CITY OF STONNINGTON

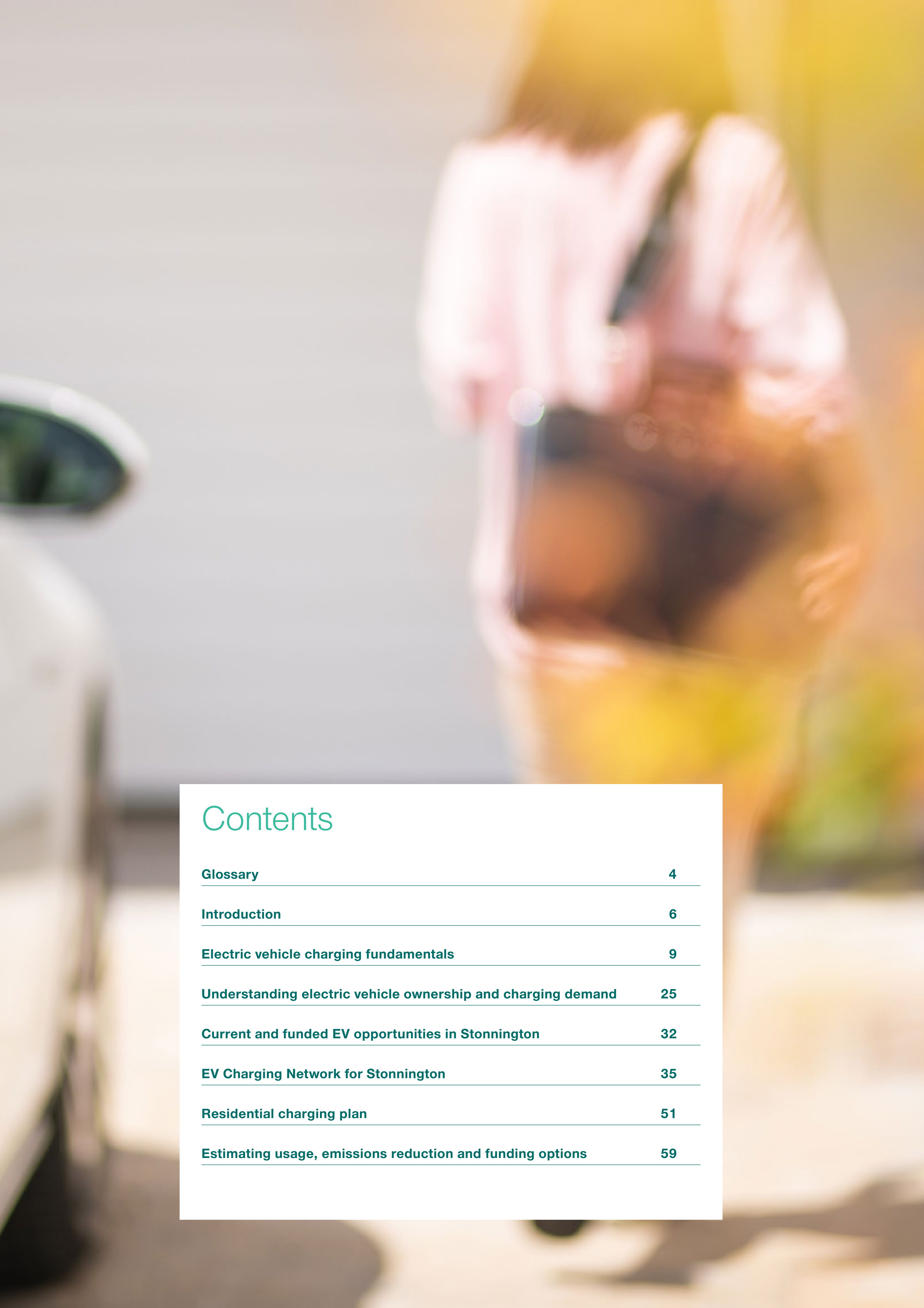
Electric Vehicle Charging Plan

City of STONNINGTON

ACKNOWLEDGEMENT OF COUNTRY

The City of Stonnington acknowledges we are on the Traditional Lands of the Wurundjeri Woi Wurrung and Bunurong peoples of the East Kulin Nations and pays respect to their Elders past, present and emerging.

We extend that respect to all Aboriginal and Torres Strait Islander peoples. We acknowledge their living connection to Country, relationship with the land and all living things extending back tens of thousands of years.



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Glossary

AC Alternating Current.
An electric current that reverses its direction many times a second at regular intervals.

BEV Battery Electric Vehicles.
A type of electric vehicle that exclusively uses chemical energy stored in rechargeable batteries. BEVs use electric motors and motor controllers instead of internal combustion engines.

DB Distribution board.
An electrical cabinet that contains circuit breakers and fuses for each electrical circuit within a building or part of a building.

DC Direct Current.
An electric current that flows in one direction only.

DNSP Distribution Network Service Provider.
They are the organisations that own and control the hardware of the distributed energy network such as power poles, wires, transformers, and substations that move electricity around the grid.

DTP Department of Transport and Planning.
A government department in Victoria that is responsible for the ongoing operation and coordination of the Victorian transport networks and the delivery of new and upgraded transport infrastructure.

EPA test The United States Environmental Protection Agency test.
This is a testing standard for a vehicle's driving range.

EV Electric Vehicle.
A vehicle that is either partially or fully powered on electric power.

EVSE Electric Vehicle Supply Equipment.
Commonly called charging stations or charging docks. EVSE provides electric power to electric vehicles and recharge the vehicle's batteries. EVSE systems include electrical conductors, related equipment, software, and communications protocols that deliver energy efficiently and safely to the vehicle.

FCEV Fuel Cell Electric Vehicle.
A type of electric vehicle that uses a fuel cell, sometimes in combination with a battery or supercapacitor, to power its onboard electric motor. They are powered by hydrogen and do not produce tailpipe emissions.

GHG Greenhouse gas.
A gas that absorbs and emits radiant energy within the thermal infrared range causing the greenhouse effect.

HEV Non-plug-in Hybrid Electric Vehicle.
A type of vehicle that combines an internal combustion engine system with an electric propulsion system that can work either simultaneously or independently.

ICE Internal Combustion Engine is powered by either diesel or petrol.

ICEing The act of deliberately parking an ICE vehicle in an EV charging bay to prevent EVs from being able to charge.

NEDC New European Driving Cycle. This is a testing standard for a vehicle's driving range.

PHEV Plug-in Hybrid Electric Vehicle. A vehicle that is powered chiefly by an electric motor and has an internal combustion engine as a back-up.

Smart charging refers to a charging system where a data connection is shared between electric vehicles, charging stations, and electricity network operators to allow users to monitor, manage and adjust energy consumption. Smart technology can alleviate pressure from the grid system and save associated charging costs for EV users.

V2L Vehicle to Load. Where the electricity stored in a vehicle's battery is used to power an external device, typically offering a standard 240V outlet.

V2H Vehicle to Home. Where the electricity stored in a vehicle's battery is used to power a home.

V2G Vehicle to Grid. Describes the capability of a vehicle to supply energy from the battery to the electricity network.

SA1 Statistical Area Level 1. A classification used by the Australian Bureau of Statistics to describe the smallest unit for the release of census data.

SA2 Statistical Area Level 2. A classification used by the Australian Bureau of Statistics to describe medium-sized general-purpose areas built up from whole Statistical Areas Level 1 (SA1s). Their purpose is to represent a community that interacts together socially and economically.

SB Switchboard. The main electrical cabinet containing the incoming electricity supply which distributes it across a building or to smaller distribution boards

WLTP Worldwide Harmonised Light Vehicle Test Procedure. This is a testing standard for a vehicle's driving range.

Introduction

The City of Stonnington is committed to increasing sustainable mobility options, including growth in the use of electric vehicles (EVs). Charging infrastructure is an essential element in achieving this ambition.

WHY DOES STONNINGTON NEED AN EV CHARGING PLAN?

EV ownership is growing rapidly in Australia. Charging infrastructure is one of the core requirements before people are willing to transition to EVs. While most charging occurs at people's home or workplace, many areas of Stonnington have a significant proportion of homes without easy access to charging on their property. This presents a significant barrier to many that may wish to own an EV. According to some surveys, around 50% of Australians are considering an EV for their next vehicle, and this is expected to increase should petrol prices maintain their historic highs. Therefore, this plan was developed to investigate and plan an approach to expand the local network of EV chargers in Stonnington.

HOW WAS THIS PLAN DEVELOPED?

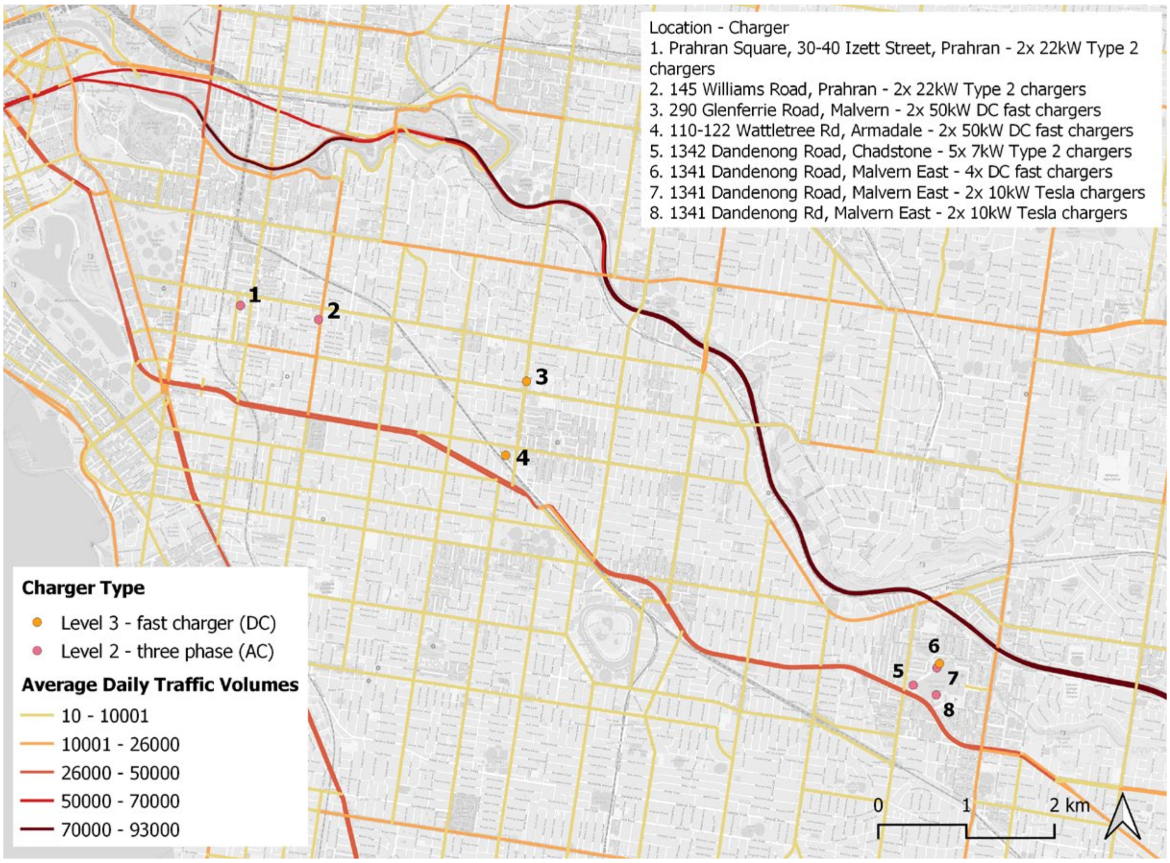
Stonnington commissioned the Institute for Sensible Transport (IST) to develop a Charging Plan and related appendices as an assessment of future public EV charging in Stonnington between now and 2030. This document is closely based on these documents and includes actions and recommendations guided by analysis undertaken by IST and presented in their Charging Plan. This Plan is also closely linked to the already endorsed Electric Vehicle Charging Infrastructure Policy developed by Council and reviewed by IST.

WHAT THE PLAN INCLUDES

- Background on EV and EV charging technology, current trends and forecast EV sales, and EV charging networks.
- Analysis of Stonnington suburbs without private off-street charging possibilities and a plan to address this potential barrier to EV ownership.
- A prioritisation framework to identify suitable ares and numbers for future EV charging stations, including predictions based on future EV ownership and public charger usage.
- An implementation plan, including estimated costs, for the development of a comprehensive EV charging plan for Stonnington, to 2030.
- Advice on funding and ownership options to increase charging opportunities at minimal cost to Council.
- Analysis of the role of on-street EV charging and options to support this in future.

Figure 1 provides a snapshot of the current public charger network within Stonnington.

FIGURE 1: Road traffic volume and location of existing chargers



Electric vehicle charging fundamentals

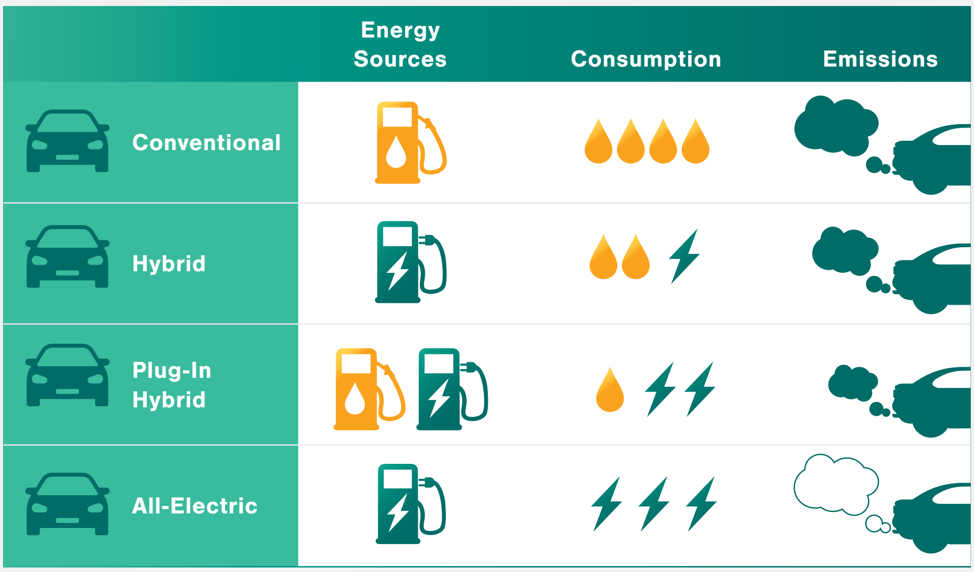
The EV market is evolving rapidly, with a greater range of more affordable vehicles and an expanding network of charging options. The growth of the EV market is expected to continue, and it has been estimated that price parity may occur in 2025/26.

WHAT IS AN ELECTRIC VEHICLE?

There are several different categories of EVs, and it is important to identify the main types, as shown in Figure 2.

- **Conventional vehicle** – also referred to as an Internal Combustion Engine (ICE) vehicle, is the standard vehicle type widely known and used since the invention of the motor vehicle. The fuel source for most ICE vehicles is petrol, diesel or gas, with some able to utilise renewable fuels such as ethanol. It is not an EV.
- **Hybrid vehicle** – a vehicle that uses petrol/diesel as its only fuel source, but also has an electric motor and battery that can store energy from regenerative breaking. A *Toyota Prius* is a common example of a hybrid vehicle.
- **Plug-in Hybrid Electric Vehicles (PHEV)** – combines a mixture of fuel combustion and electricity. It is similar to the hybrid vehicle described above; however, it has the ability to take electricity from a socket and can store this in a battery. A *Mitsubishi Outlander* is an example of a model available as a PHEV.
- **Battery Electric Vehicles (BEV)**, or **All-Electric**, take electricity from a socket and rely entirely on the electricity stored in an on-board battery for propulsion. A *Tesla Model 3* and *Nissan Leaf* are two popular models of BEV.

FIGURE 2: Different types of consumption and electric vehicles



Source: Adapted from Adnan et al (2017)

Electric vehicle charging fundamentals

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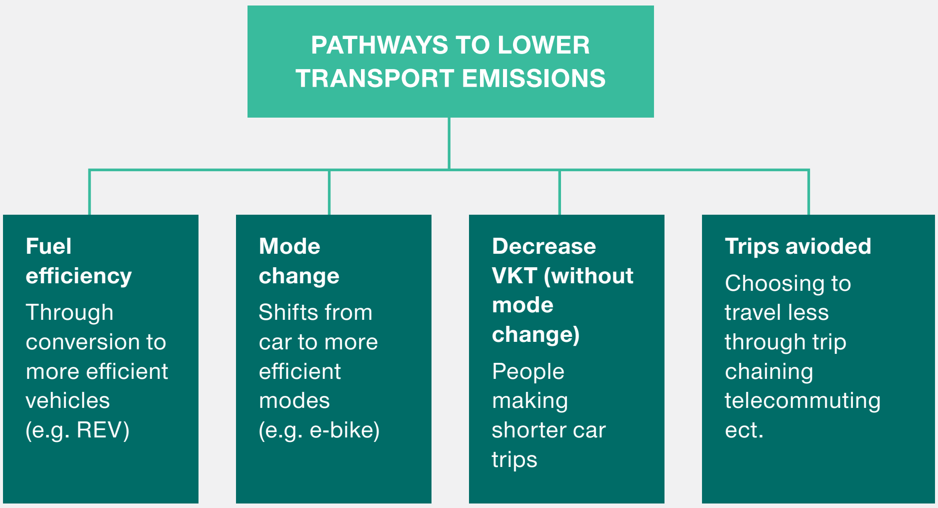
WHY IS IT IMPORTANT TO REDUCE TRANSPORT EMISSIONS?

Transport is the fastest rising source of emissions in Australia. Unlike other sectors, which have been reducing their carbon intensity, transport emissions have proved more difficult to combat. Transport emissions in Australia have risen by 60% since 1990 and the average emissions of new vehicles have not improved over recent years.

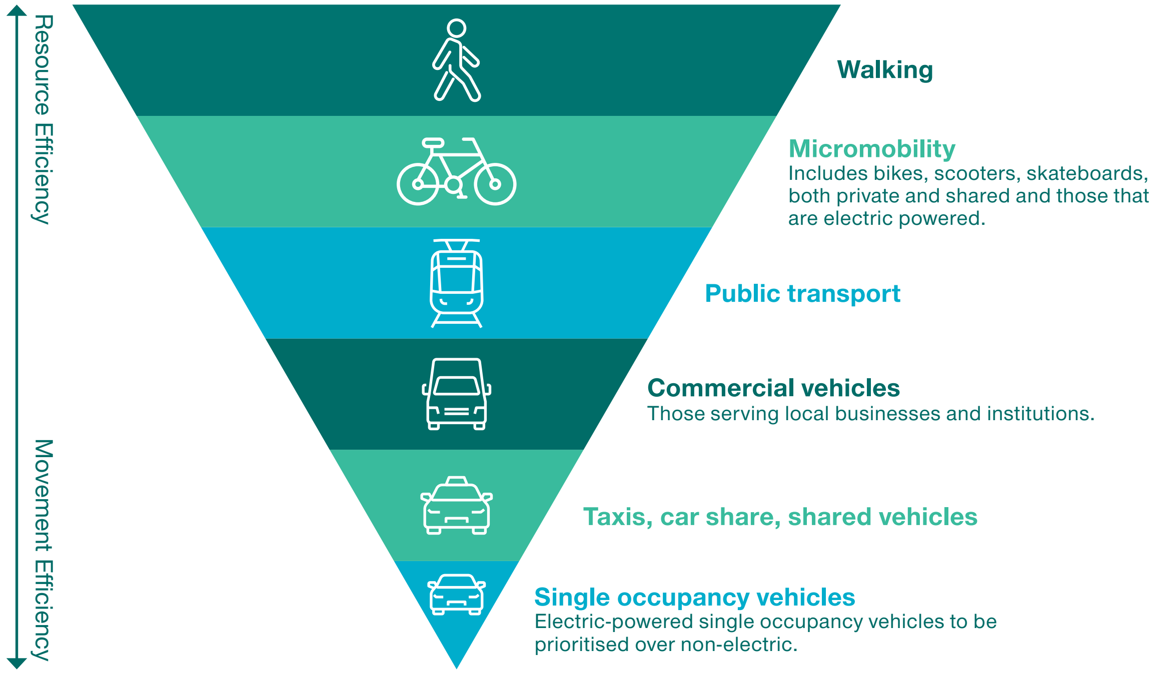
There are four key methods through which transport emissions can be lowered, as identified in Figure 3. Conversion to EVs is one key method for reducing emissions, but other pathways are also available. Figure 3 serves to contextualise the role EVs play in reducing transport emissions, within the broader scope of actions that Stonnington is focused on.

