Electrification of Transport in the City Strategy Technical Report

For City of Sydney

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SGS Economics & Planning

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SGS Economics and Planning Pty Ltd
ACN 007 437 729
www.sgsep.com.au

Offices in Canberra, Hobart, Melbourne, and Sydney, on Ngunnawal, muwinina, Wurundjeri, and Gadigal Country.

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Executive summary

SGS Economics and Planning in partnership with Kinesis were engaged by the City of Sydney to provide best practice research, technical analysis, and strategic insights to support the development of a strategy for the electrification of transport in the city. SGS and Kinesis have provided detailed technical analysis to provide an evidence-based rationale for key actions and initiatives the City of Sydney could pursue and advocate for to facilitate and encourage electrification of various transport fleets.

This involved understanding the domestic and international policy context in relation to Electric Vehicle (EV) uptake and regulation, as well as current and future technology and markets for EVs.

The technical analysis and modelling considered and forecast the uptake of EVs in all fleets operating in the city, as well as the charging requirements of these fleets in three different scenarios. Modelling also sought to understand how the charging of these vehicles would affect electricity demand.

Policy context

Australian Electric Vehicle Strategies

- Strategies have been prepared at all three levels of Australian government, identifying policies and positions that they can undertake to encourage uptake of EVs, as well as the consequences of their uptake.
- States and territories are reacting to the loss of fuel excise income and identified a need for road user pricing. With only Victoria having implemented this charge so far, it may be possible to assess its impact on EV uptake in future. This charge will result in the running costs of EVs rising for consumers, however they are still anticipated to be lower than those of an internal combustion vehicle.
- Strategies took different approaches to EVs considering characteristics of the jurisdiction and existing EV market penetration.
- Some challenges were identified in a majority of strategies:
  - Providing charging infrastructure to ameliorate ‘range anxiety’
  - Enabling private charging in apartments
  - Providing charging for those with cars but no off-street parking
  - Reducing the upfront cost of EVs for consumers

International Electric Vehicle Strategies

- The scope of international strategies were highly dependent on the purview of the agency which prepared them; however none were perfectly analogous to the City of Sydney's role. The structure of governance in NSW, and the role of the City of Sydney as a local government, are different to the roles of other bodies internationally. These comparisons are made to illustrate challenges being faced in other contexts, and to highlight actions that are being taken to ameliorate them.
- The tension between reducing car usage overall and encouraging takeup of EVs over internal combustion vehicles is being grappled with at all scales. Its key to ensure that EVs are accessible enough to be adopted, but not so accessible that demand for private vehicles is induced.
- Strategies highlight the need for a mix of EV charging methods – that is, on-street and off-street to meet the requirements of various vehicles and usage patterns. Strategies note that understanding the use of public parking (on-street) by residents is key to understanding the need or otherwise for on-street charging in future.

Technology and market context

Emerging technology

A review of the potential future developments in battery and EV technology identified:

- Wireless charging, which does not require a physical charging connection and thus makes charging easier for drivers (as well as the potential for in-motion wireless charging, whereby an electrified road charges a vehicle as it drives)
- Rapid and ultra-rapid charging, which has the potential to reduce EV battery charge times to near current fuel filling times
- Vehicle to grid technology, which enables the electricity from an EV to be used by the power grid more widely

This means that plans for electrification of transport should also be forward-looking, and adaptable to change, both foreseen and unforeseen. Understanding potential changes in how EVs can and will charge in future – for instance, where wireless charging is available in garages and cars can be charged where they park, or the potential for grid stabilisation through vehicle-to-grid power transfer – is key to a forward-looking strategy which is fit for purpose in the medium term.

Public EV charging around the city

A number of entities provide public charging around the City, with speeds of up to 120kW and at various price points, from free to up to 60c per kWh. Current charging opportunities are off-street and usually in close proximity or within destinations such as shopping centres.

Existing petrol station operator Ampol has recently announced that it will be installing a rapid (150kW) charger at its site in Alexandria, within the City. This announcement is indicative of international trends towards providing charging along major routes and at existing petrol stations, and further ties in with the NSW government's strategy for EV charging.

A key challenge is the availability of EVs available for purchase in Australia. This is across all fleets including private vehicles with Australia seen as a lower priority by car manufacturers to supply EVs with the lack of stringent emissions standards for new vehicles a key concern.

Technical analysis

The technical analysis and modelling considered and forecast the uptake of EVs in all fleets operating in the city, as well as the charging requirements of these fleets in three different scenarios. Modelling also sought to understand how the charging of these vehicles would affect annual electricity use, and to interrogate the impact on daily energy load profiles. The analysis sought to inform the following key questions.

1. What will be required to enable 100% EV takeup by 2035 to align with the City's Net Zero emissions target?
2. What will be the demand for EV chargers across different fleets and parking provision typologies (on-street, public off-street, private off-street) in the future?
3. How will EV users be charging? That is, what will be the likely time of use and charging technology used for different typologies?
4. Where can users charge their vehicles?
5. Can we decouple where people park from where they charge?
6. What level of infrastructure would be needed to support those who park on-street?
7. Who is affected? Addressing equity concerns – for instance, split incentives between renters vs owners, ensuring those who park on-street also have options to charge their EV, removing barriers for strata to install off-street EV charging.

These were then analysed across three uptake scenarios, considering state and nationwide projections which were applied to the city:

1. Baseline Uptake: This was based on the NSW EV Strategy. The strategy projects that 52% of new vehicles sales would be EVs at 2030.
2. Medium Uptake This was based on anticipated increases in the uptake of EVs due to policies that facilitate availability and affordability of vehicles. This includes policies announced during the recent federal election by the Labor Government. The policy will reduce barriers to EV uptake and projects that 89% of new vehicles sales would be EVs at 2030.1
3. Optimised Uptake: 100% of all vehicles electric. This scenario was intended to assess if there are any barriers to 100% uptake of EVs in the City of Sydney LGA and understand how this level of EV uptake can be facilitated.

[1] Based on Labor policy announcements from May 2022 during Federal Election campaign. It should be noted that this analysis was conducted during the change of government. Federal Government policies had been released but implementation was not yet fully understood.

Outcomes and key insights

RESIDENTIAL FLEET

The typical City of Sydney resident uses their car to travel 9-10km per day. Given that EVs have a range of 300-400km on a full charge, a typical resident in the City of Sydney would need to recharge their electric vehicle once or twice a month.

Using the three scenarios of electric vehicle take up and by 2035 there would be:

- Under a baseline scenario – there will be approximately 17,000 resident EVs.
- Under the medium uptake, there would be approximately 31,000 resident EVs
- Under the optimised uptake scenario, there would be approximately 70,000 resident EVs

Analysis then sought to understand where the spatial distribution of resident vehicles across the LGA villages and their parking characteristics.

Residents in the CBD, Pyrmont and Green Square have good access to residential off-street parking and can have good access to private off-street charging.

Residents in inner city villages (Oxford St, Crown & Baptist St, Redfern St, King St and Glebe Point Rd) are more reliant on on-street parking and therefore will not have the same level of ability to charge at home. However, parking can be decoupled from charging and residents can use publicly accessible off-street charging.

Further, residents in strata-title buildings face hurdles to install chargers in their off-street car parks such as building electricity transmission and heritage concerns and the requirement of approval from strata mangers to install EV charging.

Based on the number of residents and considering diversity of charging behaviour, as well as the 118 public chargers available within the city in 2022, there is already adequate capacity in the network to provide for the Baseline scenario.

Based on the modelling, the following chargers would be required for residents at 2035:

- **Baseline Uptake:** 50-100 publicly available chargers.
- **Medium Uptake**: 100-150 publicly available chargers
- **Optimised Uptake:** 200-350 publicly available chargers

Further, at 2035, between 5 and 20 EVs are expected to be present in an average strata building under the three scenarios. Due to the significant variation between buildings, a good rule of thumb is to anticipate and provide one charging space per 10 EVs.

Residential fleet energy demands

The expected EV charging electricity demand would vary under the three scenarios. The increase on 2019-20 residential electricity use is described below.

- Baseline Uptake: 10% increase on 2019-20 residential electricity use.
- Medium Uptake: 16% increase on 2019-20 residential electricity use
- Optimised Uptake: 36% increase on 2019-20 residential electricity use.

To put this into perspective, new residential buildings are expected to increase the current residential electricity demand by 40 per cent in 2035.

The impact on aggregated LGA wide electricity load profiles would be minimal. Resident EV charging is expected to increase peak demand across the LGA by under 5% as most residential charging at home will occur overnight and publicly accessible charging will mostly occur during the day.

Residential Fleet Insights

Given that most residents would typically only require one full charge one or two times a month, it is possible to decouple where residents park from where they charge. That is, EV users in the City of Sydney can consider options outside of home charging. The following would support this.

- The City can work with retail asset owners to increase fast EV chargers in retail centres
- The City can work with public parking asset owners to facilitate a commercial opportunity that benefits both the asset owner as well as EV users.
- Fuel retailers/ petrol station operators are considering a transition of their assets to service EVs.
- NSW Government has plans to deliver an EV charging network along the M1 and A4 roads within the city.

GRID IMPACTS

Based on the analysis in this report, the impact on aggregated LGA wide electricity load profiles would be minimal but localised impact in individual substations and distribution networks would need to be explored by Ausgrid on a case-by-case basis.

To understand this impact, the following steps were followed:

- Identified 14 zone substations that service the City of Sydney LGA.
- There isn't a clear mapping between these zone substations and the City's villages. As such the electricity load profiles from the 14 substations that service the LGA was aggregated to understand the impact of EV's across electricity demand for the City of Sydney LGA as a whole.
- Under an Optimised Scenario simulating 100% EV takeup within the City of Sydney LGA, the incremental impact on the peak electricity demand was under 5%. Note that resident charging demand is expected to be the most material of all fleets based on the fact most EV charging has been assumed to occur at home.

- While the impact on LGA wide electricity load profile is expected to be minimal, impacts on localised substations and distribution networks should be investigated further with Ausgrid. This will likely be done on a case by case basis by Ausgrid.

