	2014-15		24	3.6	High
	2016		24	3.6	High
	2016	30,000 – 40,000	30	3.6	Medium – High
	2018	60,000 - 80,000	40	6.6	Low
Mitsubishi Outlander PHEV	2015-18	25,000 – 35,000	12	3.7	High
Mitsubishi i-MiEV	2011-2016	8,000 – 15,000	16	4.8	Low
Mitsubishi Minicab MiEV	2011-2015	13,000 - 20,000	16	4.8	Low
Nissan Note e-Power PHEV	2013-2015	20,000 – 28,000	1.5	3.7	Low
Nissan E-NV200	2012-16	11,000 – 40,000	24	3.3	Medium – High
Toyota Prius Prime PHEV	2012-16	15,000 – 22,000	4.4	2.2	Medium – High
	2017	25,000 – 35,000	8.8	3.3	Medium – High
Tesla Model S	2012 -2018	90,000 +	60-100	22	Low

Current and upcoming electric vehicles and charging requirements (2/3)

New vehicles available in New Zealand

Vehicle type	Model Year	Price Range (NZD)	Battery size (kWh)	Max AC charging rate (kW)	Expected share in NZ EV additions
Nissan Leaf	2018	60,000 - 80,000	40	6.6	Medium
Nissan E-NV200	2018	62,000+	40	6.6	Medium
Hyundai Ioniq PHEV	2018	54,000+	8.9	3.3	Medium
Hyundai Ioniq BEV	2018	60,000+	28	6.6	Medium
Hyndai Kona / Kia Niro	2018	68,000+ (Kia), 75,000 (Hyndai)	40 - 64	7.2	Medium
Renault Kangoo Z.E.	2017	75,000+			Medium - Low
Toyota Prius Prime	2017	49,000+	8.8	3.3	Medium – High
Tesla Model 3	2019	75,000+	50	7.4	Medium - Low
	2019	90,000+	75	11	Low
Mitsubishi Outlander PHEV	2019	51,000+	13.8	3.7	High
Renault Zoe	2018	69,000 +	41	22	Low
LDV EV 80 (Cab, van)	2017	65,000+	56	7	Medium
BMW i3, i3s	2017	73,000+	30	11	Medium - Low
Tesla Model S	2018	135,000+	60-100	22	Low
Tesla Model X	2018	143,000+	75 -100	22	Low
Jaguar i-Pace (SE)	2019	154,000+	90	7.2	Low
Audi e-tron 55	2019	149,000+	84	22	Low
Hyndai Kona / Kia Niro PHEV	2018	54,000+	8.9	3.7	Medium
Mini Countryman Cooper S E PHEV	2018	60,000+	7.6	3.7	Medium - Low
BMW 225xe PHEV	2019	70,000+	7	3.7	Low
Audi A3 e-tron PHEV	2018	70,000+	8.8	3.7	Low
Volvo XC60 T8 R-Design PHEV	2019	118,000+	9.2	3.7	Low
Volvo S90 T8 R-Design PHEV	2019	126,000+	10.4	3.7	Low
BMW 530e PHEV	2018	138,000+	9.2	3.7	Low
Volvo XC90 T8 PHEV	2018	139,000+	10.4	3.7	Low
Mercedes-Benz E 350e PHEV	2019	145,000+	6.2	3.7	Low
Mercedes-Benz GLE 500e PHEV	2019	155,000+	8.4	3.7	Low
Porsche Cayenne S E-Hybrid PHEV	2018	173,000+	14.1	3.7	Low
Range Rover Sport HSE Dynamic P400e PHEV	2018	174,000+	12.4	3.7	Low
BMW 745e	2018	188,000+	12	3.7	Low
Range Rover Vogue SE P400em PHEV	2018	225,000+	13.1	3.7	Low
Porsche Panamera 4 PHEV	2018	234,000+	14.1	3.7	Low
BMW i8	2018	287,000+	7.1	3.7	Low

Appendix 4

Current and upcoming electric vehicles and charging requirements (3/3)

Vehicles announced (Overseas and in New Zealand)