FIGURE 3: Pathways for lowering emissions



NB: VKT stands for Vehicle Kilometres Travelled
Source: Institute for Sensible Transport

FIGURE 4: Stonnington's Transport Hierarchy



Stonnington's *mode hierarchy* is shown in Figure 4 and this is designed to encourage active and public transport as modes of first choice but recognises that the car is still a necessary element of the transport system. Maximising the use of EVs will assist in lowering emissions and reducing local air pollution.

Figure 5 provides a representation of the emissions intensity and space consumption of different modes of transport, drawn from Victorian data. One implication from this work is the importance of a clean, renewable electricity supply to maximise the benefits of EVs. In addition, it also shows how mode shift to e-bikes can offer significant energy, emissions and space savings. As the electricity network becomes less emissions intensive in Victoria, the emissions associated with charging EVs with grid electricity will diminish but are expected to continue to be significant for some time. Many EV charging network providers have committed to a 100% renewable supply of electricity.

Electric vehicle charging fundamentals

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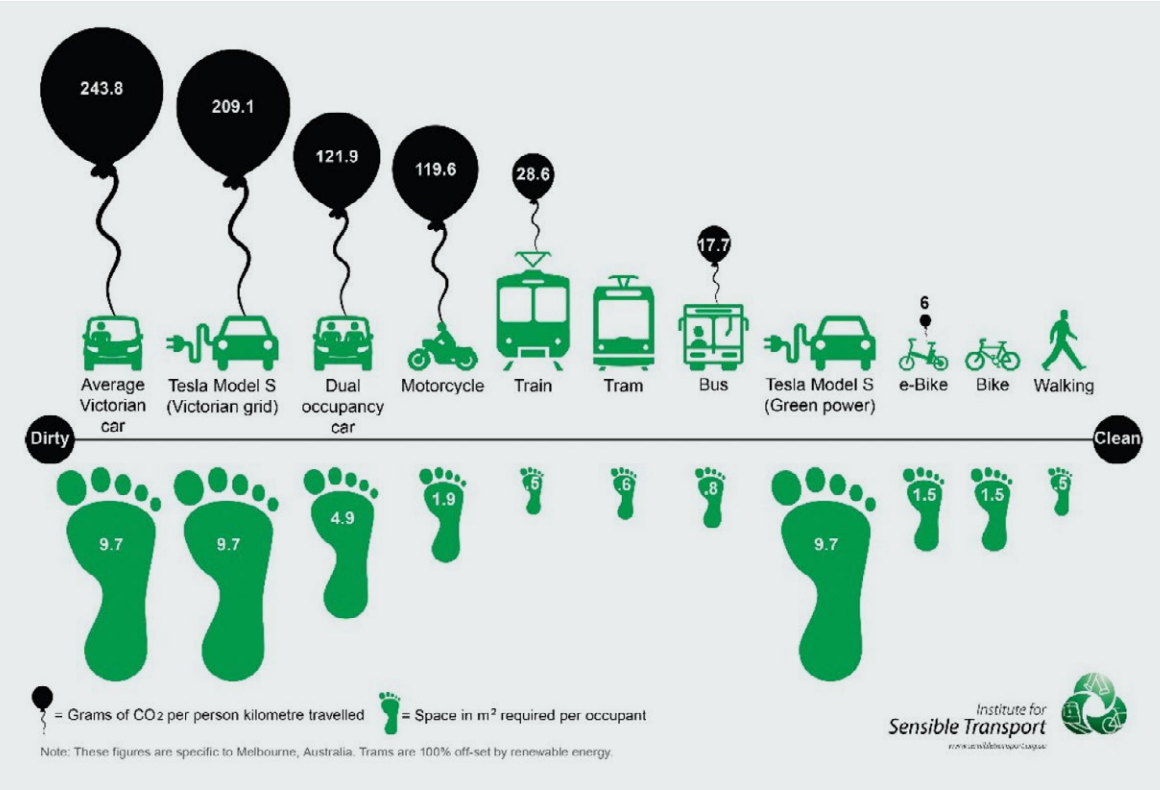
FIGURE 5: Emissions intensity and space consumption of different transport modes



ELECTRIC VEHICLES IN AUSTRALIA?

While Australia has among the lowest levels of EV adoption in the OECD, over 3% of new vehicle sales in 2022, this has doubled from a year earlier[1]. Figure 6 captures the latest EV sales in Australia, both in total and as a percentage of light vehicle sales.

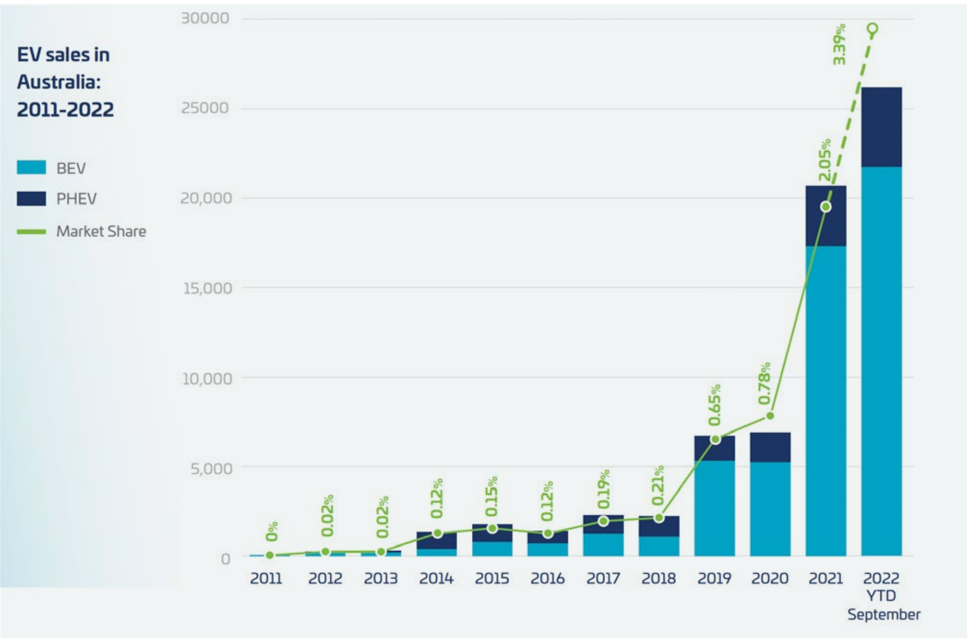
A number of surveys have found around 50% of consumers are considering an EV for their next vehicle purchase.[2] In March 2022, when petrol prices were around $2.20 per litre, around 1 in 5 website searches for carsales.com were for EVs. Figure 7 provides analysis of EV ownership in Melbourne by IST.

Many of the postcodes within the City of Stonnington have experienced a very strong growth rate in recent years.

At the time of writing this plan, one of the main barriers to EV adoption is the *supply* of EVs into the Australian market. Many models require a six month wait (or more) once ordered.

Around half of consumers are considering an EV for their next vehicle purchase.

FIGURE 6: EV sales in Australia



Source: Institute for Sensible Transport

1 Federal Chamber of Automotive Industries 2023

2 electricvehiclecouncil.com.au/wp-content/uploads/2021/10/2021-EVC-carsales-Consumer-attitudes-survey-web.pdf

Electric vehicle charging fundamentals

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ELECTRIC VEHICLE BENEFITS

Electric vehicle technology has advanced rapidly in recent years. Electric vehicles avoid the tailpipe emissions of ICE vehicles, typically have lower running and servicing costs, and last longer.

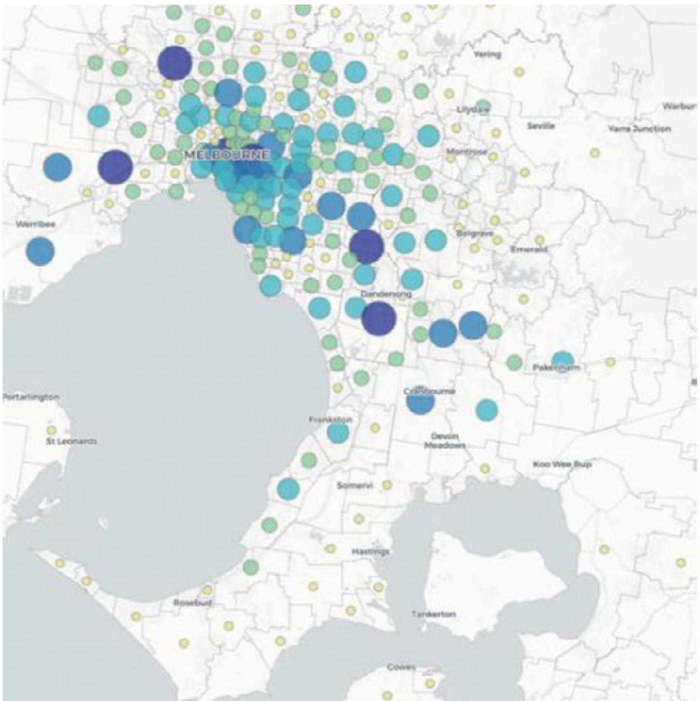
Compared to five years ago, EVs:

» Have become cheaper
» Offer longer battery range
» Are available in a wider variety of vehicle types.

Electric vehicles also now have access to more chargers, including publicly available fast chargers, in more locations in Australia and this is set to grow further in coming years. Concern regarding the ability to travel long distances is still a key stated barrier to the greater uptake of EVs and more chargers will reduce this barrier.

The next 12 months are set to see the introduction of several lower cost models that, while still more expensive to purchase than their ICE equivalents, will begin to compete strongly in terms of whole of life costs, especially for vehicles that travel a relatively high number of kilometres per year.

FIGURE 7: EV ownership in Melbourne



Source: Institute for Sensible Transport, using ABS data

ASSESSMENT OF EV ADOPTION FACTORS

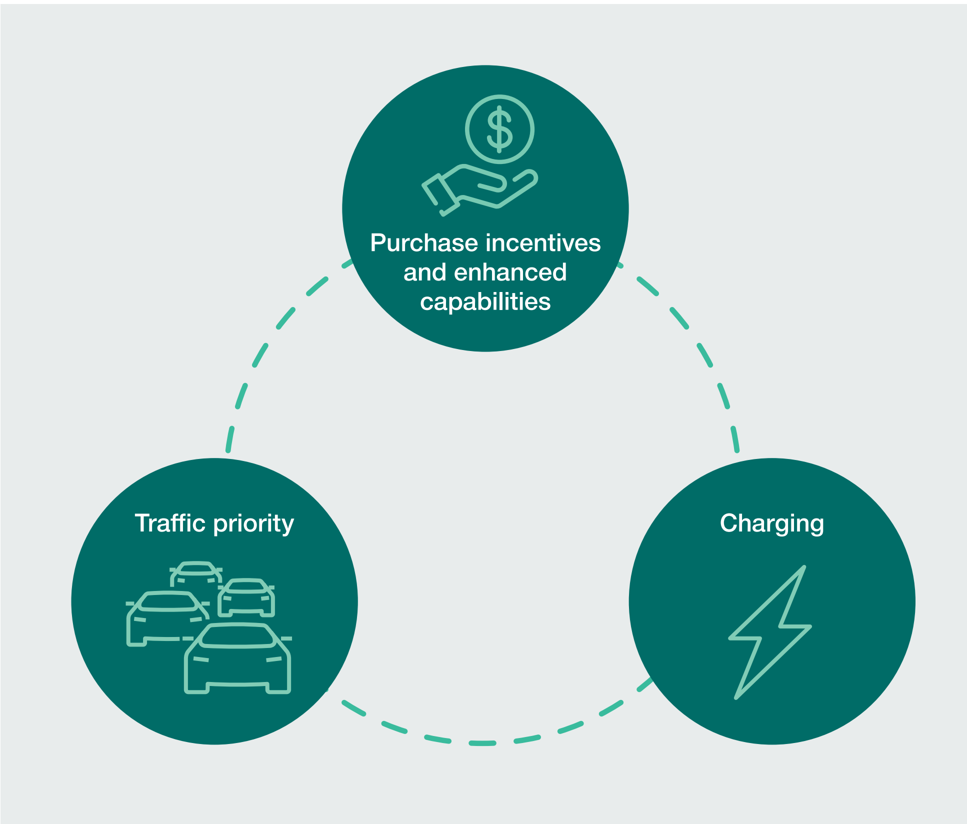
Figure 8 captures the three broad areas in which government can influence the uptake of EVs.

Purchase incentives and traffic priority are largely the domain of federal and state governments – though local governments may wish to undertake an advocacy role to encourage adoption of policies in these areas.

Purchase incentives and enhanced capabilities are focused on measures designed to make the vehicle more attractive to the market. This includes policies such as sales tax exemptions and accelerated depreciation arrangements. This category also includes enhanced vehicle capabilities, such as extended battery range or a diversity of vehicle types. Disincentives for ICE vehicles can also be used to increase the relative value proposition of EVs.

Traffic priority relates to measures such as free use of toll roads and congestion zones, as well as the ability for a single occupant EV to use High Occupancy Vehicle lanes.

FIGURE 8: Policies for boosting EV adoption – 3 categories



Source: Institute for Sensible Transport

Electric vehicle charging fundamentals

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BOX 1: EV adoption factors

Factors required to be in place for higher EV uptake

The factors required to be in place before EVs are preferred (or at least equal to ICE) for typical consumer preferences is summarised below (adapted from AEVA[3]):

1. **Awareness and social norms:** People need to be familiar with EVs and their capabilities.
2. **Range:** EVs should have an adequate range (distance) for the vehicle's intended purpose.
3. **Charging infrastructure:** A perception must exist that there is adequate charging infrastructure.
4. **Variety of vehicles:** It is important that the EV market contains a sufficient diversity of models to meet the needs of council and staff (cost and features) and the broader community.
5. **Cost comparability:** Financial incentives and/or lower sticker (official) price will assist consumers. There are two thresholds here; whole of life and sticker price.

VICTORIAN POLICY CONTEXT

The Victorian government's policies on EVs have evolved rapidly since 2022. We have seen the introduction of:

- A target of 50% EV sales by 2030
- A Zero Emissions Vehicles – Expert Advisory Panel
- A distance-based road user charge on EVs (2.5 cents per kilometre)
- A $3,000 rebate at the point of purchase for vehicles less than $68,740 (capped at 4,000 vehicles)
- Additional funding ($22.65m) for public charging infrastructure.

There are currently more than 50 DC Fast Charging sites in Victoria and 400 standard chargers available for public use. There are more than eight EVs for every public charger in Victoria.

KEY TRENDS

Several trends are identified that are important to consider in the development of a public charging network in Stonnington, including:

- Greater range of vehicle types
- Extended range, on-board 240V power sockets
- Vehicles capable of Ultra-Fast Charging
- Vehicle to Grid (V2G), Vehicle to Home (V2H) and Vehicle to Load (V2L) capabilities, enabling greater flexibility, enhanced resilience and grid stability.

These trends will be considered in the development of a future Stonnington EV charging network. Please refer to Appendix 2: Institute for Sensible Transport – Future Scan Report for a more detailed discussion.

3 Australian Electric Vehicle Association Inc.

EV CHARGERS

This section provides a brief introduction to EV charging basics.

The three main EV charging equipment characteristics that differentiate chargers from one another include (International Energy Agency 2018):

1. **Level:** the power output range of the EV charging outlet. For most cars, the maximum electric charge in Alternative Current (AC) is lower.
2. **Type:** the socket and connector used for charging.
3. **Mode:** the communication protocol between the vehicle and the charger.

The number of chargers and the speed with which a battery can be changed has improved significantly over recent years, and countries (including Australia) are building networks of fast chargers to facilitate long distance travel.

Table 1 provides a snapshot of different charging types.

One critically important observation from EV owners regarding their charging habits is that over 90% of charging happens at home or work. This has implications for the selection of appropriate sites for charging infrastructure and the speed of charger selected. There is also an implication related to land use; streets with a predominant residential form that lack off-street parking may require on-street overnight chargers, whereas this is unlikely to be helpful in areas where off-street parking is generally available. This is particularly important for the City of Stonnington, where around 20% of homes do not have off-street parking. The charging needs of this population will be addressed as part of the future Stonnington EV charging network detailed in subsequent stages of this plan.

Over 90% of EV charging occurs at home or work.

Electric vehicle charging fundamentals

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TABLE 1: EV Charging types[4]

	Power	Range added per hour	Charging Time	Typical Application
Level 1 single phase (domestic)	2.4–3.7kW	10–20km range/hour	5–6 hours	Home
Level 2 slow single phase (domestic or public)	7kW	30–45km range/hour	2–5 hours	Home, work, shopping cenres, carparks
Level 2 fast three phase (public)	11–22kw	50–150km range/hour	30 mins – 2 hours	Urban roadside
Level 3 fast charge (public)	50kw	250–350km range/hour	20–60 mins	Regoinal near highways, motorways and key routes
Level 4 super-fast (public)	120kW	400–500km range/hour	20–40 mins	Regoinal near highways, motorways and key routes
Ultra fast charge (public)	350kW	1,000km range/hour	10–15 mins	Highways and motorways

Vehicle manufacturers are continuing to upgrade their cars to accept high-capacity chargers. In essence, what this means from a usability perspective is that an EV can be fully charged in as little as 15 minutes. It is important to recognise that this will be rare (few vehicles will be able to) and expensive (it is based on a battery optimised for high-speed charging with other downsides). The reality is that most fast-charging sessions, even now, are only approximately 30 minutes.

APPROXIMATE EV CHARGER COSTS

Table 2 provides approximate costs for different EV charging capabilities. These costs include wiring and central management/control units (smart chargers). These costs are at P80 (meaning the cost should not be exceeded 80% of the time). Firm costs can only be calculated via an electrical contractor inspecting each site and undertaking the necessary testing.