OTHER FLEETS

- Car share vehicles will be charged by their fleet owners and users and the City can potentially set obligations to car share providers for 100% fleet transition to electric by 2030 while monitoring char share charging requirements for car share fleets during this time. The City does not need to provide on-street charging for car share vehicles
- Public transport (buses) will charge at the depot. The City can identify priority routes and depots for electrification and advocate to the state government, this can focus on routes within the city that have significant idling of buses such as Clarence Street and York Street services as well as routes that travel through major residential areas to reduce noise and air pollution in these areas.
- Majority of point-to-point vehicles will charge at point of origin/depot. Some rapid charging options for Taxis may be required and there is opportunity to with state government to identify these areas. A low emissions zone in the CBD would assist in the acceleration of the taxi fleet towards electrification.
- Majority of service vehicles will charge at point of origin/depot. Some rapid charging at a dedicated off-street charger may be required. There is an opportunity to align EV transition for service vehicles with shifting of loading zones off-street as well as looking at micromobility options for small freight deliveries within a short distance of off-street loading facilities.

BY VILLAGE

The requirement and use of publicly accessible charging is likely related to the level of private off-street charging available to residents.

- Residents in CBD, Pyrmont and Green Square can access private off-street parking. These private off-street car parks can be enabled with EV charging.
- Residents in inner city villages (Oxford St, Crown & Baptist St, Redfern St, King St and Glebe Point Rd) will require publicly accessible charging. Parking can be decoupled from charging for residents in these areas.

1. Introduction

SGS Economics and Planning in partnership with Kinesis were engaged by the City of Sydney to provide best practice research, technical analysis, and strategic insights to support the development of a strategy for the electrification of transport in the city. SGS and Kinesis have provided detailed technical analysis to provide an evidence-based rationale for key actions and initiatives the City of Sydney could pursue and advocate for to facilitate and encourage electrification of various transport fleets.

The study focused on providing an understanding of the following:

- What are the current policy settings for Electric Vehicles in Australia and overseas?
- How have policy settings in other jurisdictions affected the take up of Electric Vehicles and what stakeholders have been involved?
- What are the key emerging trends and technology innovations related to Electric Vehicles?
- What is the potential Electric Vehicle take up and what will be the charging requirements for different transport fleets within the city?
- How does modelling of the electricity demand reveal implications of increased usage of Electric Vehicles? Is the local electricity grid likely to be fit for purpose for this use?

Further insights were sought through consultation with key stakeholders within the City of Sydney through a Project Coordination Group (PCG) to understand the various context and needs for Electric Vehicles within the study area.

In order to facilitate and encourage electrification, the analysis was focused on all modes of transport that would require charging of the vehicle fleet including:

- Private Vehicles (Residential/Commercial)
- Commercial/Service Vehicles
- Public Transport (Buses)
- Point to Point (Uber/Taxi)
- Car Share
- Micromobility

1.1 Methodology and approach

SGS and Kinesis leveraged policy and technical experience in urban planning and policy, data analytics and dedicated experienced in Electric Vehicle charging to inform the development of the strategy.

A consultation process was undertaken with key City of Sydney stakeholders through a Project Coordination Group through a series of workshops focusing on the development of key aspects of the strategy.

1.2 Report structure

This report provides details of the research, analysis, and modelling undertaken to support the development of a strategy for electrification of transport in the city. This included an understanding of what actions other cities are undertaking, providing technical analysis, and strategic insight.

The report is structured as follows:

- Section 2: Policy context
- Section 3: Technology and market context
- Section 4: Modelling framework and approach
- Section 5: Charging needs for different fleets

1.3 Definition of key terms

TABLE 1: KEY TERMS

Term	Definition
BEB	Battery Electric Bus
BEV	Battery Electric Vehicle (differentiated from a hybrid electric vehicle, which uses an internal combustion engine)
Car Share	Shared vehicles offered for short term rental
Commercial/Service Vehicles	Vehicles for deliveries and/or services
EV	Electric Vehicle
kW	Kilowatt (how much energy is moving/ being used at one time) Used to refer to the speed of chargers.
kWh	Kilowatt hour (how much energy is used in total) Used to refer to the capacity of a battery: how much energy it can store. Further, electricity is priced at a rate per kWh – this is the unit (amount) of energy.
Micromobility	Electric bicycles or e-scooters for personal use or that can provide services and deliveries
PHEV	Plug in Hybrid Electric Vehicle
Point to Point	Licensed taxis and Ubers for the transport of passengers
Private Vehicles	Private vehicles for personal use including for commuting to work

2. Policy Context

Governments at all levels are developing plans and policies to facilitate the transition of transport towards an electric future. This section outlines the current policy positions and priorities across all levels of government in Australia as well as a review of comparable city strategies internationally. It also highlights key insights relevant to the City.

2.1 Federal strategies and trends

The Future Fuels and Vehicles Strategy (2021) was prepared by the federal Department of Industry, Science, Energy, and Resources, and sets a vision to accelerate the uptake of zero emission technologies.

The federal government identified that it has a particular role to play in addressing market failures or gaps in the rollout of charging infrastructure. The private sector roll out of infrastructure in metropolitan areas is likely to result in inequality of access in regional areas where uptake may be slower. Therefore, the government will address this need through targeted co-investment with industry and other levels of government through the expanded Future Fuels Fund.

Australian governments have been partnering with industry to develop a national highway of public fast chargers that will fill charging blackspots for EVs. Within cities, the government is committed to placing fast chargers along key roads at 5km intervals.

The Future Fuels Fund will have 4 streams of key infrastructure investment to support early uptake and consumer choice:

1. public electric vehicle charging and hydrogen refuelling infrastructure;
2. heavy and long-distance vehicle fleets;
3. light vehicle commercial fleets; and
4. household smart charging.

As part of the Trajectory for Low Energy Buildings, all Australian governments committed to ensuring new buildings can accommodate electric vehicle charging. The Australian Building Codes Board is also considering how to ensure readiness for future installation of electric vehicle charging in the 2022 update of the National Construction Code.

Further, the federal Labor government elected in May 2022 is committed to implementing policies to encourage EV uptake in Australia, focusing on lowering the cost of buying an EV. These policies include cutting import taxes and fringe benefits tax (FBT) for EVs under $80,000 to reduce the price gap between EVs and internal combustion vehicles. It should be noted that this analysis was conducted during the change of government. Federal Government policies had been released but implementation was not yet fully understood.

The policy of reducing the price gap between electric and internal combustion vehicles, aims to encourage fleet takeup of EVs[2]. This will also act to strengthen the second-hand EV market, as fleets typically have a three to four year lifespan, after which many are sold on. Labor says that the electric vehicle strategy will mean 89% of new cars sold will be electric by 2030, at which point 15% of all vehicles on the road will be electric[3].

2.2 State Strategies and Trends

The NSW Government's Electric Vehicle Strategy (2021) focuses on:

- Private EVs
- Delivering on-street charging infrastructure
- Supporting more destination chargers at commuter carparks and other key government locations
- Ensuring new buildings and precincts are 'EV ready', and households in areas with limited off-street parking live no more than 5 km from an ultra-fast charger
- A target of all Government passenger vehicle fleets being electric by 2030
- Working with local governments

Also within NSW, the Zero Emission Bus Transition Strategy (2021) was prepared by Transport for NSW. The Strategy primarily identifies Battery Electric Buses (BEBs) as the initial source of Zero Emission Buses (ZEBs). This is because the BEB technology is mature and able to service 80-90% of NSW bus route needs.

The advantage of transitioning vehicles like buses is that they currently use diesel, which contributes disproportionately to particulate emissions, and they are high mileage – the transition accordingly is a high-impact measure. The City has also identified this and engaged with the NSW government on the potential to prioritise buses running through the city to be BEBs[4].

[2] Electric vehicles 'could be as cheap as combustion-engine cars' with these tax breaks, 6 July 2022 https://www.abc.net.au/news/science/2022-07-06/electric-vehicle-uptake-tax-reform-race-for-2030-report/101210180

[3] The Economic Impact of the ALP's Powering Australia Plan https://keystone-alp.s3-ap-southeast-2.amazonaws.com/prod/61a966013f3c53001f975016-REPUTEX_The%20economic%20impact%20of%20the%20ALP's%20Powering%20Australia%20Plan_Summary%20Report.pdf

[4] Decision details: Removing Barriers to Enable More Electric Vehicles in the City of Sydney https://meetings.cityofsydney.nsw.gov.au/ieDecisionDetails.aspx?AIId=10578

Other state-level EV strategies reviewed were those of South Australia, the ACT, Victoria, and the NT. These revealed the following trends in state strategies:

- Main focus on private and commercial light vehicles.
- Provision of charging to be widespread in public-accessible off-street locations where people might wish to charge their vehicles, such as commercial centres. Strategies also emphasised the need for high-speed charging to facilitate long-distance journeys, along major highways.
- Local government to take a significant role in assisting with pilot programmes and enabling the provision of charging infrastructure, both through planning controls and by providing it directly by purchasing and installing equipment for public use. This is identified as a way to provide public confidence that there are adequate locations for EV charging.
- Transition a majority of vehicle sales to EV by approximately 2030.
- Government to lead transition to EVs with their own fleets, which will assist with a second-hand market down the track, especially as prices fall further.
- Incentives provided through cheaper or free registration and stamp duty exemptions.
- Grants provided at the state level for private and public charging of various speeds.

EV Road User Charging

Distance-based road pricing schemes on EVs, designed to replace the revenue lost from fuel excise, has been legislated but not implemented in NSW. Victoria has already implemented a Road User Charge (RUC) for electric and plug-in hybrid vehicles, at 2.5 cents per kilometre.[5]

In NSW, road pricing will come into effect when EVs are 30% of new vehicles registered, or in 2027, whichever comes first. The charge will commence at 2.5 cents per kilometre.