Vehicle type	Model Year	Price Range (NZD)	Battery size (kWh)	Max AC charging rate (kW)	Expected share in NZ EV additions
Porche Taycan	2019	200,000+	90	22	Low
Audi E-tron SUV	2019	160,000+	95	22	Low
New BMW i3, i3s	2019	80,000+	42	11	Low
Nissan Leaf	2019	90,000+	60	6.6	Medium - Low
Honda Urban EV	2019	55,000+	36	11	Medium - Low
Mercedees EQ -C	2019	130,000+	85	7.4	Low
Volvo XC 40 Electric	2019	90,000+	78	11	Low
Aston Martin Rapide	2019	200,000+	65	22	Low
Peugot 208	2019	55,000+	50	7.4	Low
VW I.D. Neo /3	2020	60,000+	48	11	Low
Tesla roadster	2020	200,000+	200	22	Low
Rivian R1T Truck, SUV	2020	200,000+	180	22	Low
Rimac C-Two	2020	1,000,000+	120	22	Low

Appendix 5

EV uptake and fleet composition projections (1/4)

New Zealand light vehicle fleet registrations (Jan 2016 - Jun 2019)

Overview

861,750	Light vehicles added
138	Number of makes
1.633	Number of models
59%	Used additions as % of additions

Price bands (estimated)

	Price as new	Depreciated price by actual age	
Base	40.1%	70.3%	Cost of vehicle up to $36k when new
Mid - Low	14.8%	12.6%	Cost of vehicle in the range of $36k-46k when new
Mid	33.8%	11.4%	Cost of vehicle in the range of $46k-70k when new
High	10.7%	5.1%	Cost of vehicle in the range of $70k-150k when new
Ultra high	0.1%	0.1%	Cost of vehicle greater than 150k when new
Classic / Enthusiast	0.5%	0.5%	No specific price range; not considered for analysis

Price depreciation by vehicle age (assumption)

Years ->	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15+	Price trends
Base	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	Corolla, Swift, Mazda 2, Peugeot 208
Mid - Low	ML	ML	B	B	B	B	B	B	B	B	B	B	B	B	B	B	Camry, Accord, CX 5, DS, Qashqai,
Mid	M	M	ML	ML	ML	B	B	B	B	B	B	B	B	B	B	B	Outback, Odyssey, Mondeo, Commodore
High	H	H	M	M	M	ML	ML	ML	B	B	B	B	B	B	B	B	5 Series, E class, Ranger
Ultra high	UH	UH	UH	H	H	H	M	M	M	ML	ML	ML	ML	B	B	B	Range Rover, Audi R8, Tesla

EV uptake and fleet composition projections (2/4)

Assumed EV models available by price band over the next few years (Scenario 1)