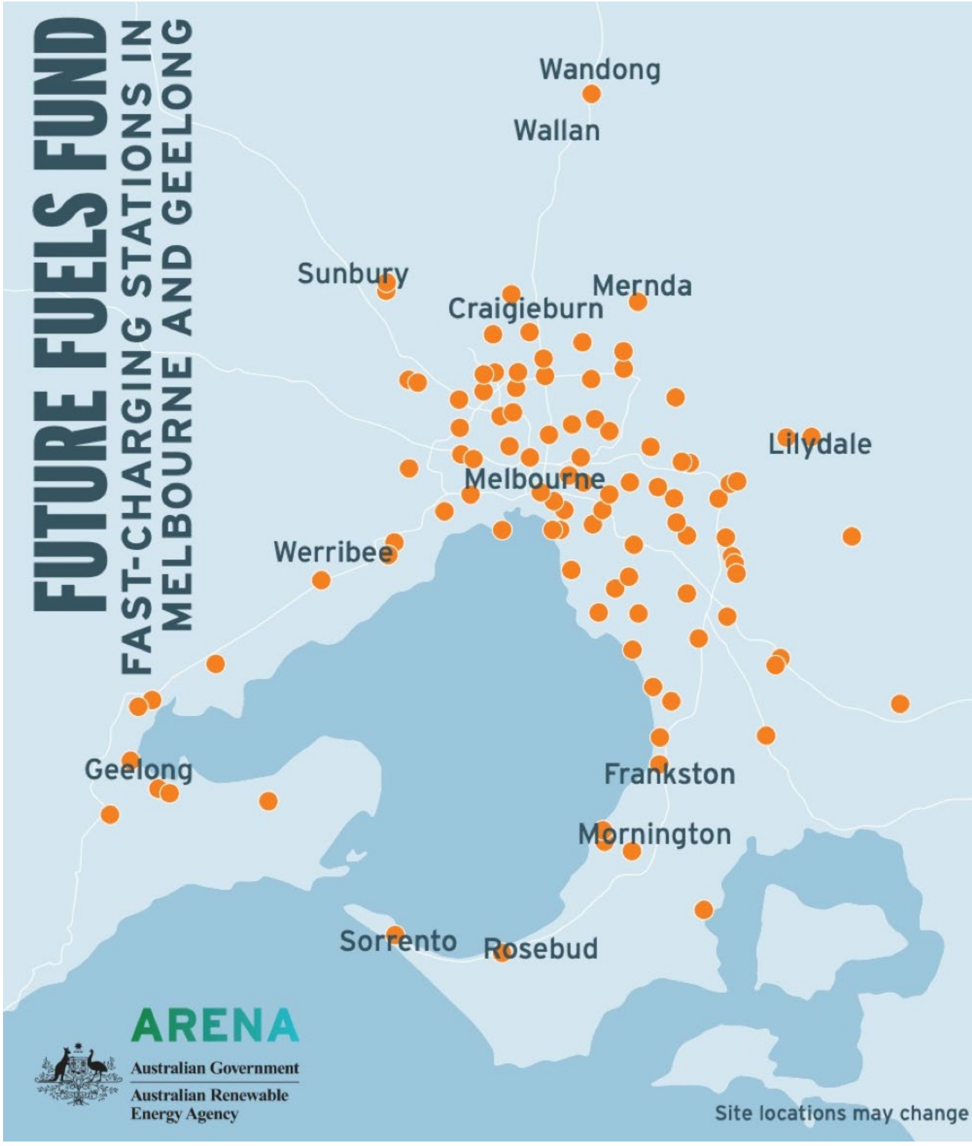
In 2021, ARENA announced a $24.55m funding pool to install a network of fast chargers around Australian cities. Figure 9 identifies the proposed locations for Melbourne, including some within Stonnington. Each of these charging stations will provide a minimum of 50kW per port. These proposed locations have been considered in designing the City of Stonnington EV charging network.

TABLE 2: EV chargers – CapEx costs (approx.)

Charger type	Cost $AU
Single port AC 32A 3-Phase 22kW charger	5,500
Dual port AC 32A 3-Phase 22kW charger	7,000
Dual port DC 25kW charger (one car at a time)	30,000
Dual port DC 50kW charger	50,000

4 Relatively few cars can use full capacity of three phase AC chargers.

FIGURE 9: Future fast charger locations (proposed)



Source: 2021 https://arena.gov.au/

Electric vehicle charging fundamentals

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DIFFERENTIATING THE CHARGING MARKET

It can be helpful to categorise how EV users differ in terms of their charging needs. Figure 10 segments the market into three main categories, based on their circumstance and the charge time they are likely to consider acceptable. At the base of each of the three categories is a suggested charger speed.

A passing through motorist will generally not want to spend a long time waiting for their battery to charge and their priority is to continue their journey with minimal delay. Fast chargers are preferred in these situations and are most suitable close to high volume arterial roads and motorways, as these locations have a much larger catchment of potential users. These are often co-located at, or within proximity to petrol stations, fast food outlets or other roadside amenities. This enables users go to the toilet or buy a coffee, while their vehicle is charging. Typical duration of stay is around 15–30 minutes.

Opportunistic charging describes the charging that takes place when someone was going to that location anyway, and takes the opportunity to top up, because of the availability of a charger. This can be thought of as analogous to charging a phone not because you are low on charge, but because it is convenient for you to top up the battery. It is common for batteries to have more than 20% charge when entering a charging location in these contexts.

A local resident without the ability to charge in an off-street car park will generally find a slow, 7kW public charger suitable for their needs, as overnight charging is possible. However, in areas where most residents don't have off-street charging (such as South Yarra, Prahran, and Windsor), higher powered chargers may be preferred to satisfy demand for charging and managing community expectations for general on-street parking. These factors may need to be reviewed once EV ownership becomes more widespread.

FIGURE 10: Three types of chargers

These chargers need to be close to where users would have parked anyway and are intended to provide a charging opportunity for those that lack an off-street parking bay in which a charger can be easily installed. As identified earlier, this category constitutes a significant proportion of the population in Stonnington.

Figure 11 matches different charging locations with typical duration of visit for these locations. For instance, a residential street with many dwellings that lack off-street parking may be a suitable site for an on-street charger, but because the user generally stays overnight, there is no need to offer anything other than a charger that takes 8–10 hours to fully charge an EV.

FIGURE 11: Matching locations with typical duration of visit with suitable charger speeds

Charging Location	Average Visit Duration	Suitable Charger
» **Residential Street**	8+ hrs	7kW AC
» **Parks and Reserves**	30mins – 2hrs	25kW DC 50kW DC
» **Cafe** » **Town Centre** » **Shopping Centre**	30mins – 1hrs	7kW AC 2 – 50 kW DC 50kW DC
» **Business Parks**	1 – 4 hrs	25kW DC
» **Petrol Stations** » **Fast Food Outlet**	8 – 15 mins	150 – 350 kW DC

Electric vehicle charging fundamentals

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SITE SELECTION – WHAT MAKES A GOOD SITE?

This section provides an outline of the key characteristics that help to guide site location, based on the three charging contexts introduced in Figure 11.

1. Passing through motorist

A summary of the criteria for choosing EV charging sites aimed at passing through motorists is shown in Figure 12.

The following characteristics are important to identifying potential locations for chargers aimed at passing through motorists:

» Potential demand, based on road volume (traffic) data within the catchment of the proposed site. All other factors being equal, a site with 100,000 daily traffic movements within 500m of a site will generally attract more charging sessions than a site with 10,000 daily traffic movements.

» Adequate power supply. As highlighted earlier, passing through motorists generally prefer very fast/ultra-fast chargers and can exert significant demands on the electricity network. It is therefore important to seek locations that have an adequate electricity supply, as the cost of network upgrades can be very high. Some ultra-fast charging sites have cost approximately $700,000, due in part to the network upgrades required.

» Existing off-street parking. It is clearly preferable to have existing off-street parking to locate a fast/ultra-fast charger as opposed to developing new off-street parking which will incur significant costs and additional utilisation of space for parking that may otherwise serve alternative purposes. It is also helpful if these parking bays are not in a location with extremely high average occupancy (e.g. above 90%), as reserving high demand bays for EVs only when, at least in the early years, they are unlikely to be heavily occupied, can cause public resistance to additional EV charging locations.

FIGURE 12: What makes a good site – Passing through motorist

1	Potential demand – based on road traffic volumes
2	Adequate power supply
3	Existing off-street parking and expansion potential
4	Proximity to desirable amenities
5	Minimal installation work required and a lack of other fast chargers nearby

- Finally, having the potential for expansion in future years is beneficial to reduce the likelihood of motorists arriving to find all charging bays full. Queuing for EV charging is considered more frustrating than for petrol/diesel vehicles, as each charging session is generally longer. International experience suggests that ultimately installing fast chargers with 4–6 bays is suitable to minimise the likelihood of demand exceeding supply. Starting with two charging bays initially, and then expanding, is the general practice.
- Proximity to desirable amenities. One of the differences between EV charging and a filling session for an ICE vehicle is that the EV user can leave their car and do other things during the charging session. This, coupled with the fact that most EV charging sessions are longer than ICE filling means that it is convenient to co-locate fast chargers with amenities motorists may find useful while they wait for their charge to complete.
- Minimal installation work required. Each site will have its own set of complexities and sites that do not require extensive upgrades should be prioritised.
- Minimal cost to local government. Increasingly, the commercial sector, often in conjunction with federal and state government financial support are willing to fund fast charging sites.

2. Opportunistic

The following characteristics make a good site for an EV charger targeting *opportunity charging*:

- The driver is going there anyway (to do something else, such as shopping or visiting a café)
- In close proximity (e.g. within 400m) to a diversity of destinations, such as a shopping centre, shopping strip, cafes and other services.
- Has off-street parking
- Located close to high volume roads
- Has a typical duration of stay between 30 min and 2 hours.

Major shopping centres and activity centres are generally considered sites that have many, if not all the above characteristics.

3. Residential

The following characteristics are important to consider for the selection of publicly available chargers focused on *residents without off-street parking*:

- A location in which there is a cluster of housing types that make off sheet charging difficult (e.g. large number of houses without off-street parking, or multi dwelling units in which available parking does not lend itself to the installation of chargers. Older, pre-WWII suburbs can have a housing mix that typically does not include off-street parking
- A location close to where these residents would typically park overnight.

As highlighted earlier, residential chargers are easier to install but cannot service as many people as faster chargers. Residential charging can be installed either in kerbside on-street parking, or in off-street parking bays.

The next section provides some high-level information on the EV charging market.

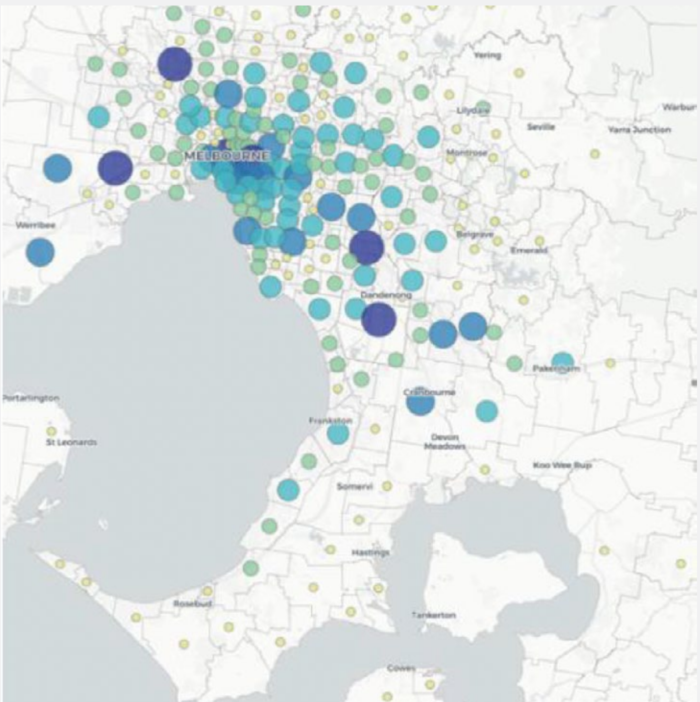

EV

Understanding electric vehicle ownership and charging demand

An understanding of the current and future number of EVs expected to be on the road in Stonnington is necessary to inform the development of the EV charging network. As highlighted earlier, EV sales have been growing rapidly in Australia, albeit from a very low base. This section highlights forecasts for the EV market in Australia, to gain a stronger picture of current trends and market penetration over the medium term.

Australian EV sales figures are shown in Figure 13. It should be noted that the 2021 figures are an estimate based on figures from the early part of 2021. Some commentators have identified that the slowing rate of new ICE vehicles and the sharp increase in EV sales may be described as an Osborne Effect, whereby people delay the purchase of a product they fear may become obsolete soon and are waiting for the new form of the product to be affordable. The announcements by many major vehicle manufacturers that they intend to stop producing ICE vehicles between 2025 and 2035 (e.g. GM, Ford, Volvo and VW) reinforces the notion that it is inevitable EVs will become the dominant form of drivetrain in the future, and may be influencing current trends.

FIGURE 13: EV ownership in Melbourne



Source: Institute for Sensible Transport, using ABS data

Understanding electric vehicle ownership and charging demand

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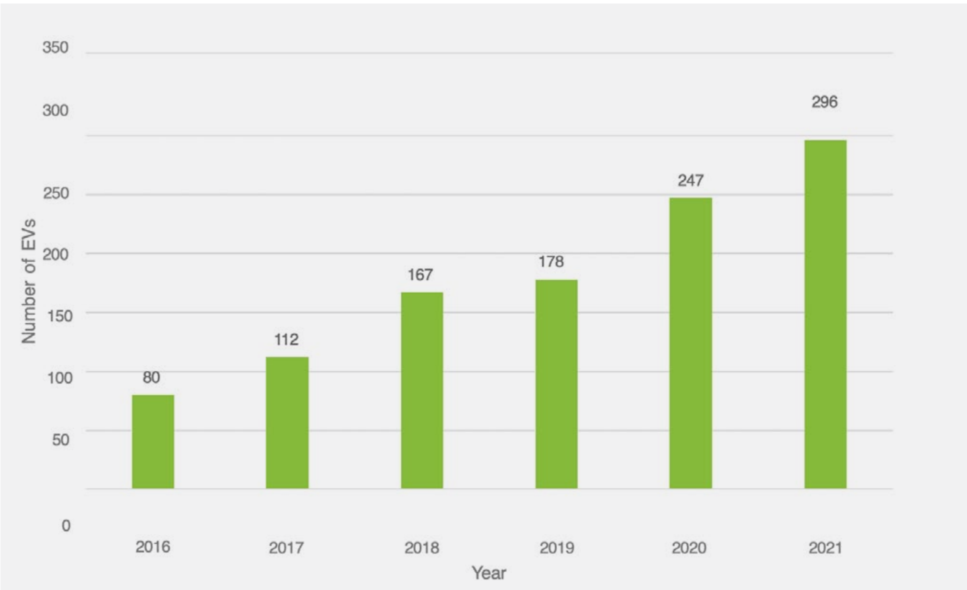
CURRENT EV OWNERSHIP IN STONNINGTON

According to the most recent Australian Bureau of Statistics Motor Vehicle Census (2021), there were approximately 296 EVs in Stonnington postcodes. Figure 14 shows the number of EVs registered over the last few years in Stonnington demonstrating significant growth from approx. 80 EVs in 2016 to almost 300 in 2021.

A map of EV ownership can be found in Figure 7.

FIGURE 14: BEVs registered in postcodes in Stonnington, 2016 to 2021



Note: Postcode boundaries do not always line up perfectly with local government area boundaries, hence figures may not be 100% accurate.

Source: Australian Bureau of Statistics (2021)

FUTURE EV UPTAKE IN AUSTRALIA

The Australian Energy Market Operator (AEMO) commissioned the CSIRO in 2021 to forecast EV adoption rates in Australia.[5] Five scenarios were modelled:

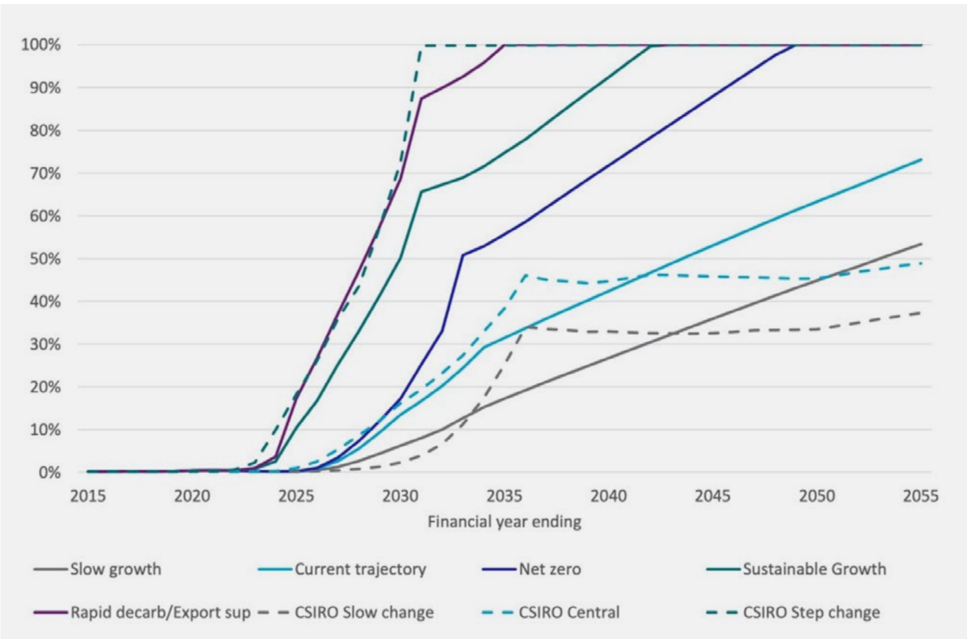
1. Slow Growth
2. Current Trajectory
3. Sustainable Growth
4. Export Superpower
5. Rapid Decarbonisation.

Figure 15 illustrates the results from the CSIRO modelling, indicating that EVs are predicted to account for approximately 50% of all sales by 2027 in the *rapid decarbonisation scenario*, compared to 2044 in the current trajectory scenario. One might question this forecast given that most major vehicle manufacturers have indicated they will no longer produce ICE vehicle by 2030–2035.

As highlighted in the CSIRO report, it is not just the share of new vehicle sales that are important, but the projected share of the national fleet. Even in Norway, in which over 75% of new vehicles sold are EVs, only a minority of vehicles on the road are EVs, as it takes time for this to filter down to the vehicle inventory. The results from CSIRO (shown in Figure 16) forecast that all vehicles are estimated to be electric by 2045 in the rapid decarbonisation scenario and the *slow growth scenario* indicates that only 40% of the fleet are expected to be EVs by 2055.

Finally, the CSIRO report forecasts the total number of EVs, across all vehicle types for 2050, by scenario, as shown in Figure 17. This indicates that in the more ambitious scenarios, over 20m EVs are expected to be within the fleet by 2050, and just over 10m in the current trajectory scenario.

FIGURE 15: Projected sales share, all EVs, compared to selected 2020 projections



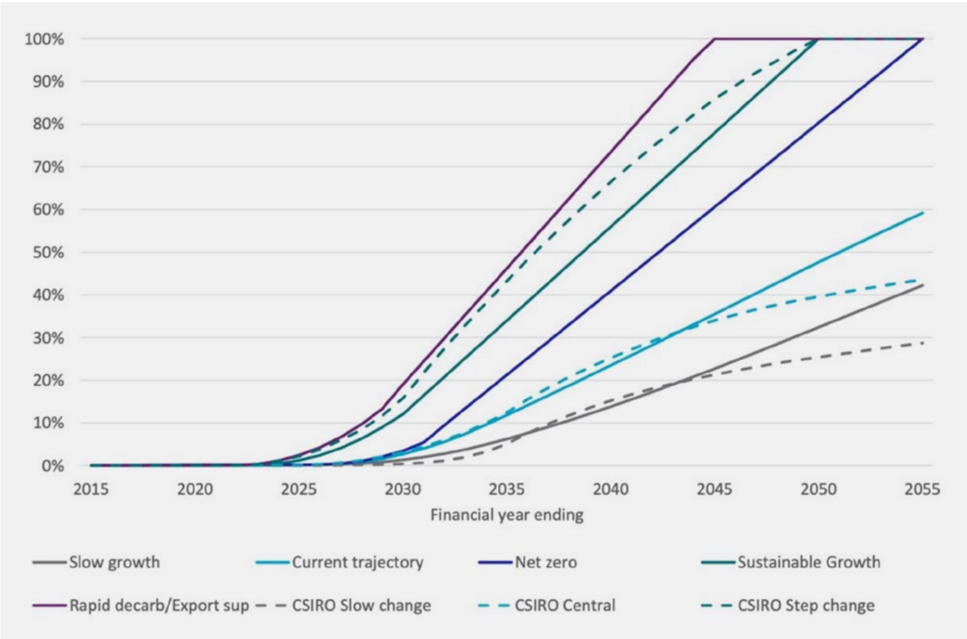
Source: CSIRO

5 https://tinyurl.com/uj7yytxc

Understanding electric vehicle ownership and charging demand

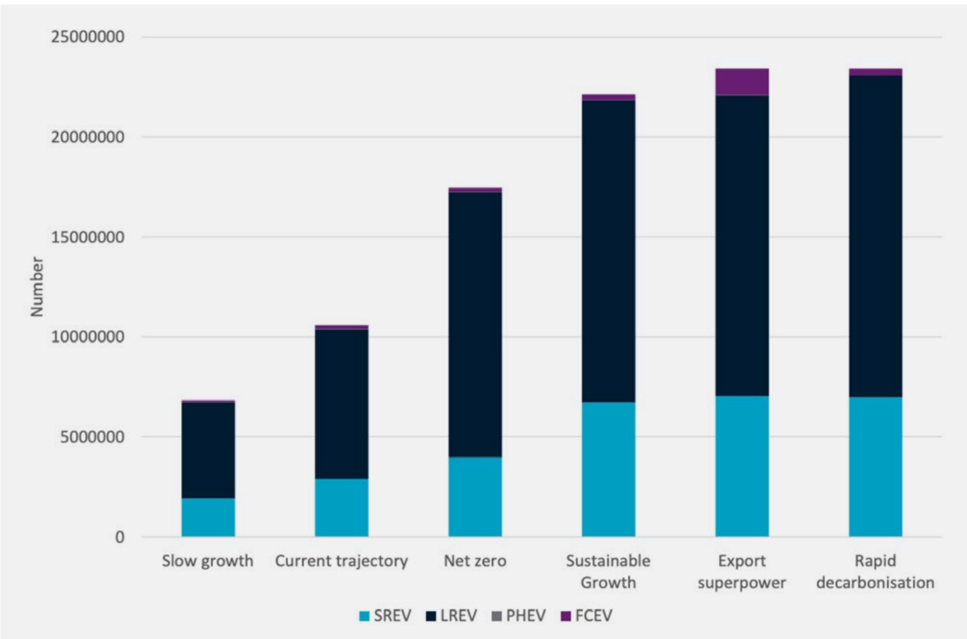
continued...