[5] ZLEV road-user charge https://www.vicroads.vic.gov.au/registration/registration-fees/zlev-road-user-charge

Other local government strategies and policies

Key findings of a review of surrounding LGAs' policies regarding EVs included:

- Bayside Council sees electric vehicles as a way to mitigate climate change through a reduction in emissions.[6]
- Inner West Council will shortly exhibit its policy for EVs. They will also move forward providing pilot public kerbside and council parking area EV charging, in response to concerns about a lack of charging opportunities in the LGA for residents without off-street parking[7]. Council does not wish to directly fund chargers or the associated electricity – they are seeking to leverage grants and private initiatives.[8]
- Woollahra has codified a requirement to require Level 2 charging (7-22kW) wiring in each parking space of a new development in their DCP.[9]
- Randwick are providing rebates for EV charging within the LGA: up to $2,000 as 25% of the total cost of shared charging, or $500 for an individual dwelling.
- Waverley's Electric Vehicle Transportation Policy highlights the need for additional local charging. Where Council installs chargers, they will only seek to recover the cost of the electricity, not the infrastructure itself, as a way to support accelerated uptake.[10]
- Woollahra Municipal Council, Waverley Council, and Randwick City Council cooperated to install nine electric vehicle chargers in the area – these have a capacity of 22kw per port and are priced at 10-25c per kWh.[11]

[6] State of Environment Report 2021 https://www.bayside.nsw.gov.au/sites/default/files/2021-11/2021%20State%20of%20Environment%20Report.pdf

[7] Electric car woes as chargers fall short https://www.innerwestreview.com.au/story/7625757/electric-car-woes-as-chargers-fall-short/?cs=23035

[8] Inner West to trial public EV charging stations https://www.innerwest.nsw.gov.au/about/news/media-releases/2022-media-releases/inner-west-to-trial-public-ev-charging-stations#:~:text=Council's%20EV%20strategy%20needs%20to,charging%20infrastructure%20six%20months%20sooner.%22

[9] Electric Vehicles: Leading the Way https://yoursay.woollahra.nsw.gov.au/evreqs#:~:text=The%20new%20planning%20controls%20for,community%20better%20access%20to%20them.

[10] Electric Vehicle Transportation Policy https://www.waverley.nsw.gov.au/__data/assets/pdf_file/0012/200208/Electric_Vehicle_Transportation_Policy.PDF

[11] Eastern Suburbs Public Electric Vehicle Charging Station Network https://www.woollahra.nsw.gov.au/environment/sustainable_transport/electric_vehicle_charging_stations

Key insights from Australian strategies

Strategies have been prepared at all three levels of government, identifying policies and positions that they can undertake to encourage uptake of EVs, as well as the consequences of their uptake.

States and territories are reacting to the loss of fuel excise income and identified a need for road user pricing. With only Victoria having implemented this charge so far, it may be possible to assess its impact on EV uptake in future. This charge will result in the running costs of EVs rising for consumers, however they are still anticipated to be lower than those of an internal combustion vehicle.

In the light vehicle market, the federal government is committed to reducing the prices of EVs to enable greater market reach

Most strategies see improving, providing, and subsidising public and private charging infrastructure to reduce 'range anxiety' as a key component of the EV future.

Differing strategies based on needs – for instance, the Northern Territory is emphasising different aspects of EVs considering the greater distances required of the average vehicle in that jurisdiction.

2.3 International Strategies and Trends

Considering the essential differences between governance models, a review sought to identify international local level strategies for transport electrification. These are summarised at a high level within Table 2 and Table 3.

Within the strategies reviewed, a theme emerged from a significant proportion of them where the private sector was not seen as providing charging quickly enough – the public sector was seen as needing to step in and provide charging infrastructure as a 'public good' to provide confidence in uptake of EVs. This appeared to be a particular issue in places where wide-scale uptake of EVs had not yet taken place, with commercial charging ecosystems appearing to be more mature in countries including Norway and the United Kingdom, where uptake is significantly higher than Australia. Regardless, the strategy for London still identified an ongoing need for local boroughs there to provide charging in less affluent areas which seen had less private charging investment.

Strategies also identified issues around the so-called 'right to charge', which is a policy which has been proposed where tenants and owners in strata-titled (or equivalent) buildings had come across issues in gaining permission to install charging equipment from the strata or landlord. The 'right to charge', as a policy or regulation, means that permission cannot be denied by the landlord or strata body, where there are no safety or cost implications for the building or owner. This is likely to be an issue within NSW and the City more specifically (due to the relative prevalence of strata buildings and the large proportion of rented properties).

Grid management and power generation were not always considered in the policies reviewed, but there were no examples where the grid stability or power availability were seen as significant barriers to long-term EV uptake and usage. Places including London and Seattle saw grid upgrades as a necessary expense to be undertaken only where shortfalls existed, and which were worthwhile in the long-term. Further, with future Vehicle-to-Grid technology, Vancouver saw EVs as a way to increase the grid resilience.

London, Seattle, and Toronto were found to be most relevant to inform the City's forward planning. While the governance structure of local and state government within NSW means that the City's role will differ from these examples, the long-term nature of the strategies developed is helpful for considering potential pitfalls and issues which may arise in Sydney.

Table 2 and Table 3 provide an illustration of the issues considered by, and actions proposed by, a number of international strategies.

TABLE 2: ACTIONS CONSIDERED WITHIN INTERNATIONAL STRATEGIES

	Power generation and distribution	Grid management	Infrastructure provision	Regulatory environment	EV uptake and usage
Vancouver 2016		O	X	X	X
North Vancouver 2018			X	X	X
New York 2021		O	X	O	X
Toronto 2019		O	O	X	X
Seattle 2020	O	X	X		X
Oslo 2016	X	X	X	X	X
Tokyo 2019		O	X	X	X
London 2021		O	X		

X = Actions to be undertaken by the relevant authority
O = Actions pertaining to advocacy for other agencies to undertake action

Source: SGS Economics and Planning (2022)

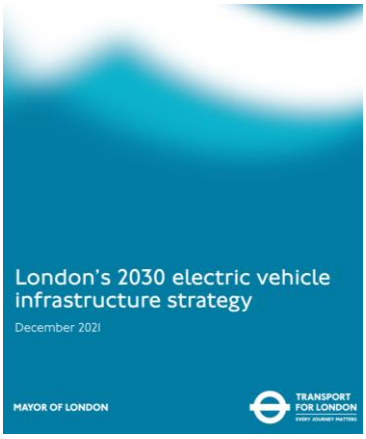
TABLE 3: KEY CONSIDERATIONS WITHIN INTERNATIONAL STRATEGIES

	Commercial / heavy vehicles	Point to point	Public transport	Micro mobility	On-street public	Off-street public	Off-street private
Vancouver 2016		X		X	X	X	X
North Vancouver 2018	X				X		X
New York 2021		X	X		X	X	
Toronto 2019		X	X		X	X	X
Seattle 2020	X	X	X		X	X	X
Oslo 2016	X		X			X	
Tokyo 2019			X	X	X	X	X
London 2021		X			X	X	

X = Strategy includes actions addressing this key point

Source: SGS Economics and Planning (2022)

London – 2030 Electric Vehicle Infrastructure Strategy (2021)



London's strategy was prepared by Transport for London (TfL) which is a part of the Greater London Authority. While London's strategy focused on the infrastructure to support light vehicle EV usage only, it did use modelling to understand how uptake rates might eventuate, and how much charging infrastructure would potentially be required, but sought to avoid a 'predict and provide' model. It also aimed to use modelling and analysis to consider the impact and desirability of scenarios.

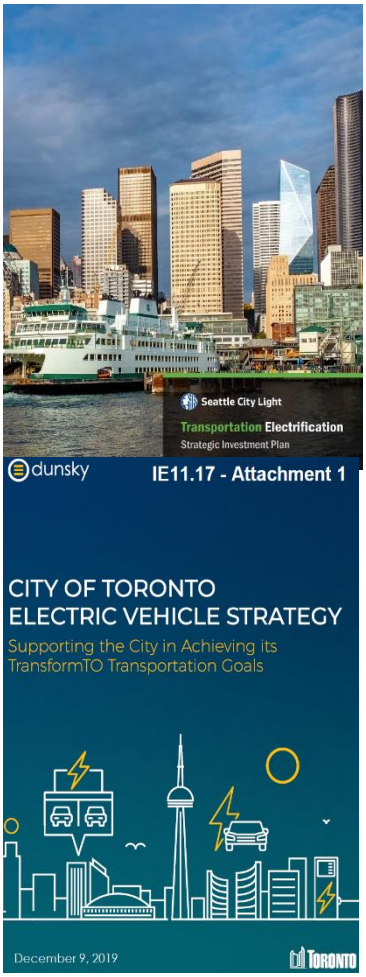
London further has strategies in place to reduce inner-city traffic and pollution, with EVs seen as a way of reaching pollution goals. In line with these measures, they have implemented ambitious emissions requirements for the taxi fleet, which is regulated and licensed[12]. Supporting this, TfL has facilitated on-street, taxi-only charging bays in the city[13].

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

[13] TfL Rapid Charger Pricing for Taxis and Public https://network.bppulse.co.uk/tfl-pricing/

Seattle – Transportation Electrification Strategic Investment Plan (2020)

Seattle City Light – the public organisation providing electricity to the city – aimed to develop a plan to electrify all forms of vehicles and transport. The Plan had a strong focus on equity and considered the city-wide benefits of the electrification of transit and high-mileage services. City Light is at an advantage relative to the City of Sydney due to its relative size and purview, providing utilities to over 400,000 households[14]. By directly linking utilities to EV rollouts, the organisation is able to leverage its internal expertise on the electricity grid, as well as its understanding of any challenges regarding generation capacity.



Toronto – Electric Vehicle Strategy (2019)

The City of Toronto worked over several sequential strategies and studies to develop a final strategy to implement EVs. The strategy highlights future technology relevant to the City of Sydney's context and future EV trends. The city undertook comprehensive and wide-ranging stakeholder engagement to develop quantifiable actions across multiple horizons.