	A. Remaining 2019	B. 2020	C. 2021	D.2022	E.2023
Base	i. 2011-2016 24kWh Nissan Leaf (used); 2012-16 Nissan e-nv200 vans (used) ii. 2015-16 Mitsubishi Outlander PHEV (used); iii. Prius / Aqua plug ins used iv. Used i-mev	i. 2011-2017 24kWh Nissan Leaf (used); 2016-18 30kWh Nissan Leaf (used); 2012-16 Nissan e-nv200 vans (used) ii. 2015-17 Mitsubishi Outlander PHEV (used); iii. Prius / Aqua plug ins used iv. Used i-mev	i. 2014-2018 24kWh Nissan Leaf (used); 2016-18 30kWh Nissan Leaf (used); 2012-16 Nissan e-nv200 vans (used) ii. 2015-18 Mitsubishi Outlander PHEV (used); iii. Prius / Aqua plug ins used iv. Used i-mev	i. 2014-2018 24kWh Nissan Leaf (used); 2016-18 30kWh Nissan Leaf (used); 2012-16 Nissan e-nv200 vans (used) ii. 2015-17 Mitsubishi Outlander PHEV (used); iii. Prius / Aqua plug ins used iv. Used i-mev	i. 2014-2018 24kWh Nissan Leaf (used); 2016-18 30kWh Nissan Leaf (used); 2012-16 Nissan e-nv200 vans (used) ii. 2015-17 Mitsubishi Outlander PHEV (used); Prius / Aqua plug ins used iii. Used i-mev
Mid - Low	i. 2016-18 30kWh Nissan Leaf (used); ii. 2017-18 Mitsubishi Outlander PHEV (used) iii. 2012-16 22kWh Renault Zoe (Used)	i. 2016-18 30kWh Nissan Leaf (used); ii. 2017-19 Mitsubishi Outlander PHEV (used); iii. 2016+Prius Prime PHEV iv. 2012-16 22kWh Renault Zoe (Used)	i. 2016-18 30kWh Nissan Leaf (used); ii. 2017-19 Mitsubishi Outlander PHEV (used); iii. 2016+Prius Prime PHEV iv. 2014-17 22kWh Renault Zoe (Used)	i. 2016-19 30kWh Nissan Leaf (used); Some 40kWh leafs ii. 2019+ Mitsubishi Outlander PHEV (used) iii. 2016+Prius Prime PHEV iv. 2015-18 22kWh Renault Zoe (Used)	i. 2016-20 30kWh Nissan Leaf (used); some 40kWh leafs ii. 2020+ Mitsubishi Outlander PHEV (used); iii. 2016+Prius Prime PHEV iv. 2016-20 22kWh Renault Zoe (Used)
Mid	i. 2016-18 40kWh Nissan Leaf (Used); ii. 2018+ Mitsubishi Outlander PHEV ;Hyundai Ionic PHEV; Hyundai Kona/ Kia Niro PHEV (new); Mini Countryman PHEV; 2018+ Prius Prime iii. Hyundai Ionic 28kWh iv. 2014-15 BMW i3/i3s (used)	i. 2016-18 40kWh Nissan Leaf (Used); ii. 2018+ Mitsubishi Outlander PHEV ;Hyundai Ionic PHEV; Hyundai Kona/ Kia Niro PHEV (new); Mini Countryman PHEV iii. Hyundai Ionic 28kWh iv. 2014-16 BMW i3/i3s (used)	i. 2016-18 40kWh Nissan Leaf (Used); ii. 2018+ Mitsubishi Outlander PHEV ;Hyundai Ionic PHEV; Hyundai Kona/ Kia Niro PHEV (new); Mini Countryman PHEV iii. Hyundai Ionic 28kWh iv. 2016+ BMW i3/i3s (used)	i. 2016-18 40kWh Nissan Leaf (Used); ii. 2018+ Mitsubishi Outlander PHEV ;Hyundai Ionic PHEV; Hyundai Kona/ Kia Niro PHEV (new); Mini Countryman PHEV iii. Hyundai Ionic 28kWh used, Hyundai Kona 40-64kWh iv. 2016+ BMW i3/i3s (used)	i. 2016-18 40kWh Nissan Leaf (Used); ii. 2018+ Mitsubishi Outlander PHEV ;Hyundai Ionic PHEV; Hyundai Kona/ Kia Niro PHEV (new); Mini Countryman PHEV iii. Hyundai Ionic 28kWh used, Hyundai Kona 40-64kWh iv. 2016+ BMW i3/i3s (used)
High	i. BMW i3 30 kWh ii. 2018 Hyundai Kona, Kia Niro 40-64kWh ; iii. Audi A3 e-tron PHEV iv. 2018 Renault Zoe 41kWh v. 2019 Volkswagen e-golf	i. New Nissan Leaf 40kWh ii. BMW i3 30kWh iii. 2018 Hyundai Kona, Kia Niro 40-64kWh ; Audi A3 e-tron PHEV iv. 2018 Renault Zoe 41kWh v. 2019 Volkswagen e-golf	i. New Nissan Leaf 40kWh ii. BMW i3 42kWh iii. 2018+ Hyundai Kona, Kia Niro 40-64kWh ; Audi A3 e-tron PHEV iv. 2018 Renault Zoe 41kWh; Tesla model 3 v. 2019 Volkswagen e-golf /ID3 48kWh	i. New Nissan Leaf 40-60kWh ii. BMW i3 42kWh iii. 2018+ Hyundai Kona, Kia Niro 40-64kWh ; Audi A3 e-tron PHEV iv. 2018 Renault Zoe 41kWh; Tesla model 3 v. 2019 Volkswagen e-golf/ID3 48kWh	i. New Nissan Leaf 40-60kWh ii. BMW i3 42kWh iii. 2018+ Hyundai Kona, Kia Niro 40-64kWh ; Audi A3 e-tron PHEV iv. 2018 Renault Zoe 41kWh; Tesla model 3 v. 2019 Volkswagen e-golf/ ID3 -48kWh
Ultra high	i. 2015+ Tesla Model S, X 75- 100kWh ii. Audi e-tron 55 84 kWh iii. 2016-17 BMW i8/ sports models iv. 2017-19 Volvo XC 90 PHEV Range rover sport PHEV; other Mercedes, BMW, Audi PHEVs	i. 2015+ Tesla Model S, X 75- 100kWh ii. Audi e-tron 55 84 kWh iii. 2017+ BMW i8/ sports models iv. New Volvo XC 90 PHEV Range rover sport PHEV; other Mercedes, BMW, Audi PHEVs	i. 2016+ Tesla Model S, X 75- 100kWh ii. Audi e-tron 55 84 kWh iii. 2017+ BMW i8/ sports models iv. New Volvo XC 90 PHEV Range rover sport PHEV; other Mercedes, BMW, Audi PHEVs	i. 2015+ Tesla Model S, X 75- 100kWh ii. Audi e-tron 55 84 kWh iii. 2017+ BMW i8/ sports models iv. New Volvo XC 90 PHEV Range rover sport PHEV; other Mercedes, BMW, Audi PHEVs v. Tesla roadster, Rivian truck	i. 2015+ Tesla Model S, X 75- 100kWh ii. Audi e-tron 55 84 kWh iii. 2017+ BMW i8/ sports models iv. New Volvo XC 90 PHEV Range rover sport PHEV; other Mercedes, BMW, Audi PHEVs v. Tesla Roadster, Rivian track