FIGURE 16: Projected fleet share, all EVs, compared to selected 2020 projections



Source: CSIRO

FIGURE 17: Projected number of EVs, of all types by 2050



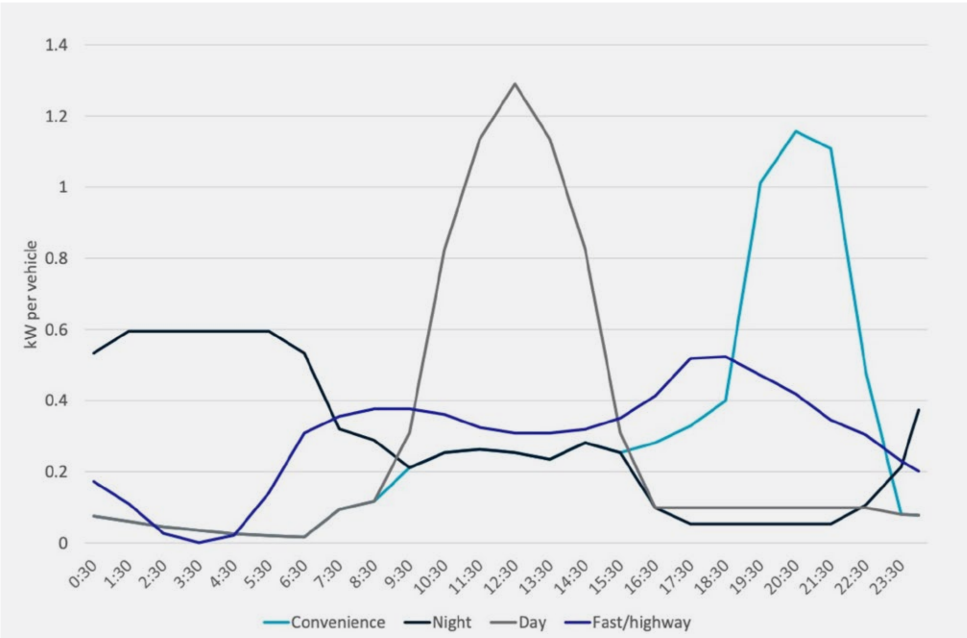
Source: CSIRO

NB: SREV is Short Range Electric Vehicle, LREV is Long Range Electric Vehicle, PHEV is Plug In Electric Vehicle and FCEV is Fuel Cell Electric Vehicle

ESTIMATED TIME OF DAY CHARGING PATTERNS

The average daily charging profiles for light passenger EVs is shown in Figure 18. The day and night profiles are dependent on pricing signals to limit their charging to off-peak times. The convenience charging is most pertinent for the Stonnington EV charging network, as these form the basis for most of the public chargers recommended (called opportunistic chargers in the network plan).

FIGURE 18: Average daily charging profiles for light passenger EVs



Source: CSIRO

Understanding electric vehicle ownership and charging demand

continued...

ESTIMATING FUTURE EV UPTAKE IN STONNINGTON

The data shown earlier in this section makes it clear that there will be significantly more EVs in Stonnington by 2030. It can be expected that between 5%–20% of all passenger cars owned by Stonnington residents will be EVs. There is considerable uncertainty on these figures, which is why the range is so large. As highlighted earlier, the automotive sector is undergoing a rapid transformation and many of the large car manufactures have a stated goal of ceasing internal combustion engine vehicles by 2025–2035. Therefore, it is plausible that by 2030 EVs may constitute 50% or more of total vehicle sales (this is the Victorian government target). As has been the case in Norway, strong EV sales do take many years to have a major impact on *total fleet composition*; and therefore, even achieving 50% of new vehicle sales as EV by 2030 may mean only 5%–10% of the entire fleet in Stonnington is EV.

There will be significantly more EVs in Stonnington by 2030.

Given most dwellings within Stonnington do not have easy access to on-site charging possibilities, (as detailed in Section 7) it can be expected that a significant proportion of future EV owners will seek public access charging.

Stonnington has a higher proportion of residents that will seek public access charging due to the prevalence of dwellings without off-street parking.

Estimates of potential EV fleet size in Stonnington are shown in Figure 19. This shows three different scenarios underpinned by differing assumptions. There are two constant assumptions: that there will be a growth in dwellings in line with projections by *id. consulting.*; and that current vehicle ownership rates per dwelling will remain stable at 2021 Census levels. Three different growth assumptions are modelled:

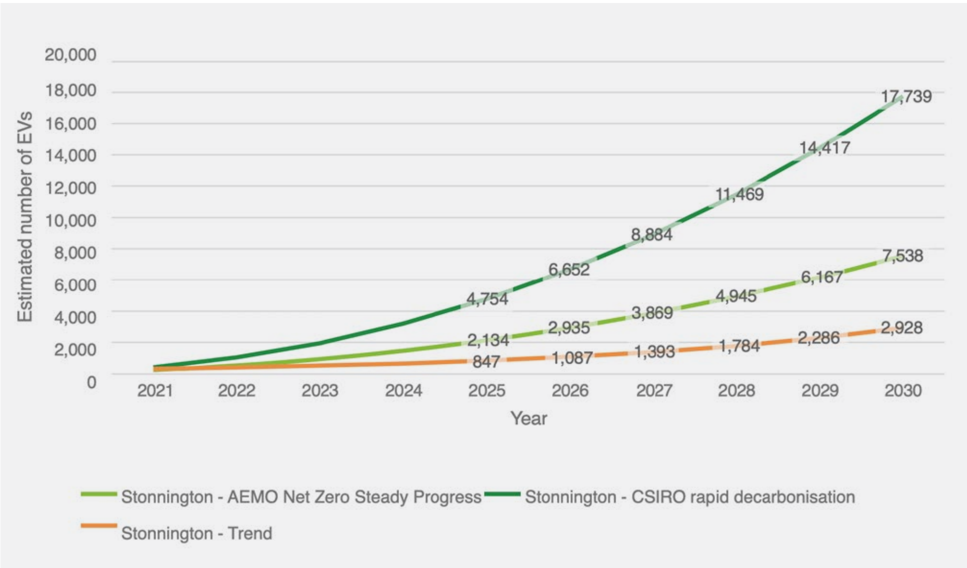
- AEMO *Net Zero 2050* and *Steady Progress*: projects 8.5% of the fleet will be EV by 2030[6]
- CSIRO rapid decarbonisation: projects 20% of the fleet will be EV by 2030
- Stonnington – Trend: which extends the growth rate of the last five years across to 2030, projecting 3.3% of the fleet will be EV by 2030.

In all cases, a curved growth rate has been applied scaling to that target over the next eight years in a non-linear way (i.e. powered or exponential).

6 https://aemo.com.au/-/media/files/major- publications/isp/2021/2021-inputs-assumptions-and-scenarios-report.pdf?la=en

As shown in Figure 19, under an AEMO steady progress scenario, it is estimated that there will be around 2,100 EVs in Stonnington by 2025, rising to around 7,500 EVs in 2030. The results shown in Figure 19 will be used in subsequent components of this project, particularly the estimated demand for the EV chargers recommended in the network plan.

FIGURE 19: Estimated EVs in Stonnington by 2030



Source: CSIRO

Current and funded EV opportunities in Stonnington

This section identifies the publicly available charging that currently exists or funded but not yet implemented.

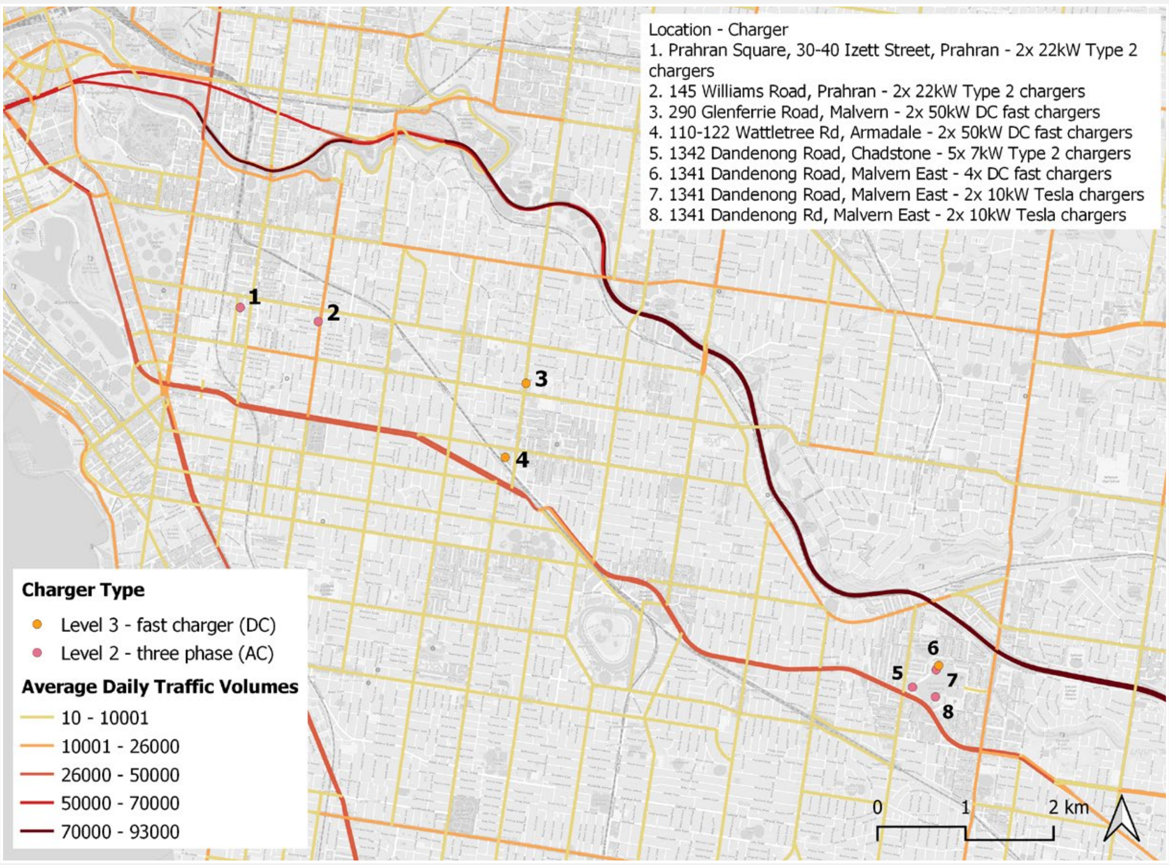
Many of the maps included in this section also include daily average road traffic volumes. As highlighted earlier, locating chargers on higher volume roads increases the likelihood of use and is a well-accepted industry metric used in site selection.

EXISTING AND PLANNED (FUNDED) EV CHARGING LOCATIONS

Figure 20 provides a map of existing publicly available chargers with at least a 7kW AC charge. This map has been created using data from plugshare.com, which is the most widely used platform for EV users to find charging sites.

Currently, there are few fully public EV chargers available in Stonnington; Council manages a 22kW AC charger at Prahran Square and a 50kW DC charger at 290 Glenferrie Road, Malvern. There are also 50kW DC fast chargers at Malvern Central and various charging options available at Chadstone Shopping Centre. There is a charger at BMW South Yarra however this is not always available to the public and may shift to private use as EV ownership increases. Level 1 chargers have been omitted from the network due to their slow rate of charging.

FIGURE 20: Existing and planned EV charging locations



BOX 2: Tesla Chargers and the implications for planning the Stonnington network

Tesla Chargers and the Stonnington EV Charging Plan

Tesla has a network of their own chargers. These are either *destination charger* (offering AC charging), as well as Super Chargers providing between 120–250kW DC charging. At the time of writing, only Tesla vehicles can use these chargers. In a small selection of other countries, Tesla has begun to open its Super Charger network to other EVs. However, at present this generally only includes those in quieter areas where this would not impede access by Tesla drivers. There is no indication of when all EVs will be able to use the Tesla network in Australia. The Stonnington EV charging network proposed in this Plan has been developed under the assumption that:

» Tesla may not open their network for an extended period

» The fee charged to non-Tesla users will be substantially higher than it costs Tesla owners

» The proportion of EVs that are Tesla diminishes as new models from other companies become available.

Given the above considerations, the Tesla network has not been considered when identifying and prioritising locations for future EV charging. Ultimately, the Stonnington charging network is designed to support people regardless of their brand of EV.

EV Charging Network for Stonnington

This section describes the locations in which EV charging is recommended as part of the Stonnington EV charging network for the implementation period 2023–2030. Three categories of charger have been recommended based on segmenting the public charging market into three key categories: passing-through motorist, opportunistic and local resident.

METHODOLOGY

A framework has been developed to inform the Stonnington EV charging network plan. This includes the three categories of public charging identified below. Additionally, a description of this charging market segmentation was captured in Figure 10.

1. Ultra-Fast Chargers (150kW DC+) catering to the *Passing Through Motorist*
2. Medium/Fast Chargers (25–50kW DC) catering to the *Opportunistic* charger
3. Slow Chargers (~7kW AC) catering to the resident lacking the ability to charge at their residence.

To support Stonnington's commitment to reducing carborn emissions, it is recommended that public charging is installed in all activity centres by 2030 and prioritises those areas likely to be most heavily used and fill major gaps in the charging network.

The remainder of this section describes the approach to the development of the charging network, as well as proposed sites, implementation year and the type of charger proposed.

ULTRA-FAST CHARGERS

Ultra-fast chargers are expensive; therefore, it is necessary to install them strategically. They should only be placed in areas that have significant passing through traffic and limited alternative fast charging sites.

The process of identifying suitable ultra-fast charging sites focused on locations scoring strongly on the criteria identified in Figure 21.

A manual scan of Stonnington was undertaken, with an overlay of road traffic volumes and existing or planned EV ultra-fast chargers. Victorian road traffic volume data[7] is collected by the state government, it is relatively fine grained (compared to other transport data) and it is of high quality.

The results of this exercise can be seen in 'Results', page 43..

FIGURE 21: Passing through motorist EV charging site criteria

1	Potential demand – based on road traffic volumes
2	Adequate power supply
3	Existing off-street parking and expansion potential
4	Proximity to desirable amenities
5	Minimal installation work required and a lack of other fast chargers nearby

7 https://discover.data.vic.gov.au/dataset/traffic-volume

EV Charging Network for Stonnington

continued...

OPPORTUNISTIC CHARGERS

As highlighted earlier, opportunistic charging describes the charging that takes place when someone was going to that location anyway. The motorist takes the opportunity to top up because of the availability of a charger.

The criteria used to prioritise sites for opportunistic chargers is shown in Figure 22.

As highlighted in Figure 10, opportunistic chargers typically deliver 25–50kW DC charging, although it is possible to include 11–22 kW AC charging as a lower cost alternative. Commercial EV charging providers typically prefer DC charging, as the fee charged to motorists can be higher and more drivers are likely to take up the offer. State and Commonwealth funding is generally for DC chargers.

The prioritisation framework developed to inform the roll out of opportunistic chargers is based around activity centres. *Plan Melbourne* categorises activity centres into the categories (in order of importance):

1. Metropolitan
2. Major, and
3. Neighbourhood.

A freely available spatial dataset of Metropolitan and Major Activity Centres was used as the basis of this plan; however, locations of neighbourhood activity centres are not specified by *Plan Melbourne*. Neighbourhood activity centres were then identified using the *Stonnington Activity Centre Strategy*, Planning Zone information and Google Maps.

FIGURE 22: Opportunistic charger site criteria

1	Driver going there anyway
2	Close proximity to diversity of destinations
3	Off-street parking
4	Close to high volume roads
5	Typical duration of stay between 30 min and 2 hrs

Within Stonnington, the activity centre dataset shown in Figure 23 currently contains four major and 19 neighbourhood activity centres. The size of the neighbourhood activity centre can be further broken down into four small and 15 large activity centres based on the draft Stonnington Activity Centres Strategy 2016. Due to their large yet linear typologies, the Chapel Street and Glenferrie Road – High Street activity centres were further divided into smaller sections for the analysis. The results are presented as points in Figure 24. The numbers labelled beside each point corresponds with name of each activity centre found in Table 5.

Box 3 provides a summary of why sporting and recreational facilities are not the focus of this changing plan.

BOX 3: Charging at sporting facilities

Charging at sporting, recreational and community facilities

There are a number of reasons the EV charging industry is apprehensive about providing charging at sporting, recreational and community facilities. While it is common for libraries and other community venues to have EV charging installed, outdoor sporting and recreational facilities do present barriers to the industry's willingness to invest in these areas, as:

- These locations often have low levels of passive surveillance
- Higher levels of vandalism have been experienced at chargers in these locations
- For much of the week, these areas have low levels of use, reducing the economic performance of these chargers.

Therefore, while local governments may have an interest in providing chargers at facilities such as libraries and similar locations, sporting and outdoor recreation areas are not the focus of this charging plan, due to the likely resistance from the EV charging industry.

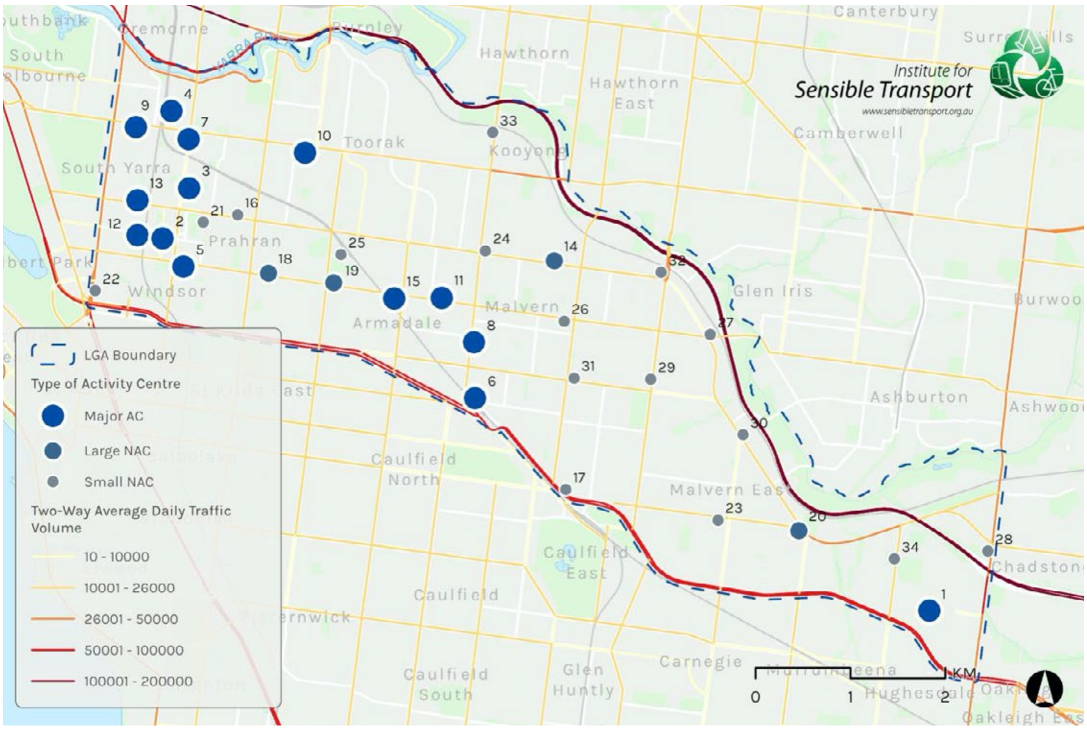
EV Charging Network for Stonnington

continued...