[14] Seattle City Light Media Information https://www.seattle.gov/city-light/about-us/communications/media-information

Key insights from international strategies

Three challenges were identified in all strategies:

- Lack of public charging;

- Enabling private charging in apartments; and

- Providing charging for those with cars but no off-street parking.

The scope of each strategy was highly dependent on the purview of the agency which prepared it; however none were perfectly analogous to the City's role. The structure of governance in NSW, and the role of the City of Sydney as a local government, are different to the roles of other bodies internationally. These comparisons are made to illustrate challenges being faced in other contexts, and to highlight actions that are being taken to ameliorate them.

The tension between reducing car usage overall and encouraging takeup of EVs over internal combustion vehicles is being grappled with at an international scale. The key seems to be ensuring that EVs are accessible enough to be adopted, but not so accessible that demand for private vehicles is induced.

Strategies highlight the need for a mix of private EV charging methods – that is, on-street and off-street, geographically distributed, and private and publicly accessible, to meet the requirements of various vehicles and usage patterns. Understanding the relative role of public parking (on-street) used by residents is important to know what charging requirements are likely in future.

While an undersupply of EV charging opportunities is identified as a potential factor reducing EV uptake in places at early stages of EV market penetration, there is limited understanding of the magnitude of this effect in relation to other factors affecting uptake. It is considered this effect is likely to be more pronounced where constraints exist for residents to charge at their dwellings overnight, whether by design limitations or by lack of parking. Public provision of charging, especially in the early stages of uptake, can act to encourage public confidence in the availability of EV infrastructure.

Further research was done to understand a fuller context of actions undertaken in other jurisdictions up to an international scale. Where possible, insights were sought to determine if these actions had worked and if the outcomes were satisfactory or if there had been unexpected outcomes or undesirable consequences. An overview is provided within Table 4 overleaf.

TABLE 4: RELEVANT ACTIONS FROM OTHER JURISDICTIONS

Context	Jurisdiction What problem are they seeking to address?	How? Link to references	Insight for the City
Off-street private & commercial	Vancouver Supporting private off-street charging	BC Hydro provides rebates for the installation of chargers for single family homes ($350), as well as various amounts for the investigation, electrical works, and installation of charging in apartments, and workplaces ($5,000 per charger and up to $25,000). The city itself is offering to install and own chargers for rental buildings, up to $93,000 (with the building owner contributing $2,000) https://vancouver.ca/streets-transportation/electric-vehicle-charging-for-rental-buildings.aspx https://electricvehicles.bchydro.com/incentives/charger-rebates BC Hydro requires that all chargers installed are networked and at least a Level 2 capacity Since 2011, Vancouver has required all new buildings to be 'ready' for EV charging by providing the circuitry at construction (if not the chargers themselves) for each car space.) https://bylaws.vancouver.ca/parking/Sec04.pdf?_ga=2.205842971.980987902.1581622488-1487957635.1537562134	Ensuring chargers are networked allows for greater insights for the City, as well as potentially for the state government and Ausgrid. Vancouver's requirements for charging enablement in new development have been brought in incrementally. While the infrastructure and wiring in buildings is a cost to development, it is much cheaper than retrofitting it later and thus forms a benefit for residents and workers in those buildings in the long term.
	UK Supporting private off-street charging	Provides a grant of up to 75% of the cost of installing an off-street private charging point https://www.gov.uk/government/collections/government-grants-for-low-emission-vehicles	Governments at higher levels intervening to provide incentives in the market for off street charging.
On-street	Port Phillip Council, Victoria Lack of on-street charging for residents without off-street parking.	For residents who don't have an off-street carpark on their property, Port Phillip have developed a kerb charging permit for their local council. This permit enables residents to install a charging facility at the kerb by the nature strip in front of your property. https://thedriven.io/2021/09/06/australian-council-approves-trial-of-kerbside-ev-charging-equipment/ https://www.portphillip.vic.gov.au/council-services/traffic-roads-and-transport/electric-vehicles https://www.kerbcharge.com.au/about-us	A company called Kerb Charge has developed a product to facilitate, but the cost of the infrastructure and installation are not clear. This type of intervention is likely to have limited success in the City for two reasons: firstly, residents in congested and high-demand suburbs do not have the right to park directly outside their dwelling, and secondly, the infrastructure takes up valuable urban green space, which would potentially have a significant impact if used extensively to account for additional uptake of EVs.
	Seattle Lack of on-street charging for residents without off-street parking.	The city is allowing residents with EVs or who plan to acquire EVs to nominate a location for an on-street charging point. https://www.seattle.gov/city-light/in-the-community/current-projects/curbside-level-2-ev- chargingutm_sourceadandutm_mediumonlineandutm_campaigncurbside_opt_in-	By allowing residents who would otherwise need to use other public charging places to nominate their areas for a charger, it targets charging where it needs to be. Criteria and setback requirements are provided to enhance transparency and communicate the goals of the scheme.
	London Air and noise pollution	The Low Emission Zone was implemented in 2015 to target heavy vehicles, and charges £100 per day for any non-complying vehicles above 1.2 tonnes. The Ultra Low Emission zone charges £12.50 per day for cars and vans which do not comply. These zones are in addition to the Congestion Charge area, which is a cordon charge to reduce traffic within the city (£15 per day). When the Congestion Charge was originally introduced, low emission vehicles including EVs were exempt, however this exemption will be removed in 2025. https://tfl.gov.uk/modes/driving/	Both emissions-based zones successfully reduced the air pollution in the City, and proponents say that this has eased air quality issues on poorer residents. However, the previous policy of exempting EV drivers from the Congestion Charge likely had some equity issues, particularly as EVs have been much more expensive than other vehicles. This was partly mitigated through increased public transport capacity. https://theconversation.com/london-congestion-charge-what-worked-what-didn't-what-next-92478

Context	Jurisdiction What problem are they seeking to address?	How? Link to references	Insight for the City
	Paris Congestion, lack of on-street charging for residents	The Mayor of Paris has committed to removing half of the 140,000 surface parking spaces in Paris. There are a further 481,000 off-street spaces, both private and public, however the reallocation of road to uses other than parking has been a central tenet of the Mayor's plans, which includes banning all vehicles except for EVs from the centre by 2030. Because of the rapid uptake in EVs expected within Paris, the relative scarcity of off-street residential parking, and the removal of a significant proportion of on-street parking, on-street public charging forms a key component of the future charging infrastructure. Total, a French liquid fuel company, announced at the end of 2020 that it had won the tender to provide and run the City of Paris' charging network, which was forecast to be 2,300 chargers by 2030. However, not all of them would be on-street, and it is unclear if other private providers are permitted to propose and install on-street charging infrastructure. https://www.forbes.com/sites/carltonreid/2020/10/20/paris-mayor-anne-hidalgo-to-make-good-on-pledge-to-remove-half-of-citys-car-parking-spaces/?sh=25e9d06116ec https://theicct.org/wp-content/uploads/2021/12/france-evs-infrastructure-transition-nov21_0.pdf https://thedriven.io/2020/11/19/total-wins-right-to-operate-2300-ev-charge-points-in-paris/	Paris, is highly constrained in terms of off-street parking for residents in historic districts – by 2035, less than 51% of EV owners in Paris are expected to have off-street home charging opportunities. This is in contrast with Sydney where many residents have access to off-street parking.
Off-street public	Vancouver Lack of public charging	Vancouver is going to charge off-street parking and petrol stations $10,000 per annum if they don't install public charging infrastructure (although the businesses will be able to charge users for the power etc) https://www.vancouverisawesome.com/local-news/vancouver-gas-stations-parking-lots-without-ev-chargers-could-face-10000-annual-fee-by-2025-petro-canada 5247552	Recent proposal: impacts likely to be measurable in future. Further, there may be jurisdictional issues for the City to implement such a charge.
Commercial/ heavy vehicles	California	Has legislated that truck manufacturers have to sell certain proportions of electric/ net zero trucks from 2024. Has also announced large amounts of funding for the infrastructure to support these vehicles. https://www.latimes.com/business/story/2020-06-25/new-california-truck-mandate-100-000-zero-emission-commercial-haulers-sold-annually-by-2030 https://www.greencarreports.com/news/1134190_california-ev-infrastructure-hydrogen-fueling-truck-charging	The electrification of heavy vehicles is a challenge which has to be undertaken with stakeholders representing the industry, as well as the location of existing depots.
Point to point	US	Uber encouraging drivers to buy EVs, partnering with a charger manufacturer to provide discounts and finance packages. American https://insideevs.com/news/570218/uber-encourages-drives-used-evs/	Example of a corporate initiative in EV takeup.
	California	At a state level California is going to require emissions reduction by sector which means that companies like Uber will have to prove they're providing a certain percentage of miles as zero emission, however by pushing this requirement through Uber which doesn't actively employ their drivers, could have poor outcomes for their 'contractors'. Further details unclear. https://ww2.arb.ca.gov/our-work/programs/clean-miles-standard/about https://www.wired.com/s25aliforniaornia-evs-uber-lyft/	Opportunity for the City to advocate further to the State Government for fleet transition measures.
	UK	London has imposed strict regulations on taxi licensing, requiring low or zero emissions vehicles (including EVs). These are expected to be charged at the growing list of rapid charging points, or at home. https://tfl.gov.uk/info-for/taxis-and-private-hire/emissions-standards-for-taxis	Difficult to implement at the city scale due to jurisdictional limitations, but a good case study.
	London	Uber has announced the intention to spend five million pounds to put chargers in the places where its drivers live (less affluent areas less well served by charging). https://thedriven.io/2020/10/22/uber-to-invest-5m-for-ev-charging-in-less-affluent-london-boroughs/	Private sector initiative to provide charging options for point to point vehicles to facilitate EV uptake, opportunity for the City to collaborate on similar initiatives.
	NYC	Private company providing EV rideshare in NYC in order to get around a ban on new ICE vehicles doing rideshare. However, they provide the vehicles and employ the drivers and have fast charging hubs for their own vehicles. Launched August 2021. https://www.axios.com/2021/08/02/revel-electric-vehicle-ride-sharing	Private sector initiative to promote EV usage for point to point journeys and facilitate charging, opportunity for the City to collaborate on similar initiatives.