Appendix 5

EV uptake and fleet composition projections (3/4)

Estimated EV model market share and charging requirements over the next few years (Scenario 1)

Vehicle type		A. Remaining 2019				B. 2020				C. 2021				D.2022				E.2023			
Base	70.3 %	(i)	3.6	60%	3.5	(i)	3.6	60%	3.5	(i)	3.6	60%	3.5	(i)	3.6	60%	3.5	(i)	3.6	60%	3.5
		(ii)	3.7	20%		(ii)	3.7	20%		(ii)	3.7	20%		(ii)	3.7	20%		(ii)	3.7	20%	
		(iii)	2.2	10%		(iii)	2.2	10%		(iii)	2.2	10%		(iii)	2.2	10%		(iii)	2.2	10%	
		(iv)	3.7	5%		(iv)	3.7	5%		(iv)	3.7	5%		(iv)	3.7	5%		(iv)	3.7	5%	
		Others	3.7	5%		Others	3.7	5%		Others	3.7	5%		Others	3.7	5%		Others	3.7	5%	
Mid - Low	12.6 %	(i)	3.6	60%	3.9	(i)	3.6	60%	4.0	(i)	3.6	60%	4.7	(i)	4.8	60%	5.6	(i)	4.8	60%	5.6
		(ii)	3.7	20%		(ii)	3.7	20%		(ii)	3.7	20%		(ii)	3.7	20%		(ii)	3.7	20%	
		(iii)	4.8	10%		(iii)	4.8	10%		(iii)	4.8	10%		(iii)	6.6	10%		(iii)	6.6	10%	
						(iv)	7.2	5%		(iv)	22	5%		(iv)	22	5%		(iv)	22	5%	
		Others	4.8	10%		Others	4.8	5%		Others	4.8	5%		Others	4.8	5%		Others	4.8	5%	
Mid	11.4 %	(i)	6.6	60%	5.9	(i)	6.6	60%	6.8	(i)	6.6	60%	6.8	(i)	6.6	55%	6.9	(i)	6.6	50%	8.4
		(ii)	3.7	20%		(ii)	3.7	20%		(ii)	3.7	20%		(ii)	3.7	20%		(ii)	3.7	20%	
		(iii)	6.6	10%		(iii)	6.6	10%		(iii)	6.6	10%		(iii)	6.6	10%		(iii)	6.6	10%	
		(iv)	7.2	5%		(iv)	7.2	5%		(iv)	7.2	5%		(iv)	7.2	10%		(iv)	7.2	5%	
		Others	3.7	5%		Others	22	5%		Others	22	5%		Others	22	5%		Others	22	15%	
High	5.1 %	(i)	11	20%	8.2	(i)	6.6	20%	8.4	(i)	6.6	25%	8.7	(i)	6.6	30%	9.1	(i)	6.6	30%	10.7
		(ii)	7.2	30%		(ii)	11	30%		(ii)	11	25%		(ii)	11	20%		(ii)	11	20%	
		(iii), (v)	7.2	30%		(iii), (v)	7.2	30%		(iii), (v)	7.2	30%		(iii), (v)	7.2	30%		(iii), (v)	7.2	30%	
		(iv)	22	5%		(iv)	22	5%		(iv)	22	5%		(iv)	22	5%		(iv)	22	5%	
		Others	3.7	15%		Others	3.7	15%		Others	7.2	15%		Others	11	15%		Others	22	15%	
Ultra high	0.1 %	(i)	22	10%	8.8	(i)	22	10%	9.2	(i)	22	10%	11.2	(i)	22	15%	12.7	(i)	22	20%	13.6
		(ii)	22	10%		(ii)	22	10%		(ii)	22	10%		(ii)	22	10%		(ii)	22	10%	
		(iii)	11	10%		(iii)	11	10%		(iii)	11	15%		(iii)	11	10%		(iii)	11	10%	
		(iv)	3.7	60%		(iv)	3.7	55%		(iv)	3.7	50%		(iv)	3.7	45%		(iv)	3.7	40%	
		Others	11	10%		Others	11	15%		Others	22	15%		Others	22	20%		Others	22	20%	