FIGURE 23: Activity Centres in Stonnington

Source: DELWP, VPA, City of Stonnington, Google Maps

FIGURE 24: Activity centres in Stonningtonn



Source: DELWP, VPA, City of Stonnington, Google Maps

General boundaries were created for each activity centre within which an EV charging station could be installed. Generally, the boundary was drawn to include the activity centre's main commercial area as well as any significant nearby parks or reserves.

Due to the quality and completeness of available activity centre information, neighbourhood activity centres had to be mapped manually. Therefore, the list has a level of subjectivity in which neighbourhood activity centres were considered significant enough to be included in analysis. The boundary of each activity centre was also drawn manually.

Prioritising activity centres

The factors influencing activity centre priority have been identified as:

» The size, diversity and regional significance of the activity centre – These are the three factors affecting the attractiveness of the activity centre for EV users. Charging duration is assumed to be between 30 mins and 2 hours, which is matched with typical stays for accessing services/ destinations near these locations.

» Nearby traffic volume – Higher traffic volumes near an activity centre is an indicator of the number of people driving to the activity centre.

» Distance from nearest EV charger – activity centres that don't have another EV charger nearby are more likely to benefit from the installation of an EV charger due to the added convenience for EV users already going to the activity centre.The variables gathered for each activity centre are shown in Table 3.

BOX 4: Why the Roadmap does not identify exact locations?

Identifying areas, not pin-pointing locations

One of the strongest messages from the EV charging industry is that they find it problematic for government to pin-point precise locations for EV charging sites. By identifying and prioritising activity centres for EV charging, Stonnington is then able to allow the EV charging industry to focus their attention on the specific location within the activity centre to install chargers.

The site assessmentsreplace within Appendix 1 may in some instances coincide with the locations preferred by operators.

TABLE 3: Variables for each Activity Centre within Stonnington.

Variable	Relevant influencing factor	Value details
Plan Melbourne Activity Centre Type Designation	Regional significance of the activity centre (Stonnington Activity Centres Strategy)	3 – Major 2 – Large Neighbourhood 1 – Small Neighbourhood 0 – Future Activity Centres or not recognised
Amount of commercially zoned area within activity centre	Size of activity centre	Square metres of land zoned as: Activity Centre Zone (ACZ1), Mixed Use Zone (MUZ) or Commercial Zone (C1Z)
WalkScore[8] in activity centre	Diversity of activity centre	WalkScore value (a proxy for diversity of destinations) at centroid of Activity Centre Polygon
Two-Way Average Daily Traffic	Nearby Traffic Volume	Highest volume segment of road within 500m of activity centre
Linear distance from nearest existing or proposed charger	Distance from nearest EV charger	Distance in metres from nearest charger over 25kW. Existing chargers sourced from Plug Share, proposed chargers sourced from ARENA Future Fuels map and Vic government funded chargers, and includes fast chargers proposed by IST

Method for standardising the variables

As variables represent different types of data, they need to be standardised into consistent variable scores between 0 and 1. Several methods were attempted to determine the best representation of activity centre priority.

8 https://tinyurl.com/ye294cpu

Weighting variables and creating a final prioritisation score

The variables were assigned a weighting, based on the estimated number of people going to an activity centre. Therefore, the amount of commercially zoned area and WalkScore were given a slightly higher weighting in the final score, as proxies for the relative number of people visiting the activity centre. Traffic volume was also given a higher weight as an indication of the number of motorists travelling near the activity centre. The weightings are shown in Table 4.

TABLE 4: Variable weightings.

Variable	Weight
Plan Melbourne Activity Centre Type	0.125
Amount of commercially zoned area	0.25
WalkScore	0.25
Traffic Volume	0.25
Distance from nearest charger	0.125

EV Charging Network for Stonnington

continued...

Local resident

A need for publicly available residential chargers can arise when dwellings do not allow for the installation of charging facilities. This may be because the dwelling does not have an off-street car park, or because the off-street car parks are shared or in a difficult location.

A local resident without the ability to charge at their home may rely on public charging facilities for most of their charging. The approach taken in this project is for these needs to be met in one of two ways, or a combination of the two. Firstly, these residents may find a medium to fast DC charger their preferred method of charging. This essentially relies on the opportunistic chargers proposed for Stonnington's activity centres. In general, the areas with the highest expected demand for residential charging need are the areas that scored highest on the prioritisation framework (meaning they are recommended for a relatively early installation period). The second option is to offer a demand responsive system for installing chargers, based on application by residents. This is detailed in Figure 25 and Residential Charging Plan.

In the first instance, it is reasonable for the City of Stonnington to suggest residents without the ability to charge an EV on their property to use one of the chargers proposed for a Stonnington activity centre (see Section 6.2.2).

Understanding spatial variation in estimated residential charging need

The VicMap Parcel_View spatial data file was joined to the Parcel table in Esri's ArcGIS Pro. The resulting layer was then clipped to the Residential land cover selected from the ABS Meshblock dataset. The Plan Zone dataset was intentionally not used because activity centre and commercial centre zones did not account for the residential dwellings within. The Parcel View was then categorised by its size, with parcels of 350m^2 and less classified as small, and parcels over 350m^2 classified as large.

Using the VicMap Address dataset, overlapping points were counted and exported as a new shapefile. The resulting shapefile showed single dwellings and multi-dwellings at any given street address. This shapefile was then spatially joined to the Parcel_View shapefile where the points within a parcel were summed. The resulting layer showed the count of points within any given parcel of land.

Further information regarding the recommended approach for Council is provided in Recommendations to reduce EV transition barrier presented to households without easy access to charges on property.

FIGURE 25: Residential charging, recommended approach

1	Cluster of the house typolgies that makes off-street charging difficult
2	Close to where these residents would typically park overnight
3	Can be installed kerbside or off-street
4	Demand responsive – residents submit online requests form for Council to consider

RESULTS

This section describes the results of the prioritisation framework, for ultra-fast chargers (passing through motorists) and fast/medium chargers (opportunistic chargers).

Ultra-fast Chargers

As part of the southeast corridor, significant traffic passes through Stonnington. The Monash Freeway is the primary corridor carrying high volumes of traffic through Stonnington and it provides the most appropriate sites for a future ultra-fast charger.

While the City of Stonnington may play a facilitation role in the development of an ultra-fast charging site, it will not be the priority provider, which is always one for either the state or commonwealth governments, in combination with the EV charging industry. Put simply, they cost too much for local government to fund.

Two sites (see Figure 26) were identified by IST on the eastern border of the municipality at a site on Waverley Road, Malvern East currently housing a fast food restaurant and Chadstone Shopping Centre. Both sites have existing off-street car parks and amenities, providing a short rest stop for motorists travelling through without adversely impacting local traffic. These sites are also within the proximity of two other main traffic arteries in Stonnington (Princes Freeway and Warrigal Road).

These sites are privately owned and so are included here for indicative purposes only.

FIGURE 26: Recommended ultra-fast, existing and planned chargers in Stonnington.

EV Charging Network for Stonnington

continued...

OPPORTUNISTIC CHARGERS

This section presents the results of the prioritisation process across Stonnington, across each of the variables introduced in Opportunistic Chargers. Chadstone SC, Greville Village and the Princes Gardens section of Chapel Street had the highest priority for opportunistic chargers. Chapel Street as a whole should be prioritised as shown in Figure 27. A full breakdown of the individual scores can be found in Table 5.

Figure 28 presents the overall results for opportunistic charging sites, categorised by recommended implementation phase, based on their prioritisation score. Table 5 identifies the individual scoring across all variables for each activity centre within Stonnington.

FIGURE 27: Activity centre prioritisation scores.

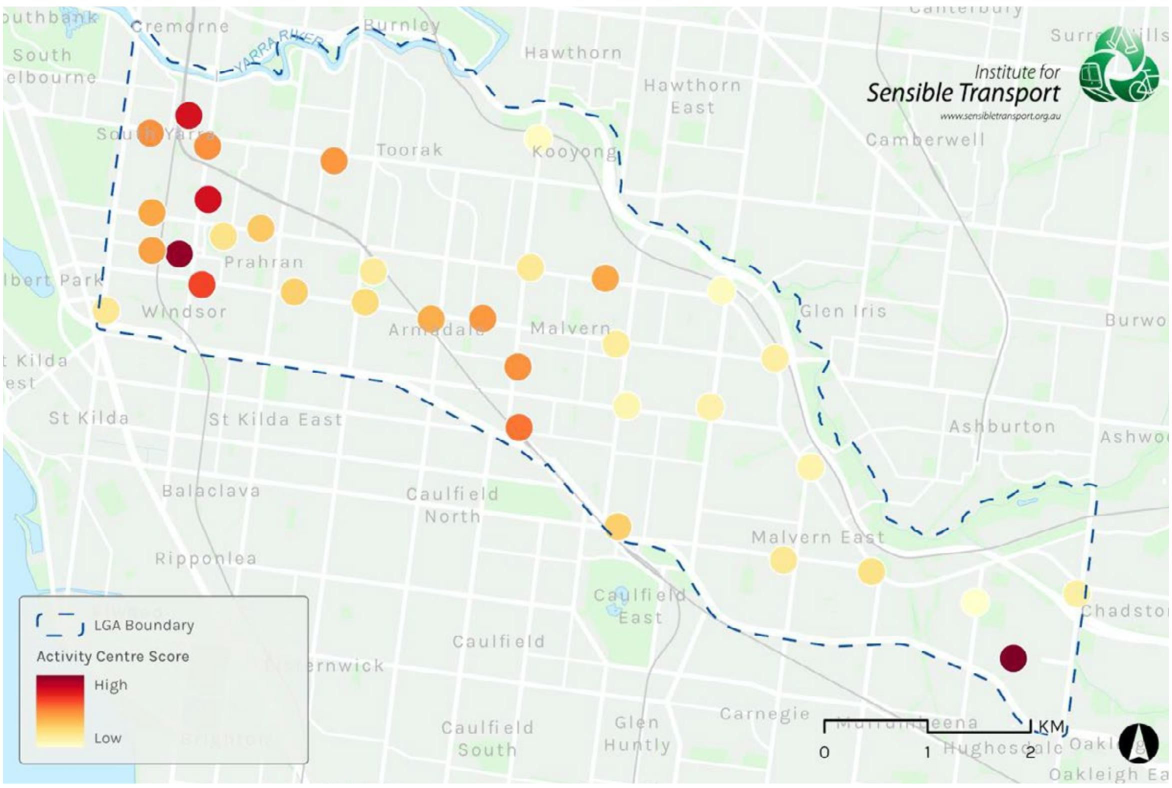


FIGURE 28: Opportunistic and ultra-fast charger implementation phase based on prioritisation score.

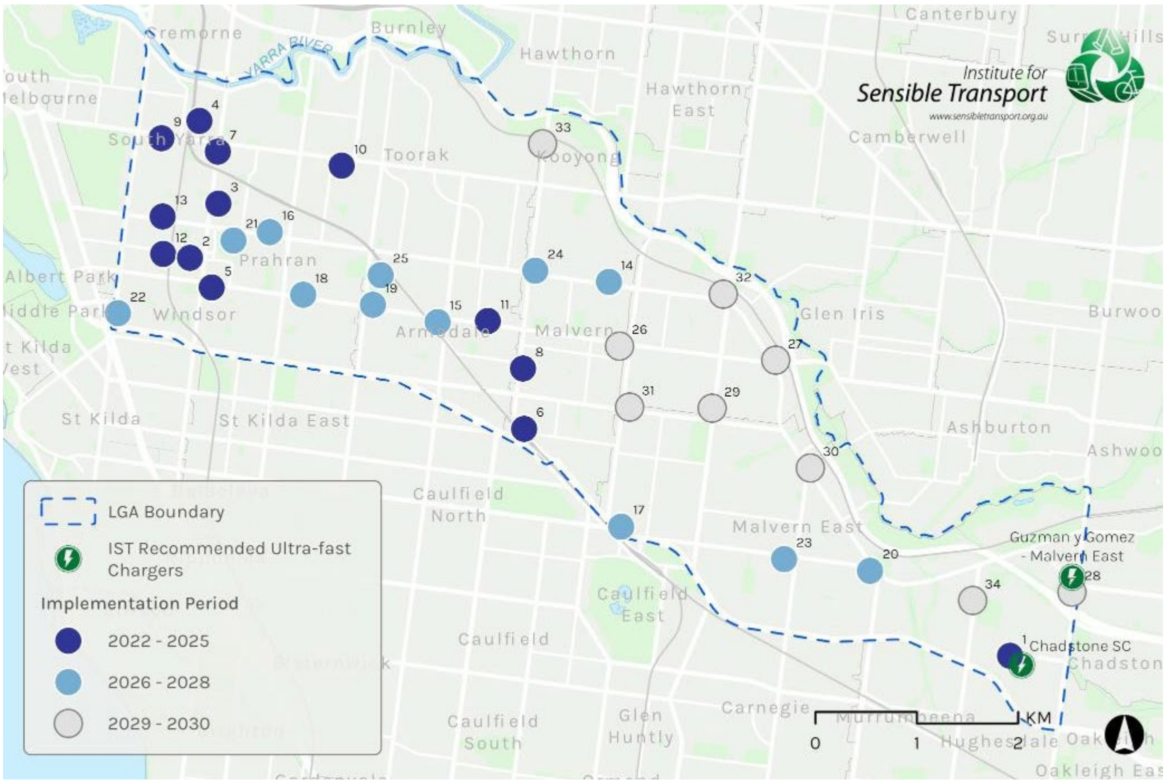


TABLE 5: Activity centre opportunistic charger standardised scores, Stonnington.

#	Variable	Type	AC Type	Commercial Zone Area	Walk score	Traffic Volume	Prioritisation Score	Year
1	**Chadstone SC**	Major AC	1.000	1.000	0.920	1.000	0.630	2025
2	**Chapel Street AC – Greville Village and Princes Gardens**	Major AC	1.000	0.928	1.000	0.146	0.611	2025
3	**Chapel Street AC – Jam Factory District and Market District**	Major AC	1.000	0.688	1.000	0.046	0.548	2025
4	**Chapel Street AC – Forest Hill**	Major AC	1.000	0.620	1.000	0.489	0.542	2025
5	**Chapel Street AC – Windsor Village**	Major AC	1.000	0.412	1.000	0.321	0.486	2025
6	**Glenferrie Road - Malvern Central**	Major AC	1.000	0.268	0.970	0.302	0.442	2025
7	**Chapel Street AC - Toorak Road Central**	Major AC	1.000	0.173	1.000	0.060	0.420	2025
9	**Glenferrie Road, Malvern**	Major AC	1.000	0.169	0.970	0.302	0.417	2025
10	**Toorak Village**	Major AC	1.000	0.190	0.930	0.091	0.407	2025
11	**High Street, Armadale**	Major AC	1.000	0.212	0.910	0.028	0.406	2025
12	**Chapel Street AC - Greville Village**	Major AC	1.000	0.061	1.000	0.146	0.394	2025
13	**Chapel Street AC - Market District**	Major AC	1.000	0.028	1.000	0.146	0.386	2025
14	**Malvern Village**	Large NAC	0.667	0.248	0.860	0.919	0.383	2028
15	**High Street, Armadale**	Major AC	1.000	0.088	0.910	0.045	0.376	2028
16	**Hawksburn SC**	Small NAC	0.333	0.216	0.910	0.352	0.332	2028
17	**Waverley Road NAC**	Small NAC	0.333	0.234	0.950	0.078	0.340	2028
18	**Prahran East Village**	Large NAC	0.667	0.082	0.900	0.074	0.331	2028

#	Variable	Type	AC Type	Commercial Zone Area	Walk score	Traffic Volume	Prioritisation Score	Year
19	**High Street and Orrong Road**	Large NAC	0.667	0.031	0.880	0.019	0.312	2028
20	**East Malvern Village**	Large NAC	0.667	0.050	0.780	0.209	0.296	2028
21	**Hawksburn SC**	Small NAC	0.333	0.050	0.950	0.041	0.293	2028
22	**Punt Road, Windsor**	Small NAC	0.333	0.021	0.910	0.377	0.284	2028
23	**East Malvern Terminus**	Small NAC	0.333	0.065	0.890	0.000	0.280	2028
24	**Malvern Hill Village**	Small NAC	0.333	0.023	0.920	0.026	0.278	2028
25	**Beatty Avenue, Toorak**	Small NAC	0.333	0.094	0.830	0.059	0.274	2028
26	**High Street and Toroonga Road**	Small NAC	0.333	0.054	0.860	0.027	0.271	2030
27	**Glen Iris Village**	Small NAC	0.333	0.030	0.760	1.000	0.264	2030
28	**Warrigal Road, East Malvern**	Small NAC	0.333	0.041	0.740	1.000	0.262	2030
29	**Central Park Village**	Small NAC	0.333	0.046	0.800	0.053	0.254	2030
30	**Darling Village**	Small NAC	0.333	0.068	0.740	0.280	0.251	2030
31	**Wattletree Village**	Small NAC	0.333	0.039	0.770	0.016	0.244	2030
32	**Malvern Road - Burke Road NAC**	Small NAC	0.333	0.033	0.620	0.981	0.229	2030
33	**Kooyong Village**	Small NAC	0.333	0.009	0.700	0.305	0.227	2030
34	**Malvern Valley Shopping Strip**	Small NAC	0.333	0.024	0.650	0.180	0.215	2030

Understanding where within an activity centre to install chargers

As highlighted earlier, in Box 4, the EV charging industry prefer local governments to identify areas rather than precise locations as the starting point for an EV charger network. Once an area is identified, a more detailed assessment of the most appropriate specific location can be made. The commercial EV charging sector is often willing to invest in the capital cost of installation and they are interested in determining the specific locations of the charging stations.

The site assessments later in this report may in some instances coincide with the locations preferred by operators and provide useful input to facilitate the development of the EV charging network.

MAXIMISING THE USER EXPERIENCE

A well-run, easy to use charging network helps to encourage the transition towards zero emission mobility. Conversely, a poorly maintained network can cause frustration to users and reflect poorly on local government. The following provides a set of measures to enhance the user experience:

» Match charger speed with typical duration of stay. If people generally stay at a location for 15-30 minutes, installing a 7kW AC charger is unlikely to meet most people's charging needs. Similarly, if another location has people typically spending 2 hours, there is no need to install an ultra-fast charger in that location.

» Offer one DDA compliant bay per charger station where possible

» Utilise off-street parking bays were possible

» Offer drive-through charging where possible, to allow longer vehicles or vehicles with trailers to access chargers

» Provide cables for Type 2 plugs for AC charging, and CCS and CHAdeMO for DC

» Ensure the chargers are connected to a charger network provider for App development and payment options, as well as a 24/7 driver support hotline. Ensure drivers are easily able to report a fault

» Ensure regular maintenance is carried out, and technical issues are resolved in a timely manner

» Position chargers in a location that maximises passive surveillance and install CCTV where necessary.


EV PARKING
PLUG IN
ELECTRIC
CAR BAY
ELECTRIC
CAR BAY

Residential charging plan

A significant number of residents in Stonnington do not have the ability to charge an EV on their property.

Only 42% of households have easy access to charging on site. The majority (58%) reside in houses that lack off-street parking or are in multi-dwelling properties with car parking. Such developments can be extraordinarily complex to install EV charging due to ownership structures or the physical difficulties of retrofitting suitable electrical infrastructure. For these reasons, it is likely there will be an increasing need for Council to facilitate charging opportunities for the majority of Stonnington residents that may find charging an EV difficult or impossible on their property.

ASSESSING THE NEED

The first half of this section describes the process used for assessing the spatial distribution and quantity of housing in Stonnington likely to be unable to easily accommodate EV charging on premises. The second component describes the results of this process undertaken by the Institute for Sensible Transport.