2.4 Equity

The concept of equity was discussed during the course of the project with key points and definitions discussed below and conceptually framed in Figure 1 below.

FIGURE 1: EQUITY CONSIDERATIONS

The equity discussion with the PCG is summarised below within this framework. There is some overlap in both concerns and related actions.

TABLE 5: EQUITY APPROACHES

Consideration	Methods of ameliorating concern and related actions
Access	
Ensuring people have access to charging regardless of housing tenure or typology.	– Including solutions for strata – Work with Land and Housing Corporation – Clear guidelines for building owners and community groups
Ensuring that a lack of charging or a perceived lack of charging does not prevent takeup of EVs for those residents and sectors who need to drive, including delivery and point to point	– Communicating where existing and upcoming charging points are – Support best practice charging and communication with commercial partners
Experience	
Maintaining pedestrian access and amenity as the highest and best use of public space and preventing the proliferation of private car infrastructure in public space	– No preferential access to the kerb for EVs – Supporting EV takeup in high VKT vehicles to improve noise and emissions outcomes
Ensuring that EVs do not encourage greater takeup of private vehicles generally, while still encouraging their uptake for those with high vehicle needs for employment (for instance, those who commute to industrial areas)	– Ensuring public charging is not free or subsidised by government. Investigate demand-based pricing to consider grid impacts
Cost	
The high upfront cost is a barrier to low-income groups, but low operating cost of EVs make them a good long-term option; do not want to lock people into fuel dependency with cheap ICE vehicles	– Making charging systems user pay – Encouraging car share and rideshare to change to EVs to enable access

3. Technology and market context

EV technology is a rapidly evolving space. Technology is continually developing, and car manufacturers, considering regulatory and consumer demand, have long-term plans to develop and produce EVs with new and emerging technology, both for the vehicles themselves, and charging technologies. This section provides a brief overview of the existing and forward-looking potential technologies, with insights for the City of Sydney in developing a strategy that can consider short- and long-term priorities.

3.1 Charging types

The current paradigm of charging speeds and terminology is outlined in Table 6 below. In considering the table, it needs to be noted that terminology – particularly around names and levels of charging speed – is not standardised and varies between jurisdictions and companies. The speed of charging is also variable according to the capability of the vehicle – older EVs in particular are often not able to charge at high speeds. Further, EVs typically charge more slowly once their batteries have reached 80% capacity, and this varies the time it takes to charge regardless of the capacity of the charger.

DC (direct current) charges directly to the battery of the vehicle instead of using an onboard converter for typically slower, AC (alternating current) charging.

TABLE 6: CHARGING SPEEDS AND TERMINOLOGY[15]

Level	Other names	kW	AC/ DC	Km added per hour of charge	Approximate theoretical time to full charge assuming 400km range	Detail and typical use case
Level 1	Trickle	1.4	AC	8-10	40-50 hours	Standard domestic power outlet charging – vehicle plugged directly into wall. Home charging.
Level 2		3.3-7.4	AC	20-40	10-20 hours	Domestic charging with a dedicated charger installed at the premises. These cost around $1,000, plus installation.
Level 2	Fast	11-22	AC	50-120	3-8 hours	Requires three-phase power; this is often the speed that 'destination' chargers offer.
Level 3	Rapid	50+	DC	250-500	1-2 hours	Rapid and ultra-rapid charging is usually found on major routes and is the type of charging provided at existing petrol stations.
Level 3	Ultra-rapid	350+	DC	1,000+	Less than 1 hour	Sometimes referred to as 'future-proof', as charging at this speed is similar to filling a tank with liquid fuel.

Sources: See footnote

To contextualise Table 7 further illustrates some of the EVs available in the Australian market as at mid 2022, and the size of their batteries. Accordingly, it would take a Tesla Model 3 at least twice as long to fully charge as a Mini Electric Hatch. However, regardless of the battery capacity, if two EVs both drove, for instance, 20km, it would take a similar amount of time to recharge the battery to replace that spent range.

[15] Multiple sources: https://goevie.com.au/electric-car-charging/ https://www.whichcar.com.au/car-advice/ev-charging-levels https://www.environment.nsw.gov.au/topics/climate-change/net-zero-plan/electric-vehicle-strategy https://wallbox.com/en_au/faqs-difference-ac-dc

TABLE 7: EVS AVAILABLE IN AUSTRALIA WITH A RANGE OF BATTERY SIZES

Model	Battery Size	Approximate range
Mini Electric Hatch	32.6 kWh	233 km
Tesla Model 3	60 – 82 kWh	491-602 km
Volvo XC40	78 kWh	418 km
Porsche Taycan	79.2 – 93.4 kWh	371-431 km
Polestar 2	69 – 78 kWh	440-455 km
Nissan Leaf	40.6 – 62.1 kWh	275-390 km
Hyundai Ioniq	38.3 kWh	290 km
Audi E-tron	71 – 95 kWh	328-417 km

3.2 Emerging technology

A representation of the current technology roadmap – that is, technology currently being developed, and forecast, for electric vehicle use – is provided within Figure 2 below:

FIGURE 2: CURRENT TECHNOLOGY ROADMAP

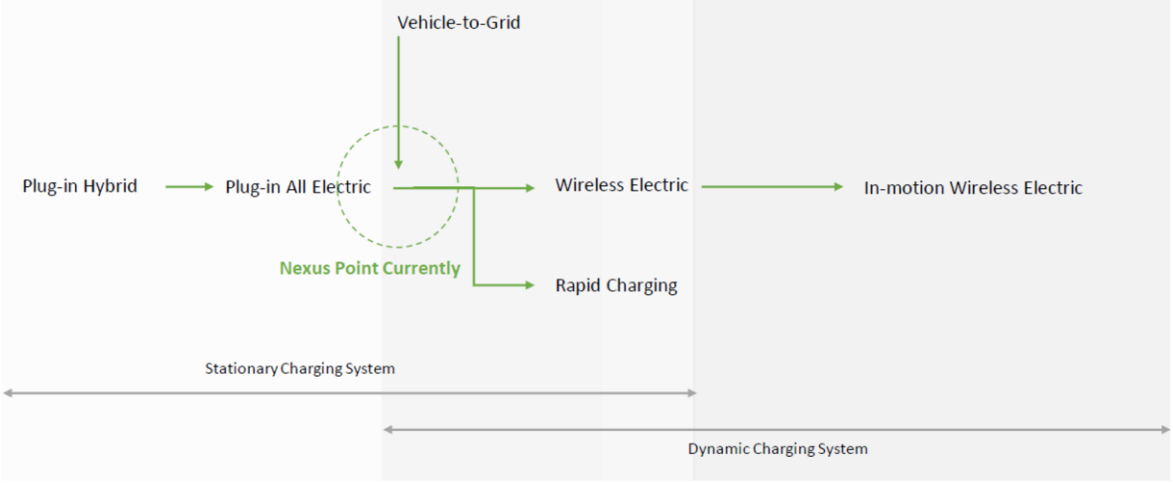


Figure 2 illustrates the following emerging charging technologies (middle-right) and their relationship with the current technological position (middle-left). There are also considerations of the potential for this technology to be deployed in different ways for different needs, as well as other, unknown technologies which may come to fruition in future.

Wireless electric charging (or wireless power transfer, WPT): Where the vehicle stops above an inductive charging pate and electricity is transferred to the on-board battery. Further, the lack of

physical charging connection means it is safer and more reliable than normal plug-in charging. These chargers can be as fast as conventional charging, however this is subject to the vehicle capability.

In-motion wireless charging: WPT over longer distances, such as a powered roadway. Theoretically, a wide network of in-motion charging available more widely means that batteries could be smaller, as they would need to travel smaller distances between charging. This technology would be highly suited to heavy vehicles on a highway, or bus routes, where the route and power needs are a known quantity.

Rapid and ultra-rapid charging: Were rapid charging to become ubiquitous, more charging would be able to take place outside of the home, in the style of existing filling stations for internal combustion vehicles. This would potentially mediate some equity concerns, however, would place an increased strain on the grid, as rapid charging has greater power requirements.

Vehicle to grid (V2G): also known as bi-directional charging, an EV can be connected to a building or place and provide power to, for instance, a house, instead of being used by the vehicle.

As V2G develops, power and utilities operators will factor in EV less as vehicles and more as linked mobile batteries and similar to home batteries currently provide a backup power source for the building.

This can be expanded and operate similar to the use of rooftop solar with electricity shared in both directions are required. This provides a significant grid balancing opportunity to manage electricity usage and consumption during the course of a day. If smart grid systems are deployed, as they have been elsewhere in the world, there is potential to offset large transmission upgrades through intelligent use of linked up batteries to stabilise the electricity network as well as mitigate and potential grid capacity issues by smoothing out peak electricity demands required of the grid.

Not all electric vehicles available currently support bi-directional charging and a specialist charger is required to be installed in homes to enable this as well. Therefore there is currently a larger upfront cost to install the required charger as well as purchase a compatible vehicle.