Key: Vehicle Type (from prev. page) | Peak charging rate (AC) | Market share within category | Average category charging requirement

EV uptake and fleet composition projections (4/4)

Estimated EV fleet composition by 2023 by charging requirements

		Current Fleet			Remaining 2019		2020		2021		2022		2023		
Scenario 1 (As Is)															
Low	Upto 3.7kWh	13,659	77%	10,562	20,521	16,359	28,167	22,580	37,573	30,161	48,822	38,941	62,001	79%	49,228
	3.7 - 7.2kWh		14%	1,851		2,825		3,969		5,472		7,497		16%	9,718
	7.2 - 11kWh		3%	352		424		592		774		977		2%	1,113
	11-22kWh		7%	893		912		1,026		1,167		1,407		3%	1,943
Medium	Upto 3.7kWh	13,659	77%	10,562	21,118	16,359	30,293	24,561	42,834	34,986	59,226	47,365	79,818	79%	62,916
	3.7 - 7.2kWh		14%	1,851		2,825		4,108		5,874		9,343		17%	13,466
	7.2 - 11kWh		3%	352		424		632		795		1,090		2%	1,303
	11-22kWh		7%	893		912		992		1,180		1,427		3%	2,133
High	Upto 3.7kWh	13,659	77%	10,562	25,593	16,359	40,885	33,473	64,399	53,020	96,540	77,293	137,726	79%	108,396
	3.7 - 7.2kWh		14%	1,851		2,825		5,542		8,853		15,656		17%	23,901
	7.2 - 11kWh		3%	352		424		813		1,118		1,698		2%	2,124
	11-22kWh		7%	893		912		1,056		1,408		1,893		2%	3,304
Scenario 2 (Incentivised price reduction)															
Low	Upto 3.7kWh	13,659	77%	10,562	20,521	15,787	28,167	21,565	37,573	28,481	48,822	35,957	62,001	72%	44,715
	3.7 - 7.2kWh		14%	1,851		3,397		5,032		6,979		10,044		22%	13,635
	7.2 - 11kWh		3%	352		424		592		941		1,415		3%	1,870
	11-22kWh		7%	893		912		977		1,172		1,406		3%	1,782
Medium	Upto 3.7kWh	13,659	77%	10,562	21,118	16,241	30,293	23,175	42,834	32,396	59,226	43,290	79,818	71%	56,974
	3.7 - 7.2kWh		14%	1,851		3,532		5,494		8,089		12,555		23%	18,166
	7.2 - 11kWh		3%	352		430		632		1,097		1,788		3%	2,498
	11-22kWh		7%	893		914		992		1,252		1,593		3%	2,180
High	Upto 3.7kWh	13,659	77%	10,562	25,593	19,649	40,885	31,205	64,399	48,495	96,540	69,855	137,726	71%	97,223
	3.7 - 7.2kWh		14%	1,851		4,540		7,810		12,676		21,434		24%	32,655
	7.2 - 11kWh		3%	352		477		813		1,685		3,040		3%	4,460
	11-22kWh		7%	893		926		1,056		1,543		2,212		2%	3,387