Methodology

Using data provided by the Victorian government, overlapping addresses in the VicMap Address shapefile were counted to identify single and multi- dwellings. This was then spatially joined to VicMap Parcel, which provided the parcel sizes for each address. As the Address dataset does not differentiate between commercial or residential addresses, the resulting shapefile was then clipped to residential area as determined by 2021 MeshBlock categorisation of land.

From this shapefile, single lots were identified and further categorised by size into small (350m2 and smaller) and large (above 350m2) parcels. This was done on the assumption that a small land parcel will, on average, not have the capacity to store a motor vehicle.

Results were then intersected with Stonnington's GIS data for driveways which presented the final dataset for analysis.

A 500m buffer was applied around the centroids for each activity centre to establish dwellings that had access to opportunistic chargers.

Proximity to the electricity network is an important prerequisite for charging infrastructure. Of all the residential addresses in Stonnington, almost 100% of them are within 10m of a public lighting point.

Data limitations

The results relied on the accuracy of the data files; however, some minor inaccuracies can be expected. The VicMap Address dataset does not differentiate between residential and commercial addresses; therefore, it was intersected with the ABS Meshblock shapefile to determine residential areas. However, this dataset covers a larger area, and it does not account for multistorey mixed developments where commercial and residential properties are, particularly in South Yarra. The driveway data is from 2005 and does not reflect development since then.

Results

The residential dwellings with the highest concentration of dwellings lacking easy access to charging were concentrated in the west of the Stonnington area. For instance, South Yarra and Windsor, where dwellings of smaller parcel sizes and high number of multi-dwelling developments, are likely to be some of the most common locations in which residents will find it difficult to charge an EV on their property.

Dwellings were classed with two graduated colour schemes as shown in Figure 29. This map identifies the spatial variation in dwellings in terms of property size, and whether a driveway is present.

The concentration of dwellings without the capacity to easily charge on their property aligns spatially with the activity centres that receive the highest prioritisation scores for the opportunistic charger network. Given this alignment, the most efficient approach to enabling these households to own and charge an EV is to recommend they use the chargers proposed for activity centres. Based on typical driving behaviour amongst Stonnington residents, an EV owner would need to charge between once and twice a fortnight. Geospatial analysis shows that 76% of all residents will be no further than 500 metres from their nearest opportunistic charger. The benefit of this approach is that the opportunistic chargers will be able to serve a larger number of EVs for two principal reasons. Firstly, the charger output is significantly higher, enabling a near empty to full charge within an hour (matching a typical duration of stay for activity centre visitors). Secondly, the locations of these chargers, embedded within activity centres with a diversity of destinations will attract a much larger spectrum of the charging market. In essence, these chargers will provide value to all three of the charging market types illustrated in Figure 10.

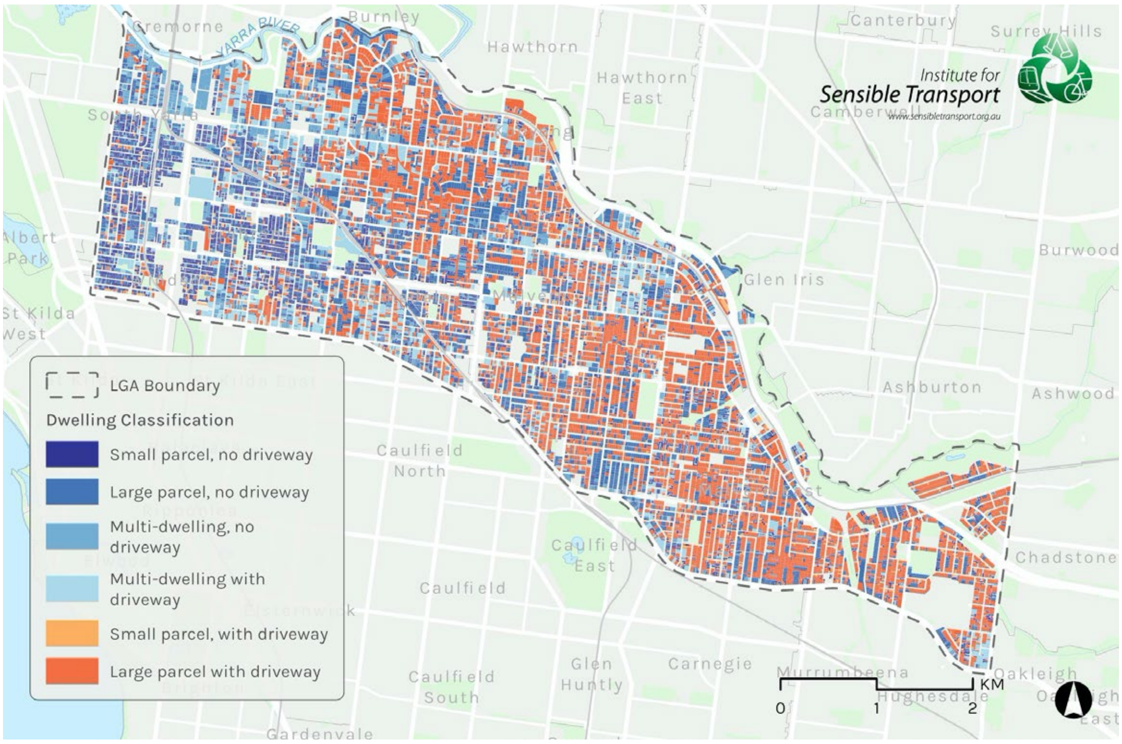
Institute for Sensible Transport also outlined a demand responsive approach detailed in Recommendations to reduce EV transition barrier presented to households without easy access to charges on property, to provide slow overnight chargers primarily for residents without the ability to charger on their property. For larger charging stations in activity centres (with perhaps 6–8 chargers) it may be useful to include two slower, AC chargers and a pricing structure that encourages their use for overnight charging.

Figure 30 overlays the recommended opportunistic chargers with the dwelling classification, showing the overlap between areas without easy access to home charging and the concentration of opportunistic chargers.

The concentration of dwellings without the capacity to easily charge on their property aligns spatially with the activity centres that receive the highest prioritisation scores for the opportunistic charger network. Given this alignment, the most efficient approach to enabling these households to own and charge an EV is to recommend they use the chargers proposed for activity centres.

Geospatial analysis shows that 76% of all residents will be no further than 500 metres from their nearest opportunistic charger.

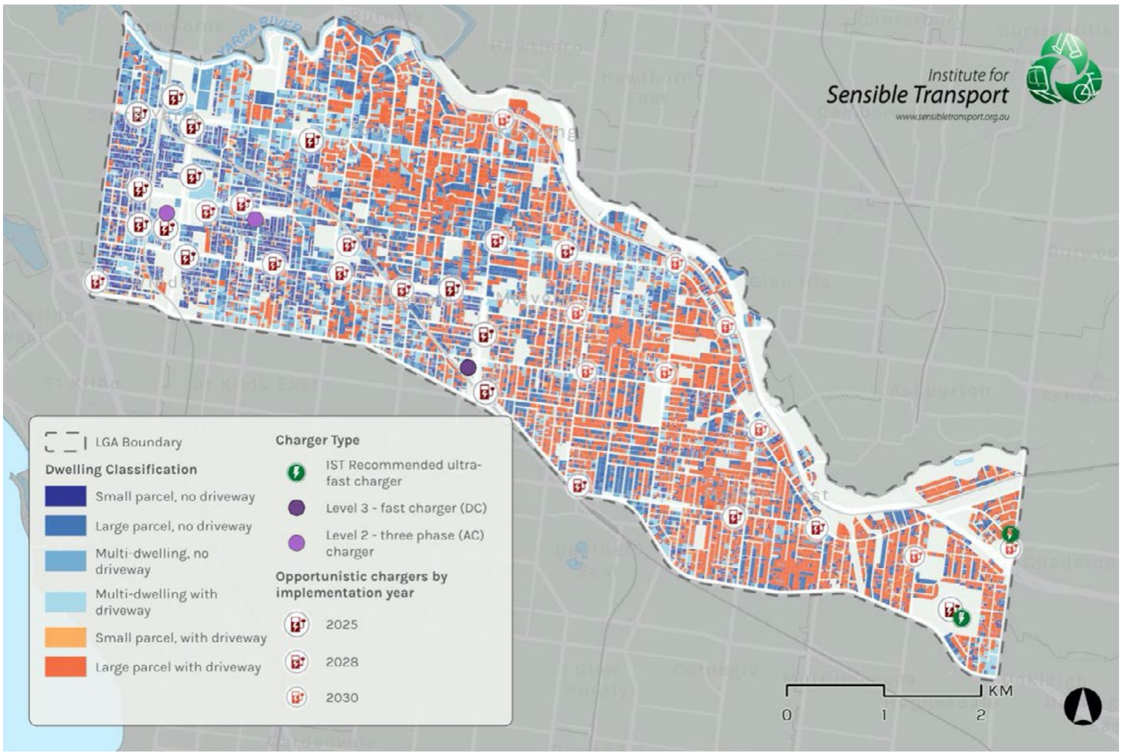
FIGURE 29: Potential EV charging demand.



Residential charging plan

continued...

FIGURE 30: Residential charging demand with opportunistic chargers



BOX 5: Snapshot of how councils seek to offer EV charging for residents without off-street parking?

What's been done elsewhere to support residents without off-street parking to charge EVs?

This box provides a summary of what other jurisdictions have done to enable residents without the ability to charge an EV on their premises to transition to EV ownership.

More information is available in Appendix 1: EV Charging Case Studies.

Eastern Councils of Sydney (Waverly, Woollahra, and Randwick Councils), NSW

This coalition of three councils work together to develop their EV charging network. Many of the residents in this area of Sydney do not have access to off-street parking. While their AC charging program does not explicitly respond to individual charging needs for residents without off-street parking, around one third of users are local. They began their AC charger network with six chargers, which has grown to 10 and expected to be 20 by October 2022. They are beginning to develop an EV Charging Strategy.

City of Port Phillip, VIC

The City of Port Phillip has announced a trial in which residents can pay around $5,000 to have an EV charger placed in an on-street car park outside their home without off-street parking. There is also a $2,500–$3,000 per annum insurance requirement, payable by the household, which Port Phillip are in the process of trying to change. This program provides the householder with the ability to charge their EV but does not grant exclusive use of the parking bay. While they are the only people able to use the charger, anyone can park in the bay. The charger is connected to the householder's electricity supply. At the time of writing, one permit has been issued, five applications are under review and no units have been installed. As highlighted elsewhere, it is a very expensive solution that blurs the line between private and public use. Having a private asset on public land, where the charger can only be used by the householder, but the parking bay can be used by all members of the public is likely to result in tension between neighbours both wishing to use the same bay.

Merri-bek, VIC

Merri-bek provide a network of free 7kW, 22kW AC and 50kW DC chargers for residents to use, as well as those outside of the Merri-bek City Council. This program began eight years ago as part of the Victorian Government's Electric Vehicle Trial. A total of sixteen chargers are offered, capable of charging fourteen cars simultaneously. Merri-bek will be looking at the performance of the City of Port Phillip trial before deciding whether to proceed with something similar.

Oslo, Norway

Norway is recognised as the global leader in EV ownership, with around 80% of new cars being EV. Oslo has a large percentage of its housing stock without off-street parking. This section offers a summary of on-street charging policy for Oslo residents. In the early days of Oslo's transition to EVs, there was one charger for every four EVs. The ratio is now around 1:10 and the City of Oslo is seeking to increase the number of chargers, as it is recognised to be a barrier to further EV adoption. There are currently around 1,300 public charging points in Oslo, with a goal to grow this by 600 per year. The City of Oslo has also subsidised 8,000 charging points in apartments.

London, UK

London has a wide variety of initiatives designed to speed the transition towards EVs. On-street chargers are commonplace in London, and these are either standalone devices, or provided as part of other electrical infrastructure, like lamp posts. As the transition matures, an increasing number of commercial businesses are filling the gaps where demand and other factors do not necessitate the implementation of an on-street public charger.

Reducing barriers to households without charging access

The Institute for Sensible Transport recommends a structured approach to assessing the need for providing EV charging infrastructure for those lacking a suitable EV charging location on their premises.

In the first instance, when a request from a resident for an EV charger near their home is received, it is recommended to suggest the resident use the opportunistic chargers in activity centres. These have been recommended in this report but are not yet constructed. Most of the high priority sites for opportunistic chargers align with suburbs that have the highest concentration of dwellings unlikely to easily accommodate charging infrastructure.

An additional approach is the development of a demand responsive process, where, requesting an EV charging facility near their home is submitted online including proof of residential and a notional fee paid. The request could then be assessed to determine suitability.

A demand responsive system takes the guess work out and only installs chargers intended for residential use where an eligible household has expressed interest and committed to signing up.

Another benefit is that these chargers can be used by anyone with an EV permit, meaning one charger can service multiple households. Given that most EVs will only require an overnight charge once a week or less, asset utilisation is maximised when multiple households can use the same charger.

Charging from light poles and power poles

Charging infrastructure integrated with power poles and light poles is common internationally (details of which are outlined in Appendix 1).

However, there are few examples of this approach currently in Australia. Ownership and management of electricity infrastructure differs state-to-state in Australia. In Victoria, electricity distributors own and manage the infrastructure.

Stonnington will continue to investigate and advocate for improved processes to allow EV infrastructure to be integrated with electricity distributor assets. Doing so would open up significant opportunities to meet future demand for EV charging, especially in the western half of Stonnington, where off-street residential parking is less common.

Regulations

To make best use of the asset, publicly available EV charging bays should be used only for EV charging, not EV storage. The regulation should be guided by the following principles:

- A vehicle not plugged in is illegal (even EVs)
- If you are plugged in, you are legal
- If you are plugged in, you are timed
- If you are timed, you pay.

The City of Stonnington's Parking Permit program would need to be updated.

Fee structure

A fee structure for residential slow chargers should be recommended and is based on the principle that it should be sufficient to cover the cost of:

- Equipment
- Installation
- Electricity costs
- Ongoing maintenance and repair.

A cost of about 30 cents per kWh should be sufficient to cover the above costs. The private EV charging market generally do not see slow AC chargers as being commercially attractive and; therefore, it can be expected that this type of charger will require the City of Stonnington to own this asset.

Estimating usage, emissions reduction and funding options

This section includes analysis undertaken by the Institute for Sensible Transport which estimates usage, impact on emissions and funding options for the Stonnington EV charging network.

ESTIMATING EV CHARGING USAGE

This section provides a usage estimate of the EV charging stations included in the proposed network. Our methodology is described, followed by an overview of our results.

Methodology

Our method of estimating EV charger usage relies on the EV fleet adoption forecasts described in Understanding electric vehicle ownership and charging demand.

Fleet assumptions

Key fleet assumptions are shown in Table 6. It is assumed that 8.5% of the fleet will be EV by 2030, which is in line with the AEMO/CSIRO figures described in Section 4. We base our assumptions on the annual distance travelled per vehicle on the ABS Motor vehicle Census, and the consumption of electricity per kilometre on the industry average.

These assumptions are critical to developing an understanding of the overall quantity of electricity that the EV fleet in Stonnington will require by 2030.

Charging site assumptions

The second step in the development of estimated charging usage is to establish assumptions on the acceptable level of charging bay occupancy and the amount of electricity transferred per charge. For the purposes of our modelling, we have assumed sites are provided with a 50kW DC charger, as this is the predominant charger output recommended in the EV charging plan.

Table 7 outlines the assumptions built into the model regarding charging sites. Four hours of charging per day, per port is the general industry standard of acceptability, beyond which, the possibility of EVs arriving with charging bays occupied becomes too high. As highlighted earlier, because charging sessions are much longer than petrol refilling, arriving to charge an EV when all ports are in use will typically result in much longer wait times (especially for stations with only two ports).

TABLE 6: Fleet Assumptions

EV fleet composition in 2030	8.5%
Annual kilometres travelled	11,400km
Average energy per km (Wh)	142 Wh

TABLE 7: Charging site assumptions

Acceptable daily hours of use per site, per port	4 hours
Port average power output (% of total output)	70%
Average charging session	25 kWh

Charging behaviour assumptions

The third step is to set out assumptions regarding how EV owners will charge their vehicles; in particular, the balance between charging at home/work versus public charging. This is important because as highlighted earlier, up to 95% of EV charging occurs either at home or work, and this has implications for the demand on public charging.

Table 8 highlights the assumptions for the percentage of homes with EV charging capability within Stonnington. It should be noted that this may vary across Stonnington, as shown in Figure 31. Almost all homes in some areas of Stonnington are detached or semi-detached homes with private off-street parking (and thus can install EV charging), whereas other areas, such as Windsor and Prahran, have many streets where all or most households do not have off-street parking.

Table 8 also includes an assumption on the percentage of public charging that occurs from those with, and without home charging. These values can be altered in the Excel tool as well.

TABLE 8: Charging behaviour assumptions

Homes with EV charging capability		42%
Charging done on the public charging network	Cars with home charging	5%
	Cars without home charging	75%

RESULTS

Total vehicle and EV fleet

Table 9 provides Stonnington's estimated fleet composition, use, and energy demands from 2023 to 2030, based on AEMO's Net Zero 2050 and Steady Progress projections. This shows the model assumptions for the total vehicle fleet (of all fuel types), based on a combination of ABS Motor Vehicle Census, combined with estimated growth in dwellings, across Stonnington. The total number of EVs expected to be within the fleet, between 2023 and 2030 is also shown in Table 9.

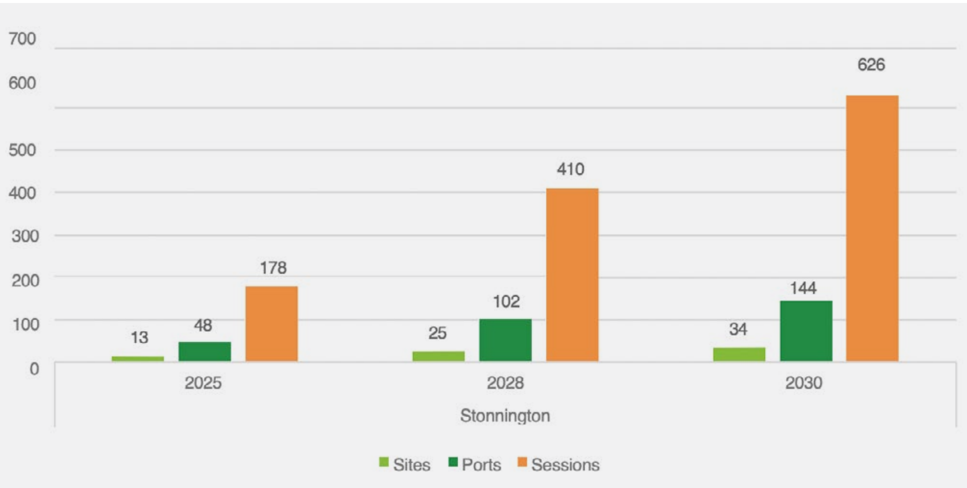
An important element in the development of an EV charging network designed to support the fleet is the estimation of the number of kilometres the EV fleet is expected to travel, and how this varies by year. These results have been generated by combining average vehicle travel per year with the forecasted number of EVs in the fleet. The estimated EV travel is shown in Table 9.

The electricity estimated to be consumed through EV travel is calculated by combining vehicle kilometres travelled (VKT) with average EV power consumption, on a per kilometre basis. The results of this exercise is shown in Table 9. We have used the assumptions contained in Table 8 to calculate the quantity of electricity (kWh) we estimate will be consumed on the public charging network, as shown in Table 9.

TABLE 9: Projections of Stonnington's vehicle fleet composition, use and energy demands, 2022 to 2030

	2023	2024	2025	2026	2027	2028	2029	2030
Total vehicle Fleet	81,160	82,310	83,461	84,612	85,631	86,651	87,670	88,690
EV share of total fleet	1.2%	1.8%	2.6%	3.5%	4.5%	5.7%	7.0%	8.5%
EV vehicle fleet	934	1,469	2,134	2,935	3,869	4,945	6,167	7,539
Annual VKT from EV vehicle fleet	10,643,482	16,744,897	24,331,069	33,456,531	44,108,184	56,372,617	70,298,140	85,933,064
Annual kWh consumption from EV vehicle fleet	1,511,374	2,377,775	3,455,012	4,750,827	6,263,362	8,004,912	9,982,336	12,202,495
Annual kWh of public charging demand from EV vehicle fleet	689,187	1,084,266	1,575,485	2,166,377	2,856,093	3,650,240	4,551,945	5,564,338

FIGURE 31: Estimated charging sites, ports and sessions



Estimated charging sites and ports required to support future EV fleet

The estimated number of charging sites and the number of ports required at each site have been calculated. A high-level overview is provided in Figure 31. This is followed by an itemised list according to the charging network prioritisation process described in Section 6.