3.3 Public EV charging around the city

A number of entities provide public charging around the city:

TABLE 8: PUBLIC EV CHARGING ENTITIES

Network	What offering?	Pricing?	Additional Details
Chargefox	Network of destination chargers from 7kW to 350kw	Pricing variable, depending on speed of charger and location	Also offer guidance for property developers and help large strata corporations with residential charging.
Jolt	25kW chargers	First 7kWh per day free, then 40c per kWh thereafter. $10/hr idle time charges	Jolt use advertising on their charging infrastructure to cross-subsidise the network. They primarily offer street and public car park charging.
Evie	50kW chargers in conjunction with bodies such as councils and destination operators Partnering with Ampol for ultra high speed 350kW chargers	50kW charging is 40c per kWh and 350kw charging is 60c per kWh.	
NRMA	50kW chargers	Currently free, with future transition to payment for those who are not members.	Developing a widespread network to cover rural and regional areas to offer certainty for those travelling intrastate.
Tesla	120kW 'Supercharger' network Slow destination chargers	120kW at 58c per kWh Destination charging free for Tesla owners.	Network for Tesla charging only.
Miscellaneous	Destination charging – variable, usually slower	Variable, often free for customers	Destinations such as shopping centres install chargers which are not always affiliated to a network

Pricing for EV charging

There are several ways that existing providers charge for EV charging:

TABLE 9: MODELS OF PRICING FOR CHARGING

Type of pricing Description	Considerations	Local Examples
Free No Cost to user, No revenue for operator	Potential lack of revenue stream to maintain chargers A big challenge with public chargers is they can often be damaged and unable to be used by customers. Incentive for people to dwell for a long time since they are getting something for free, often combined with 2 hours free parking at a retail location. Reduces viability of a paid public charging network	The NRMA fast charging network (however they will eventually charge for non-members) Slow chargers at Shopping Centres
Pricing per kwh Charge per energy use	Batteries in EVs are capable of charging up rapidly to 80% capacity, after which the speed of charging reduces, regardless of the capacity of the charger itself. Drivers who charge above 80% of capacity at these chargers are charging more slowly and taking up space which could be used to charge another vehicle more quickly. Does provide revenue stream for possible maintenance	Evie and Chargefox both use this model at the moment and charge 60c/kWh
Pricing per kWh and time Charging by both energy and time (if stay once charge complete)	Encourages users to only stay as long as needed to charge their vehicle. Should be focused in areas where people are parking just for charging rather than dwelling for other activities.	Jolt charge $5 per 30 minutes of overstay (after charging is complete)

3.4 Fleet transitions

As discussed further within Section 2, governments at all levels in Australia are committed to transitioning their light vehicle fleets. However, heavy vehicles present a greater challenge of electrification due to issues of weight and scale – commercial vehicles including trucks and delivery vehicles are more likely to travel longer distances on a normal day than private vehicles which are used for commutes and otherwise are parked. This means that the positive impact of electrification of these fleets is correspondingly larger.

The City itself has contributed to the greater usage of electrified heavy vehicles through its trial of an electric garbage truck[16]. Similar trials of electric garbage trucks have ranges of circa 120km, which is likely suitable for the purpose of collecting refuse and returning to a common base[17].

Further, Transport for NSW (TfNSW) has committed to transition the public transport standard bus fleet, which comprises over 90% of the entire Greater Sydney bus fleet. This process has begun and there are currently 100 fully electric buses operating on the network as at mid-2022. TfNSW has identified a transition strategy to fully transition this fleet to Zero Emissions Buses by 2035[18], of which a significant proportion will be electric. The target for 100% Zero Emissions Buses in Greater Sydney was previously set at 2030, but was altered to be a staggered process "to allow local industry time to prepare and technology advancements to be assessed and adopted along the way".

Rideshare platform Uber has announced that it is seeking to increase the number of EVs on its platform by discounting the fees for drivers of EVs by 50% until 2025. This is anticipated to be an incentive of approximately $3,000 per driver per annum[19]. The challenges of supporting the fleet transition of rideshare include ensuring that drivers have the ability to purchase and EV and locations to charge their vehicles overnight, considering that they often rent or live in multi-dwelling housing[20].

Internationally, major brands, including delivery companies Amazon, UPS, FedEx and DPD have all announced plans to electrify their fleets.

Shifting large fleets to BEVs, especially government fleets, is one of the ways in which governments can help to facilitate uptake of EVs. As considered previously in section 2.1 the removal of FBT from EVs is likely to increase uptake in fleets by reducing the price differential between ICE vehicles and EVs. Further, the existing policy of no FBT being charged on utes means that cars which would otherwise have been sedan or hatch vehicles were bought as utes for business purposes. With the advent of EVs having no FBT applied, they will be much more competitive with utes and it is likely that a proportion of those vehicles will instead be EVs.

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16 Decision details: Removing Barriers to Enable More Electric Vehicles in the City of Sydney https://meetings.cityofsydney.nsw.gov.au/ieDecisionDetails.aspx?AIId=10578

17 City of Fremantle Trialling Electric Garbage Truck https://www.solarquotes.com.au/blog/electric-garbage-truck-wa-mb1269/

18 Zero Emission Buses (2022) https://www.transport.nsw.gov.au/projects/current-projects/zero-emission-buses and https://www.transport.nsw.gov.au/system/files/media/documents/2021/zero-emission-bus-transition-strategy.pdf

19 Uber to offer 50 per cent fee discount to 2,500 EV drivers in Australia (2022) https://thedriven.io/2022/06/08/uber-to-offer-50-per-cent-fee-discount-to-2500-ev-drivers-in-australia/

20 World Resources Institute (2021) Electrifying ride-hailing in the United States, Europe, and Canada: how to enable ridehailing drivers to switch to electric vehicles

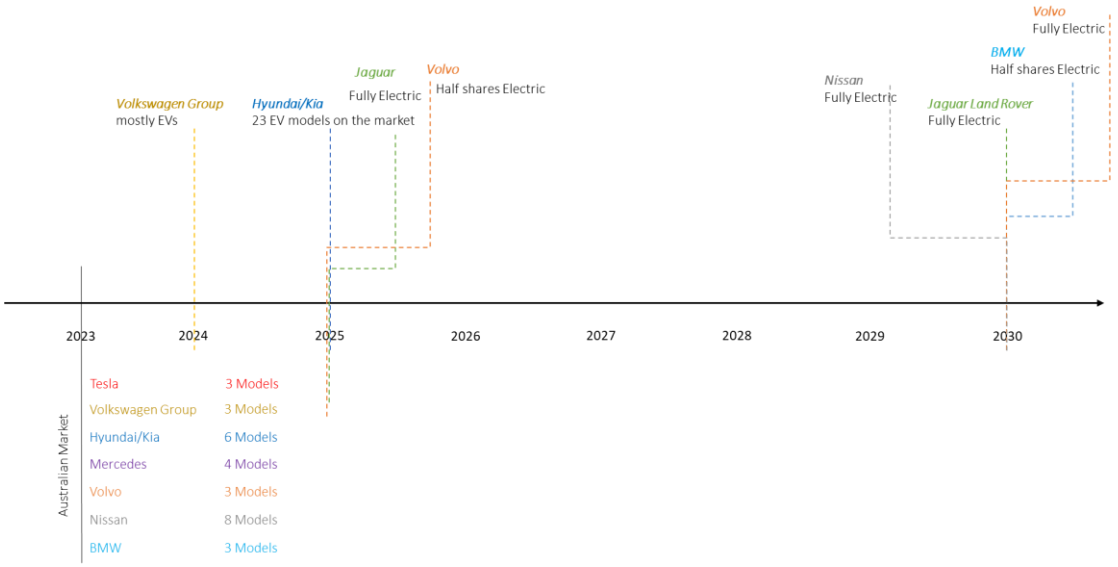
3.5 EV availability

There are currently approximately 30 different passenger EV models being offered by seven different makers in Australia, which is only a small proportion of the 450 models in production worldwide. Uptake has been slow, with the critical mass of vehicles not yet available within Australia. There is also an affordability challenge with purchasing an EV with larger upfront costs to purchase a new EV compared with an ICE vehicle.

There is a lack of urgency for manufacturers to offer EVs in Australia, due to an absence of stringent emissions standards[21]. The European Union has set emissions standards for fleet-wide CO2 emissions. These targets have been set for two timeframes (2020-2024) and (2025-2030). Further, specific targets are set annually for each manufacturer with an incentive mechanism for car and van manufacturers from 2025. If manufacturers exceed their emission target than the manufacturer must pay a penalty, effectively making it less profitable for manufacturers to sell higher emitting vehicles.

In addition, supply challenges related to the COVID-19 pandemic have resulted in long wait times for computer chips. This has affected the supply of new passenger vehicles across the board, with EVs particularly affected – as a standard EV contains twice as many chips as an internal combustion vehicle. Many major car manufacturers have announced plans to convert their offering to fully electric over the next 10-15 years as shown in Figure 3.

FIGURE 3: EV MANUFACTURER TRANSITION TIMELINE



There is limited availability of electric commercial vehicles available in Australia as at mid-2022, with a number of models being planned for release in 2022 to assist in the transition of service and commercial fleets towards electrification.[22]

[21] https://thedriven.io/2021/03/24/third-world-for-evs-vw-says-electric-id-range-wont-be-in-australia-for-years/

[22] https://www.carsguide.com.au/ev/advice/the-top-10-electric-commercial-vehicles-to-keep-an-eye-on-in-australia-85771

3.6 EV charging hubs

Publicly accessible fast charging will be a key need as part of the transition to EVs for people who don't have access to home charging, are using a rental vehicle or a long way from home and require a charge.

As discussed in Section 2.2, the NSW government is planning a network of fast chargers across the state and further details are provided on potential locations relevant to the City in Section 5.1 which focuses on locations near the Sydney Orbital Motorway network reflective of locations of higher traffic volumes as well as a higher proportion of heavy vehicles.

An integral component of current car usage is the provision of petrol stations to refuel, therefore with the takeup of electric vehicles existing petrol stations offer an opportunity for collocated EV charging. Petrol Stations are generally located in highly accessible locations by car including adjacent to major highways and motorways and in locations not as suitable for other land uses. The existing network of petrol stations across the city and Greater Sydney provides a significant opportunity for co-locating EV charging with petrol bowsers of for transitions of petrol stations to stand alone EV charging hubs that are readily accessible.