Appendix 6

Popular chargers in overseas markets (1/2)

AUSTRALIA					
Brand	**Model Name**	**Charging rate (kW)**	**Rating (A)**	**Price**	**Protection**
kWIK	kWIK Portable Single Phase Charger	2.3 - 7 kW	6-32Amp	$1,100 (Aus)	IP65
EO	EO Mini w/5m Type 2 EV Cable	7kW		$1,180 (Aus)	n/a
EO	EO Charging Station 22kW	22kW	32Amp	$1,935 (Aus)	IP54
EVSE Australia	Portable 22kW Charger	2.3 - 22kW	32Amp	$1,979 (Aus)	IP66
Zappi	Zappi 7kW	7.6kW	6-32Amp	$1,099.00 – $1,199.00 (Aus)	IP65
Cyclon	Cylon EV Charging Station EVSE	7.6kW	32Amp	$990.00 (Aus)	IP65
EO	EO Universal Charger (7kW)	7kW	30Amp	$1,280.00 (Aus)	
GARO	Wallbox Charger GLB 22kW	22kW	6-3x32Amp	$1790.00 (Aus)	IP66
GARO	Wallbox Charger GLB 22kW	22kW	6-3x32Amp	$1750.00 (Aus)	IP66
GARO	Wallbox Charger GLB 7kW EVSE	7kW	6-32Amp	$1350.00 (Aus)	IP66
HALO	Wallbox 11kW (3 Phase)	11kW	6-3X16Amp	$1,849.00 (Aus)	IP66
HALO	Wallbox 7.4kW	7.4kW	6-32Amp	$1,650.00 (Aus)	IP66
EVolution Aus	Portable/Switchable EVSE EV Charger	2.4kW	6/8/10 Amp	$499.00 (Aus)	IP54
EVolution Aus	Portable/Switchable EVSE EV Charger	3.6kW	6/10/15 Amp	$549.00 (Aus)	IP54
Giger	Portable Switchable EVSE EV Charger	22kW	6-32Amp	$1,395.00 (Aus)	
Giger	Portable Switchable EVSE EV Charger	7.6kW	6/10/15/32Amp	$795.00 (Aus)	IP54
Ray	RAY Switchable EVSE	3.6kW	6-16Amp	$1,099.00 (Aus)	IP54
JetCharge	JET Charge WallPod EV Charger	3.6 / 7.2 kW	16 / 32 Amp	$1,320 (Aus)	IP65
JetCharge	Securicharge (Token based = semi-public)	3.6/7.2/22kW	3x32/32/16/3x16A	$1,760 (Aus)	IP65

USA (+ Canada)					
Brand	**Model Name**	**Charging rate (kW)**	**Rating (A)**	**Price**	**Protection**
eMotorWerks	Juicebox Pro 40	10 kW	40Amps	619 USD	IP66
eMotorWerks	Juicebox Pro 32	7.7kW	32Amps	589 USD	IP66
eMotorWerks	Juicebox Pro 75	18 kW	75Amps	949 USD	IP66
Aerovironment	EVSE-RS 25		30 Amps	999USD	IP66
ChargePoint	ChargePoint Home 32Amp	7.6kW	32 Amps	999USD	IP66
Elmec Inc	EVDUTY-40	7.2kW	30Amps	819 USD	IP54
Elmec Inc	EVDUTY-40 SMART	7.2kW	30Amps	899 USD	IP54
EVoCharge	EVoInnovate	7.7kW	16/24/32 Amps	770USD	
Flo	FloHome X5 Hardwired	7.2kW	30Amps	1295 USD	IP54
Flo	FloHome G5 Hardwired	7.3kW	30Amps	995USD	IP66
ClipperCreek	HCS-D40 Dual Charging Station	7.7kW	32Amps	1,349USD	IP66
ClipperCreek	HCS-30	5.7kW	24Amps	565USD	IP66