Estimated cost of equipment

Table 10 presents estimated costs for the equipment and installation per install period. It is important to note:

- Installation costs can vary significantly from site to site and individual site inspections have helped provide an indication of network capacity.
- As highlighted earlier, it is not expected councils will typically be responsible for the costs shown in Table 10, as this can be met by the private market in most if not all instances.
- Due to the installation approach of only installing ports in pairs, there may be a slight discrepancy between the number of ports shown in Table 10 and earlier tables.
- For the purposes of estimating costs, a 50kW DC dual port charger has been used as the default charger type.

TABLE 10: Estimated EV charging equipment costs

Installation period	Ports	Cost
2023 to 2025	26	$650,000
2026 to 2028	76	$1,900,000
2029 to 2030	42	$1,050,000

Charger usage and ports required

The following tables outline the model's results for each of the activity centres in Stonnington, ordered by the prioritisation score it received (as described in Section 6). The estimated number of charging ports required per site, by year is shown in Table 11. The estimated use of charging ports, by average hours per port, for per site, by year is shown in Table 12. The estimated use of charging ports, by average watthours per port, for per site, by year is shown in Table 13. The estimated average daily consumption of power, in kWh per site by year is shown in Table 14. In combination, this provides Stonnington with an estimation of use (in terms of hours used, and energy consumed) across time and how many charging ports may be necessary to support this use.

TABLE 11: Ports required per site, by year

Site	2023	2024	2025	2026	2027	2028	2029	2030
Chadstone SC	0	0	4	6	6	6	6	6
Chapel Street AC – Greville Village and Princes Gardens	0	0	4	6	6	6	6	6
Chapel Street AC – Jam Factory District and Market District	0	0	4	4	6	4	6	6
Chapel Street AC – Forest Hill	0	0	4	4	6	4	6	6
Chapel Street AC – Windsor Village	0	0	4	4	6	4	6	6
Glenferrie Road – Malvern Central	0	0	4	4	6	4	4	4
Chapel Street AC – Toorak Road Central	0	0	4	4	4	4	4	4
Glenferrie Road, Malvern	0	0	4	4	4	4	4	4
Chapel Street AC – Toorak Road West	0	0	4	4	4	4	4	4
Toorak Village	0	0	4	4	4	4	4	4
High Street, Armadale	0	0	4	4	4	4	4	4
Chapel Street AC – Greville Village	0	0	2	4	4	4	4	4
Chapel Street AC – Market District	0	0	2	4	4	4	4	4
Malvern Village	0	0	0	0	0	4	4	4
High Street, Armadale	0	0	0	0	0	4	4	4
Hawksburn SC	0	0	0	0	0	4	4	4
Waverley Road NAC	0	0	0	0	0	4	4	4
Prahran East Village	0	0	0	0	0	4	4	4

TABLE 11: Ports required per site, by year *continued...*

Site	2023	2024	2025	2026	2027	2028	2029	2030
High Street and Orrong Road	0	0	0	0	0	4	4	4
East Malvern Village	0	0	0	0	0	4	4	4
Hawksburn SC	0	0	0	0	0	4	4	4
Punt Road, Windsor	0	0	0	0	0	4	4	4
East Malvern Terminus	0	0	0	0	0	4	4	4
Malvern Hill Village	0	0	0	0	0	4	4	4
Beatty Avenue, Toorak	0	0	0	0	0	2	4	4
High Street and Toroonga Road	0	0	0	0	0	0	0	4
Glen Iris Village	0	0	0	0	0	0	0	4
Warrigal Road, East Malvern	0	0	0	0	0	0	0	4
Central Park Village	0	0	0	0	0	0	0	4
Darling Village	0	0	0	0	0	0	0	4
Wattletree Village	0	0	0	0	0	0	0	4
Malvern Road – Burke Road NAC	0	0	0	0	0	0	0	4
Kooyong Village	0	0	0	0	0	0	0	4
Malvern Valley Shopping Strip	0	0	0	0	0	0	0	2

TABLE 12: Estimated average use per day in hours per port, per site, per year

Site	2023	2024	2025	2026	2027	2028	2029	2030
Chadstone SC	-	-	3.2	2.9	3.8	3.0	3.8	3.8
Chapel Street AC – Greville Village and Princes Gardens	-	-	3.1	2.8	3.7	2.9	3.7	3.7
Chapel Street AC – Jam Factory District and Market District	-	-	2.8	3.8	3.3	4.0	3.3	3.3
Chapel Street AC – Forest Hill	-	-	2.7	3.8	3.3	3.9	3.3	3.3
Chapel Street AC – Windsor Village	-	-	2.5	3.4	3.0	3.5	2.9	2.9
Glenferrie Road – Malvern Central	-	-	2.2	3.1	2.7	3.2	4.0	4.0
Chapel Street AC – Toorak Road Central	-	-	2.1	2.9	3.8	3.0	3.8	3.8
Glenferrie Road, Malvern	-	-	2.1	2.9	3.8	3.0	3.8	3.8
Chapel Street AC – Toorak Road West	-	-	2.1	2.9	3.8	3.0	3.7	3.7
Toorak Village	-	-	2.1	2.8	3.7	2.9	3.7	3.7
High Street, Armadale	-	-	2.1	2.8	3.7	2.9	3.7	3.7
Chapel Street AC – Greville Village	-	-	4.0	2.7	3.6	2.8	3.5	3.5
Chapel Street AC – Market District	-	-	3.9	2.7	3.5	2.8	3.5	3.5
Malvern Village	-	-	-	-	-	2.8	3.5	3.4
High Street, Armadale	-	-	-	-	-	2.7	3.4	3.4
Hawksburn SC	-	-	-	-	-	2.5	3.1	3.1
Waverley Road NAC	-	-	-	-	-	2.4	3.0	3.0
Prahran East Village	-	-	-	-	-	2.4	3.0	3.0
High Street and Orrong Road	-	-	-	-	-	2.3	2.8	2.8
East Malvern Village	-	-	-	-	-	2.1	2.7	2.7
Hawksburn SC	-	-	-	-	-	2.1	2.6	2.6
Punt Road, Windsor	-	-	-	-	-	2.1	2.6	2.6
East Malvern Terminus	-	-	-	-	-	2.0	2.5	2.5
Malvern Hill Village	-	-	-	-	-	2.0	2.5	2.5
Beatty Avenue, Toorak	-	-	-	-	-	4.0	2.5	2.5
High Street and Toroonga Road	-	-	-	-	-	-	-	2.4
Glen Iris Village	-	-	-	-	-	-	-	2.4
Warrigal Road, East Malvern	-	-	-	-	-	-	-	2.4
Central Park Village	-	-	-	-	-	-	-	2.3
Darling Village	-	-	-	-	-	-	-	2.3
Wattletree Village	-	-	-	-	-	-	-	2.2
Malvern Road – Burke Road NAC	-	-	-	-	-	-	-	2.1
Kooyong Village	-	-	-	-	-	-	-	2.0
Malvern Valley Shopping Strip	-	-	-	-	-	-	-	3.9

Estimating usage, emissions reduction and funding options

continued...

TABLE 13: Average uses per day, based on kWh, by site, per year

Site	2023	2024	2025	2026	2027	2028	2029	2030
Chadstone SC	0	0	18	25	33	26	32	32
Chapel Street AC – Greville Village and Princes Gardens	0	0	18	24	32	25	31	31
Chapel Street AC – Jam Factory District and Market District	0	0	16	22	29	23	28	28
Chapel Street AC – Forest Hill	0	0	16	22	28	22	28	28
Chapel Street AC – Windsor Village	0	0	14	19	25	20	25	25
Glenferrie Road – Malvern Central	0	0	13	18	23	18	23	23
Chapel Street AC – Toorak Road Central	0	0	12	17	22	17	22	22
Glenferrie Road, Malvern	0	0	12	17	22	17	22	22
Chapel Street AC – Toorak Road West	0	0	12	17	22	17	21	21
Toorak Village	0	0	12	16	21	17	21	21
High Street, Armadale	0	0	12	16	21	17	21	21
Chapel Street AC – Greville Village	0	0	12	16	21	16	20	20
Chapel Street AC – Market District	0	0	11	15	20	16	20	20
Malvern Village	0	0	0	0	0	16	20	20
High Street, Armadale	0	0	0	0	0	16	19	19
Hawksburn SC	0	0	0	0	0	14	18	18
Waverley Road NAC	0	0	0	0	0	14	17	17
Prahran East Village	0	0	0	0	0	14	17	17
High Street and Orrong Road	0	0	0	0	0	13	16	16
East Malvern Village	0	0	0	0	0	12	15	15
Hawksburn SC	0	0	0	0	0	12	15	15
Punt Road, Windsor	0	0	0	0	0	12	15	15
East Malvern Terminus	0	0	0	0	0	12	15	15
Malvern Hill Village	0	0	0	0	0	12	15	15
Beatty Avenue, Toorak	0	0	0	0	0	12	14	14
High Street and Toroonga Road	0	0	0	0	0	0	0	14
Glen Iris Village	0	0	0	0	0	0	0	14
Warrigal Road, East Malvern	0	0	0	0	0	0	0	14
Central Park Village	0	0	0	0	0	0	0	13
Darling Village	0	0	0	0	0	0	0	13
Wattletree Village	0	0	0	0	0	0	0	13
Malvern Road – Burke Road NAC	0	0	0	0	0	0	0	12
Kooyong Village	0	0	0	0	0	0	0	12
Malvern Valley Shopping Strip	0	0	0	0	0	0	0	11

TABLE 14: Charger use, in kWh per day, by site, per year

Site	2023	2024	2025	2026	2027	2028	2029	2030
Chadstone SC	0	0	445	612	807	638	795	794
Chapel Street AC – Greville Village and Princes Gardens	0	0	432	594	783	618	770	769
Chapel Street AC – Jam Factory District and Market District	0	0	388	533	703	555	692	691
Chapel Street AC – Forest Hill	0	0	383	527	695	549	684	683
Chapel Street AC – Windsor Village	0	0	344	472	623	492	613	612
Glenferrie Road – Malvern Central	0	0	312	430	567	447	558	557
Chapel Street AC – Toorak Road Central	0	0	297	408	538	425	530	529
Glenferrie Road, Malvern	0	0	295	406	535	422	527	526
Chapel Street AC – Toorak Road West	0	0	294	404	533	421	525	524
Toorak Village	0	0	288	396	522	412	514	513
High Street, Armadale	0	0	287	395	521	411	513	512
Chapel Street AC – Greville Village	0	0	278	383	505	398	497	496
Chapel Street AC – Market District	0	0	273	375	494	390	487	486
Malvern Village	0	0	0	0	0	388	484	483
High Street, Armadale	0	0	0	0	0	380	474	473
Hawksburn SC	0	0	0	0	0	344	428	428
Waverley Road NAC	0	0	0	0	0	336	419	418
Prahran East Village	0	0	0	0	0	335	417	417
High Street and Orrong Road	0	0	0	0	0	315	393	393
East Malvern Village	0	0	0	0	0	300	374	373
Hawksburn SC	0	0	0	0	0	296	369	369
Punt Road, Windsor	0	0	0	0	0	287	358	357
East Malvern Terminus	0	0	0	0	0	284	354	353
Malvern Hill Village	0	0	0	0	0	281	351	350
Beatty Avenue, Toorak	0	0	0	0	0	277	346	345
High Street and Toroonga Road	0	0	0	0	0	0	0	341
Glen Iris Village	0	0	0	0	0	0	0	333
Warrigal Road, East Malvern	0	0	0	0	0	0	0	330
Central Park Village	0	0	0	0	0	0	0	321
Darling Village	0	0	0	0	0	0	0	316
Wattletree Village	0	0	0	0	0	0	0	308
Malvern Road – Burke Road NAC	0	0	0	0	0	0	0	289
Kooyong Village	0	0	0	0	0	0	0	286
Malvern Valley Shopping Strip	0	0	0	0	0	0	0	271

Estimating usage, emissions reduction and funding options

continued...

POTENTIAL EMISSIONS REDUCTION

Introduction

The Institute for Sensible Transport developed a model to estimate future emissions savings due to the electrification of vehicles. The model compares emissions savings under different scenarios and shows the impact of different variables on emissions savings.

Model limitations

Due to the complexity and uncertainty of future scenarios, estimates of emissions and abatement are subject to a high level of uncertainty. demonstrated by the variability between the different modelled scenarios.

There are also many factors for which Stonnington has no influence over including ICE and EV future fuel efficiencies, and electricity grid decarbonisation so likely scenarios are included. The model also does not consider the possible impact of the EV charging network boosting levels of EV adoption, with a growth in charger availability already built into the CSIRO/AEMO model.

Scenarios

Model results presented below are based on the combination of variables. The three scenarios modelled only differed on two of the parameters as described in Table 15. The two parameters are assumed to be somewhat correlated, as a high uptake in EV is likely to result in ICE vehicle manufacturers abandoning all effort to improve the vehicle efficiency.

All three scenarios assumed the same levels for the other variables:

» **Share of EV charging performed at public stations:** 5% (for those with home charging capability) 75% (for those without home charging capability)

» **%-renewable-energy used at public stations:** 100% renewable; at-home charging is 100% grid-based

» **Future improvement to EV travel efficiency:** similar to historical improvements to ICE efficiencies over 2000–2018

» **Grid decarbonisation rate:** Fast Transition (e.g., reducing from 0.8 to 0.3 kg CO_2-e per kWh by 2030; net zero by 2033), as shown in Table 15.

TABLE 15: Model parameters

Model parameter	Scenario 1	Scenario 2	Scenario 3
Rate of EV uptake (exponential growth to 2030)	20% EV uptake by 2030	8.5% EV uptake by 2030	3.3% EV uptake by 2030
Projected improvement to ICE efficiency	No improvement (i.e., 2030 ICE fuel efficiency = today's efficiency)[9]	No improvement	Extension of historical ICE improvements (2000 – 2016, ABS)

TABLE 16: Grid emissions projections, 2021 to 2030

Financial Year	kg CO2-e per kWh
2023	0.78
2024	0.74
2025	0.67
2026	0.63
2027	0.53
2028	0.52
2029	0.45
2030	0.31

9 This is due to the announcement from a number OEMs that they will cease their work on improvements to ICE technology.

Results

Model results presented below are based on the combination of variables highlighted earlier. The graphs below depict key outcomes from these scenarios:

» Figure 32 shows the expected vehicle emissions per year for each scenario
» Figure 33 compares the net emissions avoided per year for each scenario.

The Excel tool produced for the emissions modelling component of this project allows the user to generate more specific outputs and alter key parameters to better understand the potential emissions impact of the EV Charging Plan.

FIGURE 32: Total vehicle emissions by scenario, 2022 to 2030

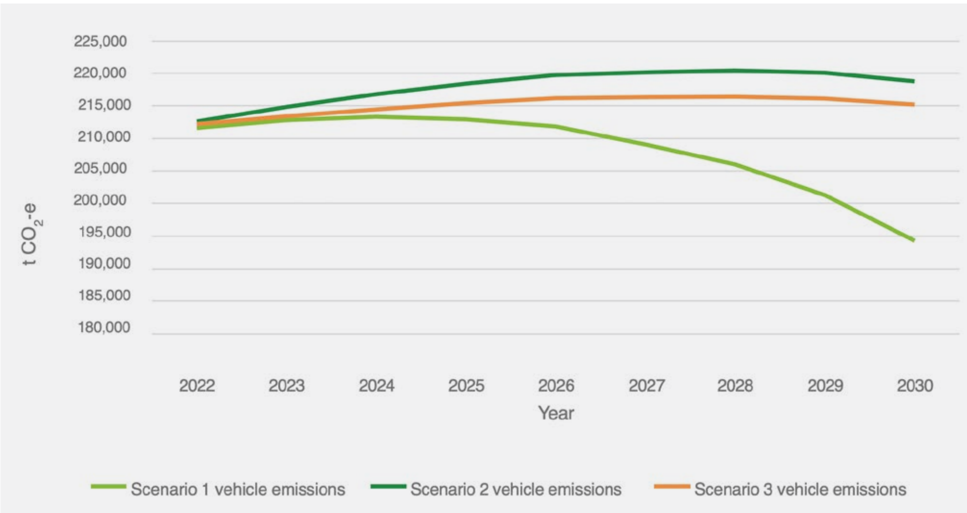
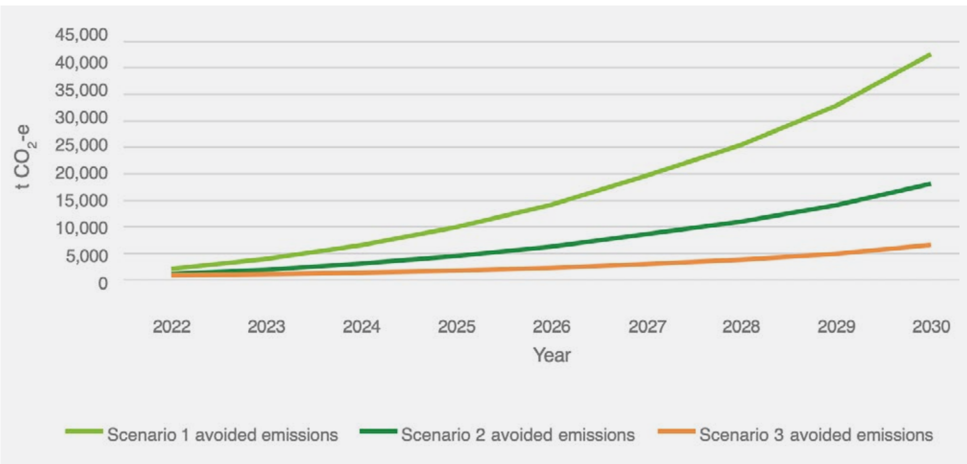


FIGURE 33: Avoided vehicle emissions by scenario, 2022 to 2030



Conclusion

This process has found that the rate of EV adoption has a major influence on the emissions impact of the Stonnington EV Charging Plan and that there are many factors impacting EV adoption that are outside Stonnington's control. This model attempts to illustrate the range of outcomes and what could be most realistically expected.

The rate of uptake of EVs has the largest impact on transport emissions abated in 2030, since this is being helped by the continued decarbonisation of Victoria's electricity grid. Other factors such as fuel efficiency improvement and grid decarbonisation have a smaller impact. For instance, even in the most pessimistic scenario (where EVs constitute only 3.3% of vehicles by 2030), Stonnington vehicles could avoid almost 25 kilotonnes of CO2-e between 2022-2030. However, this could be as high as 156 kilotonnes of CO2-e if EV uptake reaches 20% by 2030.

Even today, swapping an ICE vehicle for an EV can save approximately 1.5 tonnes CO2-e emissions per year, for an average year of driving (about 12,000km)[10].

Per-vehicle annual savings may improve as much as 50% over the next few years due to further EV efficiency improvements and electricity decarbonisation. Furthermore, the incremental increase in uptake in prior years could compound in later years and further hasten full-scale EV adoption.

Ensuring the use of renewable energy used for public charging stations (as included in the model already) and encouraging home charging to use renewable energy (e.g. through rooftop solar PV) are two ways we can help reduce emissions further.

BOX 6: The importance of renewable energy.

Statement on the importance of being powered by renewable energy

If powered by standard Victorian grid electricity, EVs only provide very marginal reductions in transport emissions (see Figure 6). This highlights the importance of creating a charging network that is powered by renewable energy. It is now commonplace for the commercial EV charging networks to purchase an equivalent amount of electricity from certified renewable energy. To support Stonnington's commitment to reducing emissions, it is paramount that the electricity is sourced from renewable means. Furthermore, the marketing and branding of the EV charging stations should make it clear that all electricity for the charging network is sourced from zero emission generation.