Some jurisdictions have already mandated that existing petrol stations offer EV charging:

- Germany – announced the requirement for all petrol stations to provide EV charging as part of Covid recovery measures, in line with €500M Euro of funding for EV transition[23]
- Vancouver – will be levying taxes of $10,000 per annum on petrol stations which do not install EV charging by 2025[24]

Locally, existing petrol retailers are at varying levels of rollout and commitment:

- Ampol[25] has announced a high-speed (150kw+) charging network
  - ARENA funding from federal government – for 121 charging points in four cities by October 2023. Pilot of five locations includes Alexandria within the city, which is now operational.
  - Also has a partnership with Evie, which will be for 'future-proof' 350kw chargers. There are already 10 in Victoria, and one in the northwest of Sydney.
  - Ampol see on-the-go charging as the largest proportion of the potential value pool of EV charging, but only 15% of the charging energy demand, indicating that the company anticipates higher-speed charging to be priced at a premium (especially considering the cost of associated infrastructure).
  - Ampol plans for its nationwide network of service stations to become EV fast-charging locations, hydrogen fuel retailers, neighbourhood stores, cafes and restaurants, online delivery centres, and even small-scale utilities, with solar generation and battery storage.

[23] Germany to mandate EV charging at all petrol stations https://www.drive.com.au/news/germany-ev-charging-petrol-stations/
[24] Vancouver Requires Gas Stations & Parking Lots Without EV Chargers To Pay $10,000 Per Year https://cleantechnica.com/2022/05/24/vancouver-requires-gas-stations-parking-lots-without-ev-chargers-to-pay-10000-per-year/
[25] https://www.ampol.com.au/about-ampol/news-and-media/ampol-evie-partnership https://arena.gov.au/news/future-fuels-fund-revved-up-to-provide-ev-charging-nationally/ https://www.ampol.com.au/about-ampol/sustainability/future-energy/ev-charging-network

- BP[26] is also implementing a charging network across its sites. Signed agreement with Brisbane-based charging tech provider. They have a strategy of high-speed charging only. No timing or confirmation on locations yet.
  - BP also see EV charging as having comparable profit margins to fuel retailing, however the newness of the offering means it's not yet turning a profit on it: but that is just a matter of time, especially considering EV market share growth.
- Shell[27] has invested in Australian domestic battery production but hasn't installed any charging points in Australia. Internationally, they have a network of destination chargers and on-street charging, the latter particularly in the UK.
  - Further, Shell has a network of chargers at their service stations in Singapore, as well as destination chargers.
- 7-11[28] has no plans for EV charging in Australia, but is rolling out 60-125kw charging in the USA

The rollout further expands the available public charging network: many petrol stations are optimally located on key routes or near key destinations, and drivers know that there is a fuel offering there already. There is uncertainty around whether the transition will just be providing a charge point or full conversion – this is likely dependent on speed of EV uptake.

There is a capacity consideration for petrol stations when converting from petrol bowsers that can fill up a vehicle in a short period of time compared to potentially 5-10 minutes for an electric charge, dependent on the type of charger. As noted in Ampol's plans for alternative uses on site including collecting deliveries or for shopping that is longer than that of the convenience store associated with most petrol stations. This is already occurring overseas, such as in Norway, with charging hubs inclusive of offerings of lounges and restaurants in new EV charging stations (with liquid fuels still offered).

The provision of other services on site and associated revenue streams may assist offsetting upfront costs to convert to EV charging hubs.

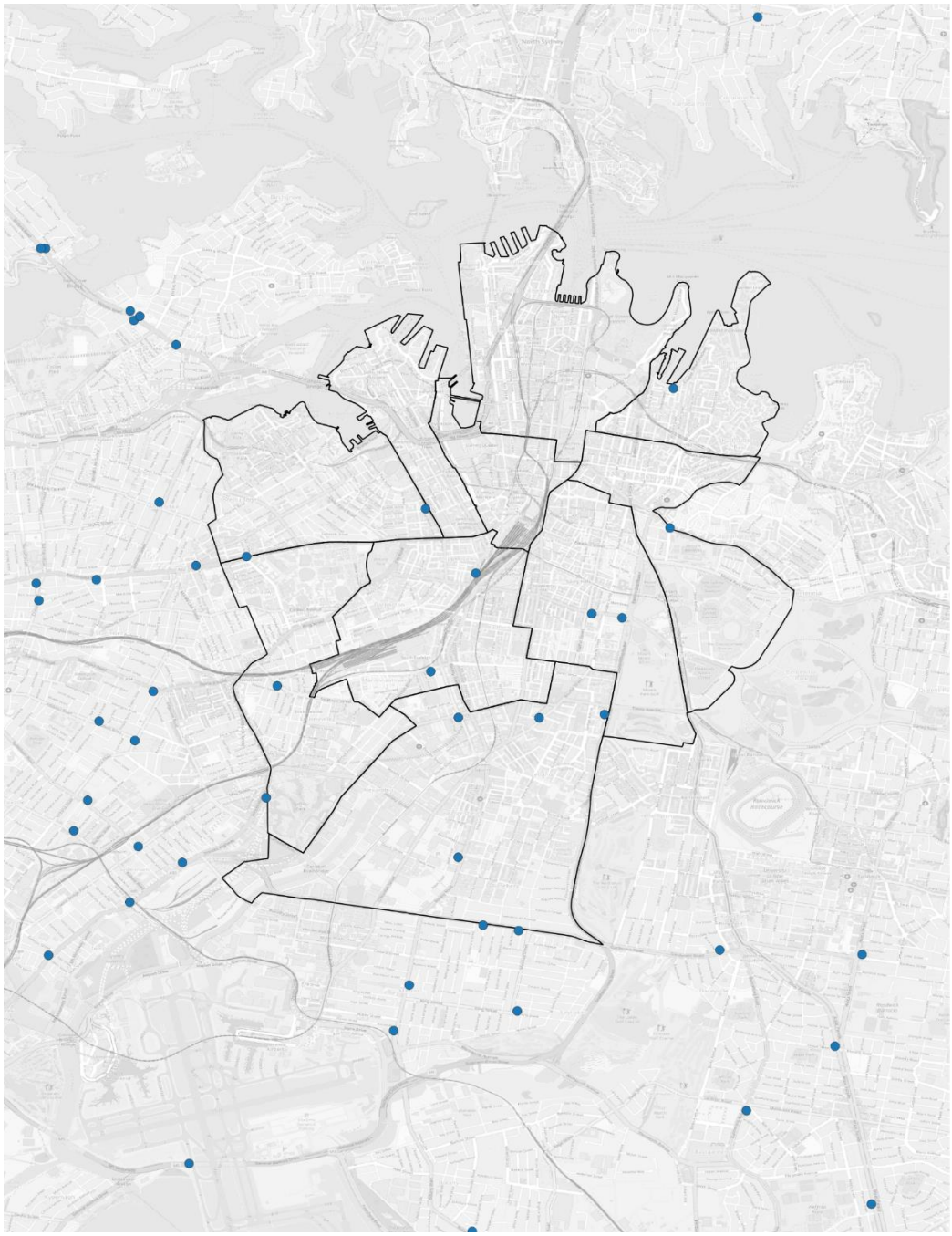
[26] https://www.carexpert.com.au/car-news/bp-planning-local-ev-charger-network-using-australias-tritium https://premium.goauto.com.au/bp-ev-chargers-close-to-being-as-profitable-as-petrol/
[27] https://premium.goauto.com.au/shell-invests-in-ev-charging/#:~:text=Shell%20plans%20no%20connection%20fee,would%20cost%20%2423.60%20to%20recharge. https://www.shell.com/energy-and-innovation/mobility/electric-vehicle-charging.html
[28] https://www.cnet.com/roadshow/news/7-11-charging-station-ev-500-2022/ https://www.drive.com.au/news/7-eleven-australia-chooses-not-to-install-electric-vehicle-chargers-locally-despite-us-pledge/

FIGURE 4: EXAMPLE OF A NEW EV CHARGING STATION IN NORWAY

Source: In Norway & The UK, The EV Revolution Is Reinventing The Gas Station (2021) https://cleantechnica.com/2021/07/12/in-norway-the-uk-the-ev-revolution-is-reinventing-the-gas-station/

There are 16 petrol stations within the City of Sydney LGA and 35+ petrol stations within a 2km radius of the LGA. This represents approximately 300-400 bowsers. Figure 5 indicates the locations of petrol stations.

FIGURE 5: EXISTING PETROL STATIONS IN AND AROUND THE CITY



Source: NSW Fuel Check

4. Technical analysis

4.1 Purpose and framework

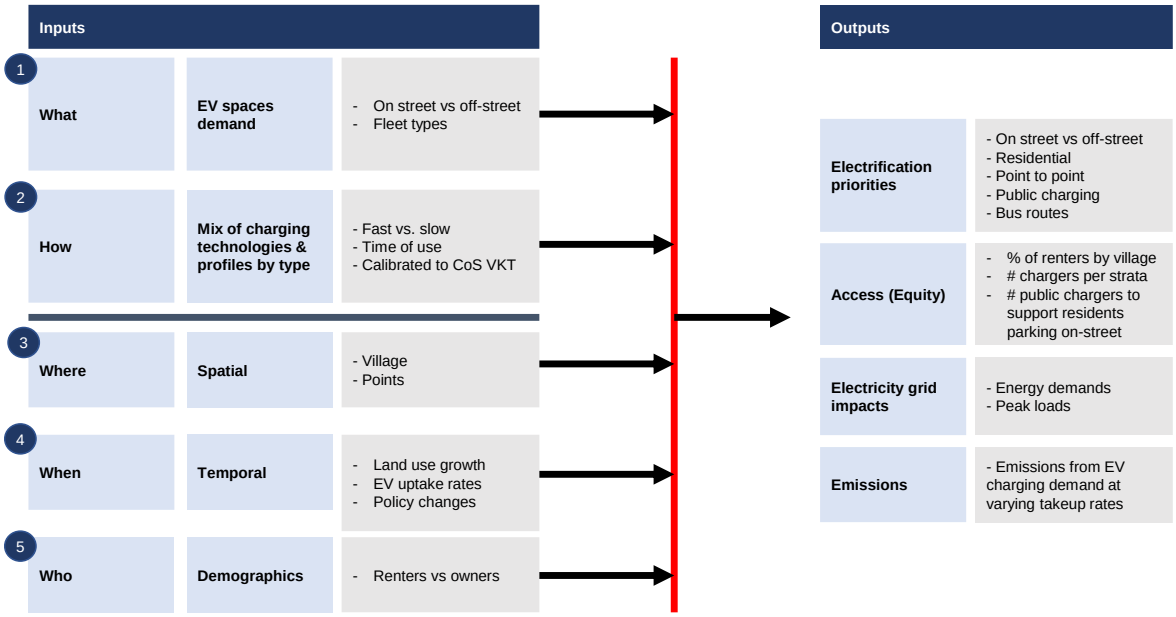
The technical analysis and modelling considered and forecast the uptake of EVs in all fleets operating in the city, as well as the charging requirements of these fleets in three different scenarios for EV uptake. Modelling also sought to understand how the charging of these vehicles would affect annual electricity use, and to interrogate the impact on daily energy load profiles. The analysis sought to inform the following key questions.