Appendix 6

Popular chargers in overseas markets (2/2)

UK					
Brand	**Model Name**	**Charging rate (kW)**	**Rating (A)**	**Price**	**Protection**
Pod Point UK	PodPoint Solo Charger 3.6kW	3.6kW		£779	WP
Pod Point UK	PodPoint Solo Charger 7kW	7kW		£859	WP
Pod Point UK	PodPoint Solo Charger 22kW	22kW		£1499	WP
EO Charging	EO Mini Pro	3.6 / 7 kW		£495.00 (incl OLEV grant)	
EO Charging	EO Mini Smart Home	3.6 / 7 kW		£695.00 (incl OLEV grant)	
EO Charging	EO Basic	3.6 / 7 / 11 / 22 kW		£845.00	
Rolec EV	Wallpod EV	3.6 / 7.2 kW	16 / 32 Amps	NA	IP65
Rolec EV	Wallpod EV Ready	2kW	13 Amps	NA	IP65
Rolec EV	Wallpod EV Multimode	3.6 / 7.2 kW	16 / 32 Amps	NA	IP65
Rolec EV	Wallpod EV Homesmart EV	3.6 / 7.2 kW	17 / 32 Amps	NA	IP65
Alfen	Eve Single S-Line	3.7/7.4 kW		NA	IP55
Alfen	Eve Single Pro-Line	3.7-22kW		NA	IP55
Alfen	Eve Double Pro-Line	3.7-22kW		NA	IP54
EVBox	Elvi	3.7/7.4/11/22kW	16/32Amps	NA	

Europe (ex. UK)					
Brand	**Model Name**	**Charging rate (kW)**	**Rating (A)**	**Price**	**Protection**
Webasto	Webasto Pure	3.7-22kW	16/20/32	NA	IP54
Garo	Chargebox +	3.7kW	32Amps	NA	
ABB	EVLunic Basic	4.6kW		NA	
ABB	EVLunic Basic +	11 / 22 kW		NA	
ABB	EVLunic Pro S	4.6 / 11 / 22 kW		NA	
ABB	EVLunic Pro M	4.6 / 11 / 22 kW		NA	
Wallbox	Copper	7.4 / 22 kW	6-32 Amps	NA	
Wallbox	Commander	7.4 / 22 kW	6-32 Amps	NA	
Wallbox	Pulsar	3.7 - 22 kW	6-32 Amps	NA	
Alfen	Eve Single S-Line	3.7/7.4 kW		NA	IP55
Alfen	Eve Single Pro-Line	3.7-22kW		NA	IP55
Alfen	Eve Double Pro-Line	3.7-22kW		NA	IP54
EVBox	Elvi	3.7/7.4/11/22kW	16/32Amps	NA	

China					
Brand	**Model Name**	**Charging rate (kW)**	**Rating (A)**	**Price**	**Protection**
Besen	Wallbox EV Charging Station	7.2kW	32Amps	$320 (USD)	
Besen	AC EV Charging Station	3.6kW		$310 (USD)	
Besen	32A Wall Mount EV Charger	3.6 / 7.2 kW	16 / 32 Amps	$320 (USD)	IP66
Pengtu	ev home charger PT500 500W	0.5kW		NA	
Jekayla	Jekayla Charging Station		32Amps	$599 (USD)	
Zencar	ZenCar Home Charging Station		32Amps	NA	IP65
Khons	EV 3 phase charger		32Amps	$450-480 (USD)	IP66

Asia (ex. China)					
Brand	**Model**	**Charging rate (kW)**	**Rating (A)**	**Price**	**Protection**
Nichicon	V2H Converter	7.2-14.4kW	15 Amps	$NZD 24900	
Delta Electronics	AC Wallbox	7.2kW	32 Amps	NA	Type 3R
Kepco	AC Wallbox	7.2kW	32 Amps	NA	