10 Assuming grid electricity for home charging (95% of all charging) and 100% renewable for public charging

Estimating usage, emissions reduction and funding options

continued...

FUNDING MODELS AND OPTIONS

What is the City of Stonnington's role in the development of EV charging?

The commercial EV charging sector in Australia is growing rapidly. The industry's appetite for investment is growing, due to the growth of commonwealth and state funding opportunities, as well as the increase in the number of EVs themselves. The commercial sector has a demonstrated interest in funding and managing public EV charging equipment and services. As of 2022, it is generally no longer necessary for councils to fund the provision of fast chargers at sites that have relative high forecast demand.

Increasingly, the role of local government in charging will be one of *facilitation*. Local governments often own or manage sites that have car parking, and these locations can be focal points for the community (e.g. libraries, town halls and leisure centres), often in the heart of activity centres. Local governments are in a powerful position to engage with the EV charging industry to negotiate outcomes in which charging is provided by the private sector at little or no direct financial cost to the council. Indeed, it is possible for some sites to attract rental payments from commercial EV charging providers.

BOX 7: Fees for charging - Guidance for Stonnington

Guidance on fees for charging

The Institute for Sensible Transport recommendation was that where the City of Stonnington chooses to operate our own chargers, a fee should be applied that covers electricity, network and maintenance costs of the chargers. In general, this results in a fee of between 20 – 40 cents per kWh. Pricing at the lower end for AC and higher for DC charging reflects the cost of provision, electricity consumption and user benefit differences for these different types of chargers.

Providing free charging was not recommended due to the following impacts:

» Reduces the commercial sector's willingness to develop the EV charging network, as it becomes commercially unviable to compete with a supplier offering free charging. This reduces EV charging possibilities.

» Limits the funds available to properly maintain charging stations. Without a dedicated budget for maintenance and repair, EV charging stations can be out of order for long periods, frustrating potential users.

» Distorts the market and provides an incentive for people to drive further than they should, to receive free charging. Many users reside in another local government area, and this effectively means the Stonnington ratepayers are subsidising the electricity costs of others.

These recommendations have been taken up and endorsed in the Electric Vehicle Charging Infrastructure Policy.

Estimating usage, emissions reduction and funding options

continued...

THE COST OF USING EV CHARGERS: APPLYING FEES FOR TIME, ENERGY CONSUMPTION OR BOTH?

One consideration for EV charging in Stonnington relates to what is more valuable: space or electricity? Not all EVs can accept kWh at the same rate. Therefore, a time-based charge may favour high end vehicles. For fast chargers, it is appropriate to charge for both space and electricity usage. A time charge pays for the equipment, and an energy fee pays for the electricity used.

For chargers delivering 7kW or less, the cost of electricity dominates, and the cost of the charger is negligible. However, a time charge encourages turnover, and can be set at a level that recovers energy cost too, as charge rates do not vary as much between vehicles. Ideally, both time charge and energy charge should vary over the day to reflect relative demand and costs, as per the Oslo time example in Appendix 1: Electric Vehicle Charging Plan – Additional Information..

Requiring users to pay a fee for slow AC charging is not a viable business model, without some form of public subsidy.

WHAT'S THE DIFFERENCE BETWEEN THE DC AND AC MARKET?

The DC charging market is fundamentally different from the AC market because DC:

- Offers much faster charging and can therefore charge many more vehicles per day
- Consumers are more willing to pay higher usage charges, as it saves time
- Is more expensive to install
- Has greater interest from commercial investors (due to the first two points) for installing to directly raise revenue from charging.[11]

BILLING SYSTEM MANAGEMENT

Unlike petrol stations, EV charging stations have no staff on site and payment is done via cloud-based software, RFID cards, credit cards and mobile Apps. Companies that have sought to create a billing system have encountered more difficulties with its execution than initially anticipated. This is leading to EV charging becoming an oligopoly or potentially a monopoly, as the work required to adapt systems to ever changing markets benefits from the economies of scale present in large operations.

Developing and maintaining a system for a network of 500 charging points is often like doing this for a network of five charges, and this is at the heart of why billing and customer interface operations is a natural monopoly/duopoly.

11 Site hosts (e.g. local businesses) seeking to attract customers are more likely to put in lower powered AC chargers.

EXPLORING DIFFERENT OWNERSHIP OPTIONS

There are several different types of ownership for EV charging networks on public land, and these are summarised below:

1. Full City of Stonnington-owned, built and operated (Option A)
2. City of Stonnington-owned, third party to build and operate under City of Stonnington supervision (Option B)
3. City of Stonnington contracts a third party to build, own and operate charging infrastructure on leased council property (Option C)
4. City of Stonnington leases out its property for a third party to build, own and operate but without Stonnington dictating any terms of use (i.e. minimal supervision) (Option D).

An additional option also exists, in which chargers are provided by the private sector on private land, with minimum if any involvement from local government. Given the high demand parking assets on City of Stonnington – managed land, this option is not recommended as significant charging demand will likely exist at Stonnington owned car parks in the near future.

As per the endorsed Stonnington Public Electric Vehicle Charging Infrastructure Policy, Council will largely focus on Option C to install public chargers.

Option A
City of Stonnington has Full Control

Under this option, Stonnington undertakes the full process of determining the scope and planning of the project, technology selection, tendering for contractors, contracting, project management, marketing (including pricing, promoting, location), negotiation with electricity distributor and retailers, customer contact service/user interface/platform, billing and ongoing operation and maintenance.

This option gives Stonnington maximum control and visibility. It provides flexibility to determine the siting, configuration, technology and all aspects of the user experience.

Stonnington can also maintain complete control of the branding of each site without needing to adhere to any outside commercial imperatives.

On the downside, Option A has the highest demands on City of Stonnington resources. It requires expertise and upskilling in a specific, technical industry and contains many complex facets with constant change. These employees will have to be recruited or re-allocated away from other services.

It is highly unlikely this model would work for DC charging, as the capital costs are too expensive for Stonnington’s existing budget. A dual port DC charger is estimated to cost approximately $50,000 for the first charger where there is an adequate power supply.

As the City of Stonnington would pay for and own the charging assets, the scope of the offer will be limited by the available CAPEX dedicated to the project. As will be discussed later (Option C), the potential to leverage private investment may mean a larger charging network, as the investment is not limited to the CAPEX available.

Option B
Outsource Building and Operating

Option B retains ownership, but the building and operation of the charging infrastructure is outsourced. Stonnington contracts a provider of charging infrastructure and operations to implement a stipulated technology, site selection, pricing and payment strategy. This aims to retain a high level of control, while outsourcing implementation and operation to a sector expert on a fee for service basis.

The benefits of this model are reduced risk and lower demand on Stonnington resources, while maintaining a strong level of control and visibility. Ownership is also retained, giving access to potential future revenue streams.

The City of Stonnington is the investor, and the commercial sector installs and operates the chargers. They are likely to charge around $1,000–$2,000 per site for management/service fees (annual), and then around 5% of the transaction to manage the billing service.

Stonnington still pays for the charging assets, limiting the scope of the charging network to the CAPEX available. While Stonnington visibility is maintained, reputational risk is still present, along with slightly less control over the rollout, compared to Option A.

Option C
City of Stonnington Facilitated but not Owned

In this option a third party builds, owns and operates the charging infrastructure, with the locations and specifications of the chargers listed as requirements by the City of Stonnington. Theoretically, this option has the private sector covering the CAPEX, with Council's role primarily one of facilitation, and the provision of the assets necessary for EV charging (land, parking spaces, street lighting poles). The project proponent adheres to rollout requirements stipulated by Stonnington. This option could potentially result in a larger charging network, as commercial developers may have greater incentive to leverage third party revenue streams. This may offer good visibility for Stonnington branding, minimised implementation risk and ongoing service KPIs.

Option C is considered suitable to the existing market for DC charging only. The speed and higher fees associated with DC charging makes it something that is market ready.

Downsides to this option include lower control, possibly less ability to require uneconomic installations for equity purposes, and limited but still required ongoing contract monitoring. In terms of equity, it is always possible for Stonnnington to provide a subsidy to cover losses. The key to success for this option is likely to be the correct selection and careful contracting of the implementation partner and ensuring incentivisation is tied to performance in meeting program objectives. Contingencies should the operator cease business need to be included in the contract, both for this option as well as the others for which a private sector partner is involved.

Option D
Low Involvement

At the other end of the spectrum from a City of Stonnnington-built, owned and operated model is Option D, in which Stonnington offers the market access to its assets for the purpose of providing EV charging. Bidders then offer different types and extents of service. This might be based on City of Stonnington contribution, or, depending on the appetite of the market, a bidder may wish to pay for access. It is unlikely slow charging will attract commercial providers without a subsidy, but for fast chargers it is possible this could be commercial with minimal government subsidy, other than access to land. Under Option C, Stonnington maintains a level of control via requirements listed within the contract. For Option D, Stonnington leaves all considerations to the market beyond a simple lease agreement for the use of local government land.

Under this configuration, there is a minimal impost on Stonnington resources; financial and human, and reputational risk is minimised. Council may be exposed to reputational risk in the event it is seen as unsuccessful, as it is widely understood that Council manages parking.

Loss of control means Stonnington's strategic goals are more difficult to prosecute. Visibility of any success is held by the contractor rather than the Ctiy of Stonnington and revenue both from charging and other sources do not accrue to Stonnington. Under this scenario, Council may lose complete control of where the charging infrastructure is placed (although they are able to deny access to any site with reasonable grounds). It can be expected that the private sector will cherry-pick the most lucrative locations, which means that in the future Council will lose the ability to leverage these more profitable spots to cross-subsidise less profitable areas of the city (for equity reasons). Stonnington may be able to charge rent for relatively lucrative locations and no or low rent at less attractive sites (effectively a cross subsidy).

A recommendation that spans all options; Stonnington should apply scrutiny to bids/expressions of interest from the commercial sector, especially those without a significant, positive track record of running similar systems in Australia. The billing and user interface is fraught with a myriad of issues that are complex and ever changing.

Software issues associated with billing, new cars, and new plugs makes reliability difficult and the less experience and market coverage the operator has, the more likely it is that there will be technical difficulties that undermine the usability of the system.

Table 17 provides a summary of all four options, their pros, cons, risks, financial costs, emissions impact potential and capacity for Stonnington to demonstrate leadership.

It is unlikely slow charging will attract commercial providers without a subsidy, but for fast chargers, it is possible this could be commercial in Stonnington, due to the demographics and land use characteristics of the area.

TABLE 17: Accessing EV charging delivery options

Options	Pro	Con	Risks	Financial Costs	Leadership
OPTION A **100% City of Stonnington-owned, built and operated**	› absolute control › Stonnington seen to be exemplar for LG action on climate change › Stonnnington seen to be providing a practical service › ability to subsidise uneconomic siting for equity reasons (to poorer households › asset ownership enables council to access potential third party revenue streams › potential for long term return if well manage)	› limited capability (no economies of scale) › limited capacity (need to provide customer support) › size limited by CAPEX	› financial exposure › marketing risk › structure of offer › pricing › placement of sites › promotion of service › implementation risks leading to potential reputational damage › budget overrun › milestone overrun › OH&S › poor level of service/reliability	› high	› high
OPTION B **100% City of Stonnington-owned; build and operation outsourced under Stonnington direction**	› high control › Stonnington seen to be exemplar in LG action in partnership with private sector › Stonnington seen to be providing a practical service › ability to subsidise uneconomic siting for equity reasons (to poorer households) › asset ownership enables City of Stonnington to access potential third party revenue streams › potential for long term return if well managed	› 50% capability requirement › 25% capacity requirement limited to manage private sector contracts › size still limited by Stonnington CAPEX budget	› financial exposure › marketing risk › structure of offer › pricing › placement of sites › promotion of service › reputation loss in case of failure › lower (75%) Implementation risks › budget overrun › milestone overrun › OH&S › poor level of service/reliability	› high	› high

Options	Pro	Con	Risks	Financial Costs	Leadership
OPTION C **City of Stonnington sets project standards, outsources build and operation, leases access out, does not own asset**	› moderate control › greater capacity to attract third party services › smart city goals › utility backhaul › citizen WIFI › 5G base stations › dedicated and incentivised customer service offer › scale benefit of potential rollout to other council areas › size of offer not limited by Stonnington CAPEX, potential for cross- subsidisation of EV chargers by third party revenue streams › lower financial, reputational and implementation risks	› loss of control › limited ability to require uneconomic siting of chargers › lower visibility of Stonnington involvement, potentially offset by larger potential size when cross-subsidised › difficult to upgrade › private sector contracts and partnerships still has to be managed and supervised by Stonnington	› partner selection mistake › equity considerations may be more difficult to enforce (use subsidies as incentive)	› low	› med-high
OPTION D **City of Stonnington offers access to its assets (lease) and external parties bid in EVC offers**	› low control › size of offer not limited by council CAPEX revenue streams › lowest financial, reputational and implementation risks	› loss of control, difficult to upgrade › limited ability to require uneconomic siting of chargers › no visibility of council involvement › still potential for reputational risk	› tenderer selection mistake (long term contract) › lack of control leaves exposure to unknown factors (e.g. obsolescence) › opportunity costs of giving up control and ownership	› low	› low

Estimating usage, emissions reduction and funding options

continued...

THIRD PARTY REVENUE STREAMS

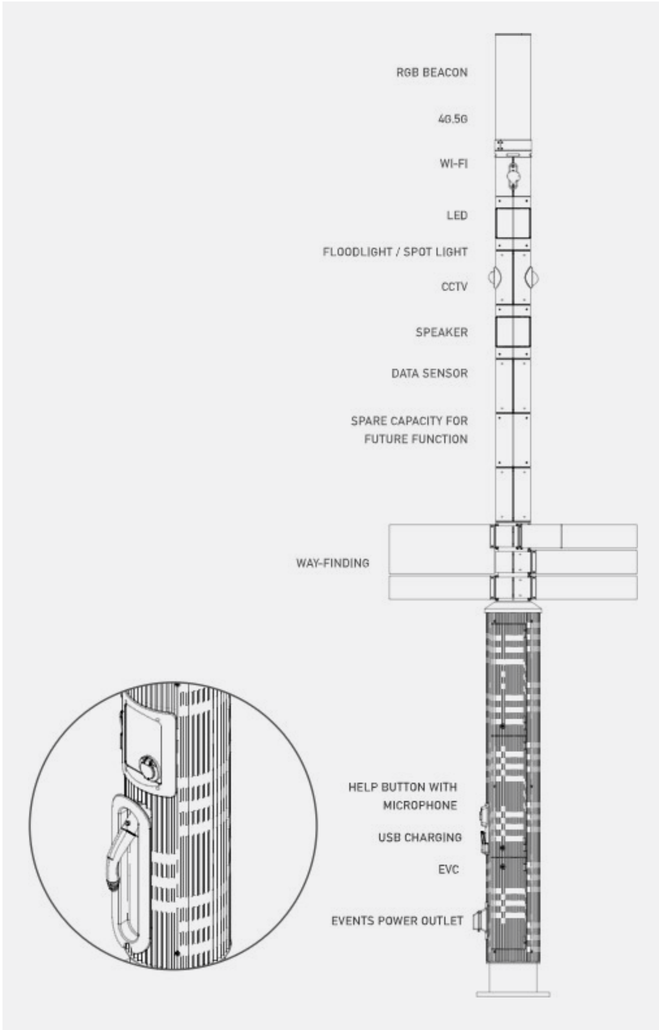
The implementation of an EV charging initiative may open a number of potentially profitable revenue streams for project participants. The access to on-street points where electrical power and/or communications infrastructure (wired or over the air) is very valuable. This value can be parlayed into subsidisation for a more extensive charger rollout, other services to citizens and their service providers, and could become a model for Smart City infrastructure. Examples include:

- 5G base stations
- Public WIFI
- Backhaul communications for utilities (gas and water meters, solar and battery inverters, smart home hubs)
- Micro-weather and pollution monitoring devices
- Foot and vehicular traffic counting and monitoring
- Advertising.

Figure 34 offers an illustration of the type of infrastructure cities are now beginning to explore that offer a wide range of services, in addition to energy efficient LED street lighting.

While it may appear an elegant solution to provide charging at the base of a light pole, the experience in Australia demonstrates the difficulty in having DNSPs (who own the lights) working with local governments.

FIGURE 34: EV charging linked to Smart City technology pole



Source: http://ene-hub.com/smartnode/

More information on kerbside charging can be found here: https://renew.org.au/renew- magazine/electric-vehicles/ev-charging-hits-the-streets/

BOX 8: Ownership and operational considerations

Multiple approaches for different contexts

As highlighted in Table 17, a range of approaches may be taken, such as:

- Own and operate on City of Stonnington land (e.g. for own fleet vehicles and contracted overnight use by residents)
- Own and contract operations for chargers on City of Stonnington land (for on-street overnight charging for residents)
- Tender for providers to establish chargers on City of Stonnington land on suitable terms but attractive enough to obtain providers (for fast chargers on Stonnington car parking areas)
- Provide incentives to private providers to establish chargers on private land.
- If on Stonnington land, we may wish to maintain ownership of and contribute to the cost of long-lived infrastructure such as power supply upgrades and civil works.
- Organisations with a small portfolio of chargers (whether public or private sector) have a mixed record on maintaining a reliable charge network. If it is not their primary business, the issues that can arise will not always get the priority they require. This can lead to poorly maintained infrastructure and poor customer service with resulting dissatisfaction with both the charge service and the use of EVs in the public's eyes. On the other hand, doing it properly may take more resources than we would choose. If based on a cost recovery model, it may also result in an expensive system for the user.
- Charge network operators, for whom this is their principal business, are more likely to have a large portfolio of chargers. Lessons learned about equipment and user issues are applied across a wider base. Customer support is necessary to maintain their own reputation. Operations have significant economies of scale. But not all operators offer the same quality or value for money, so selection is important.

In general, there are likely to be significant benefits in contracting out operations and maintenance if there is a well-structured contract to ensure specified standards are met. This may extend to contracting out supply and site design as well.

Estimating usage, emissions reduction and funding options

continued...

Victorian government support

The following provides a set of Victorian government EV related programs:

- **Zero Emissions Vehicle Roadmap:** https://www.energy.vic.gov.au/renewable- energy/zero-emissions-vehicles
- **Zero Emissions Vehicles Commercial Sector Innovation Fund:** https://business.vic.gov.au/grants-and-programs/zero-emissions-vehicles-commercial- sector-innovation-fund
- **Electric Vehicle Subsidy Program:** https://www.solar.vic.gov.au/zero-emissions- vehicle-subsidy
- **Destination Charging Across Victoria Program:** https://www.energy.vic.gov.au/grants/destinatio n-charging-across-victoria-grant-program
- **EV Charging for Business Fleets Program (DELWP Grant), for which applications closed 4th February 2022:** https://www.energy.vic.gov.au/grants/ev- charging-business-fleets
- **EV Charging for Council Fleets, for which applications closed 4th February, 2022:** https://www.energy.vic.gov.au/grants/ev-charging- council-fleets

Commonwealth government support

The following provides a set of Commonwealth government EV related programs:

- **Future Fuels Program** https://arena.gov.au/funding/future-fuels- program/#step-2-prepare-your-response

This funding round opened on the 21February, 2022 and will close when all funds have been exhausted.

Additional rounds of Commonwealth funding are expected to be announced in 2022 intended for public charging. This is of direct relevance to Stonnington.

Private sector

The Australian EV charging sector is growing rapidly and is increasingly seeing opportunities for installing fast charging stations at no or low cost to local government. Indeed, some providers are willing to pay local governments a monthly fee for the right to provide a charging station at certain (usually high value) locations.

In additional-to-traditional models, whereby a charging network installs a charger with the intention of covering their costs via a fee, there are other models that rely on advertising. JOLT is one such business, whereby the initial electricity consumption is offered at no cost to the vehicle owner. JOLT seek to draw revenue from advertising. It may be important to ensure the correct incentives are available to ensure such operators are focused on maximising the use of their charger, rather than simply relying on advertising revenue as their principal source of income.

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