Appendix 7

Smart charging (overseas platforms available)

Snapshot of smart charging platforms available overseas

Manufacturer	Platform	Application / messaging protocols	Network communication interfaces
ABB	External (e.g., Microsoft Azure)	OCPP w/ Demand/ Response API add-on	Cellular (GSM), Ethernet
Addenergie	Charging Station Network Management System	OpenADR 2.0	Cellular, ZigBee, Wi-Fi
ACT	Not available	SEP 1.x, SEP 2.0	Ethernet, Wi-Fi (IEEE 802.11 b/g/n, ICPT IP/ Internet, Cellular GSM (GPRS), ZigBee
Aerovironment	External (e.g., eMotorWerks JuiceNet platform or Liberty PlugIns HYDRA-R platform)	SEP 2.0	Wi-Fi, Ethernet, Cellular
Andromeda Power	ORCA InCISIVE Power Cloud platform	OpenADR 2.0b, OCPP 1.6, Open Smart Charging Protocol (OSCP)	Wi-Fi (IEEE 802.11g), Cellular (3G/4G), Ethernet
Blink	NA	NA	Wi-Fi (IEEE 802.11g and 802.15), Cellular (3G), Ethernet
Bosch	NA	OCPP 1.5	Wi-Fi (IEEE 802.11 b/g/n)
Chargepoint	ChargePoint platform, including ChargePoint Home	OpenADR 2.0b, OCPP 1.6, IEEE P2690, and other API-based Systems	Wi-Fi (IEEE 802.11 b/g/n), Cellular (GSM (3G) and CDMA (3G))
Clippercreek	External (e.g., eMotorWerks JuiceNet platform or Liberty PlugIns HYDRA-R platform)	NA	W-iFi, Ethernet, Cellular
Delta	NA	NA	Ethernet, Wi-Fi, Cellular GSM/GPRS (3G)
EmotorWerks	JuiceNet platform	OCPP, OpenADR, other API-based systems	Wi-Fi, Ethernet, Cellular
EVSE LLC	External (e.g., Greenlots SKY Smart Charging platform)	OCPP	Ethernet, Cellular, radio, Wi-Fi
GE	EV Connect cloud platform	OpenADR 2.0 VEN	Ethernet (CAT5), Wi-Fi, Cellular (CDMA)
Itron	OpenWay network	Proprietary	Wi-Fi, RF Mesh, Cellular, ZigBee
Kebaag	NA	OCPP 1.5 and 2.0	Ethernet, Cellular (GSM)
Leviton	External (e.g., ChargePoint platform or Liberty PlugIns HYDRA-R platform)	Not available	Wi-Fi (IEEE 802.11 a/b/g/n), Cellular (GSM (3G) and CDMA (3G))
MoEV	Cloud-based control center	NA	Ethernet, Wi-Fi, Cellular, ZigBee
Oxygen	Oxygen eOperate	OpenV2G	Cellular (3G)
Schnieder electric	EV Cloud connected platform	OCPP 1.5	Wi-Fi (IEEE 802.15.4), Cellular
Sema Connect	SemaConnect Network platform	Proprietary	Cellular (CDMA and GSM/GPRS)
Siemens	Siemens proprietary cloud via CEA2045 compliant module	OpenADR 2.0b, OCPP	Wi-Fi (IEEE 802.11 b/g/n)
Tritium	NA	OCPP 1.5 and 1.6J	Cellular (3G), Ethernet

Source: SEPA Managed Charging Report

Abbreviations

AC	Alternating Current
Amps	Amperes
BEV	Battery Electic Vehicle
CAGR	Compound Annual Growth Rate
CCS	Combined Charging System
CHAdeMO	CHArge de Move
DC	Direct Current
DERMS	Distributed Energy Resource Management System
EV	Electric Vehicle
HEV	Hybrid Electric Vehicles
IP ratings	Ingress protection ratings
kW	Kilo Watts
OCPP	Open Charge Point Protocol
Open ADR	Open Automated Demand Response
OSCP	Open Automated Demand Response standard
PHEV	Plug in Hybrid Electric Vehicle
RCD	Residual Current Device
V2G	Vehicle to Grid
V2H	Vehicle to Home

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