EV spaces and associated charging demand modelling was conducted to answer the following key questions:

1. What will be required to enable 100% EV takeup by 2035 to align with the City's Net Zero emissions target?
2. What will be the demand for EV chargers across different fleets and parking provision typologies (on-street, public off-street, private off-street) in the future?
3. How will EV users be charging? That is, what will be the likely time of use and charging technology used for different typologies?
4. Where can users charge their vehicles?
5. Can we decouple where people park vs where they charge?
6. What level of infrastructure would be needed to support those who park on-street?
7. Who is affected? Addressing equity concerns - split incentives between renters vs owners, ensuring those who park on-street also have options to charge their EV, removing barriers for stratas to install off-street EV charging.

The following modelling framework was developed to enable us to answer these key questions.

FIGURE 6: MODELLING FRAMEWORK



4.2 A fleet-by-fleet approach for decision making

The modelling approach tried to break down the charging demand by various fleet types and potential charging locations. Potential charging locations investigated included

- off street private (residential, commercial),
- off street publicly accessible (retail, public parking, petrol station conversions)
- on street public

The purpose was to clearly identify the City's role to facilitate electrification within each fleet and enable clear decision making.

Fleets considered as part of the analysis included:

- Private vehicles driven by residents of the LGA
- Private vehicles driven by people visiting and working in the LGA
- Car share
- Public transport
- Point to Point (Taxi/Ride Share)
- Service and loading vehicles

After discussions with the City and the PCG it was decided to not explicitly model micromobility charging, i.e. electric scooters and electric bikes. These will either be charged at end trip destination facilities or at home for private ownership and share operators will charge their own fleets.

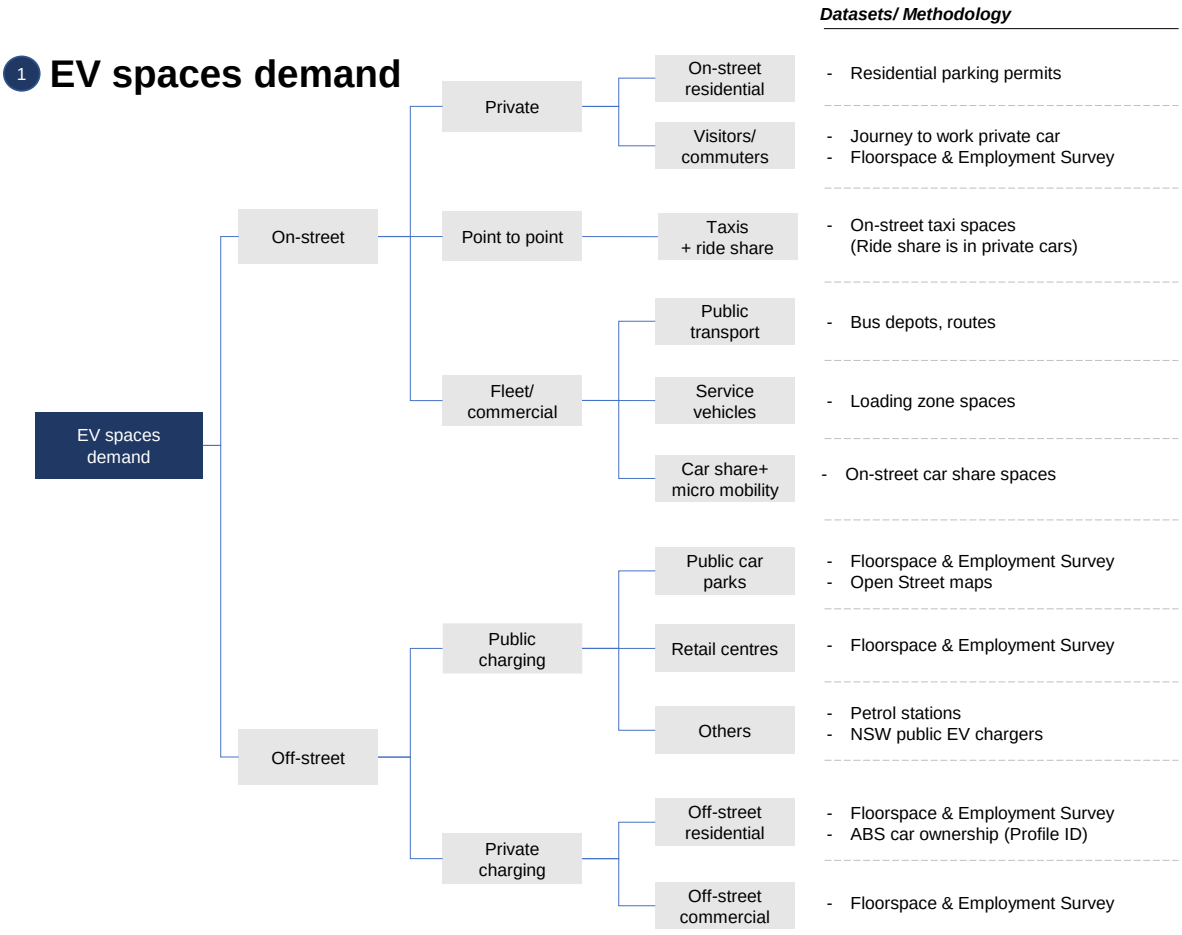
The demand for EV spaces was understood by interrogating where vehicles are parked and their usage patterns. The logic diagram in Figure 7 segments the demand for EV spaces in three parts:

1. First, by on-street vs off-street.
2. Second, by broad fleet type
3. Third, by detailed vehicle type that can be mapped to available data sources.

The aim of this exercise was to understand, that if charging could not be decoupled from parking, what would the EV charging requirement be across various fleet types and locations.

But where vehicles park is only one part of the puzzle. How they are used will inform the charging requirement as discussed in Section 5.1.

FIGURE 7: LOGICAL SEGMENTATION OF EV SPACES DEMAND



At a high level, the demand for EV spaces across the different fleets was analysed alongside parking supply. Looking at both the potential demand for EV spaces under three scenarios as well as the supply of parking in the city provides:

- An understanding of the scale and varied nature of the challenge across different fleet types and locations.
- Opportunity to use existing off-street parking infrastructure for EV charging.

Figure 8 provides an indicator for the potential number of electric vehicles by fleet type operating in the city.

FIGURE 8: INDICATORS OF POTENTIAL NUMBER OF ELECTRIC VEHICLES BY FLEET TYPE

Resident vehicles	Worker vehicles	Service vehicles	Car share	Buses	Taxi	Ride share
65,000 resident cars	**92,000** work car trips per day	**35,000** commercial vehicles movement per day	**858** car share bays	**50-100+** buses in the city at any point	**25,000** taxi trips intro and within the city centre	?? Data vacuum
5% EVs	**10%** by residents	Majority originate outside the LGA	**5 hours** average use per day			
1,400 new EVs in 2 years. (▲68%)	Car mode share 11% CBD 57% Green Square					
Source: ABS census, NSW registrations	Source: ABS census JTW	Source: City freight vehicles study	Source: City car share data	Source: TfNSW bus routes/ city	Source: City centre access strategy	

Figure 9 provides a summary of the parking supply by different locations. This provides an indication of the potential to service EV charging through existing off-street parking infrastructure.

FIGURE 9: SUMMARY OF PARKING SUPPLY BY DIFFERENT LOCATIONS

Off-street	**Off street residential**	**Off-street commercial offices**	**Off-street retail**	**Public car parks**	**Off-street other non-residential**	**Bus depots**
	60,882 off-street residential car park spaces	**25,582** off-street commercial offices car park spaces	**1,649** off-street retail car park spaces	**25,513** public car park spaces	**19,710** other off-street non-residential car park spaces	**30-40** bus depots across Greater Sydney
On-street	**On-street spaces**	**Car share bays**	**Taxi ranks**	**Loading zones**	**On-street residential**	**Bus**
	46,670 on-street parking spaces (restricted, non-restricted, permit and non-permit)	**858** car share bays	**39** taxi ranks	**1,405** loading zones Mostly in City centre	**13,404** resident parking permits	**50-100+** buses in the city at any point

Data sources and rationale for the use of each data input are provided in Appendix A

4.3 Scenarios

3 key scenarios were developed to understand EV takeup into the future. The three scenarios were based on state and nationwide projections for EV takeup and used to model EV takeup in the city. The three scenarios were:

1. Baseline Uptake: This was based on the NSW EV Strategy. The strategy projected that 52% of new vehicles sales would be EVs at 2030.
2. Medium Uptake This was based on anticipated increases in the uptake of EVs due to policies that facilitate availability and affordability of vehicles. This includes policies announced during the recent election by the Labor Government. The policy will reduce barriers to EV uptake and projects that 89% of new vehicles sales would be EVs at 2030.[29]
3. Optimised Uptake: 100% of all vehicles electric. This scenario was intended to assess if there are any barriers to 100% uptake of EVs in the City of Sydney LGA and understand how this level of EV uptake can be facilitated.

Table 10 outlines the EV takeup assumptions across different fleet types under each scenario at 2035. Note that the percentages refers to the proportion of EVs within each fleet.

TABLE 10: SCENARIO ASSUMPTIONS

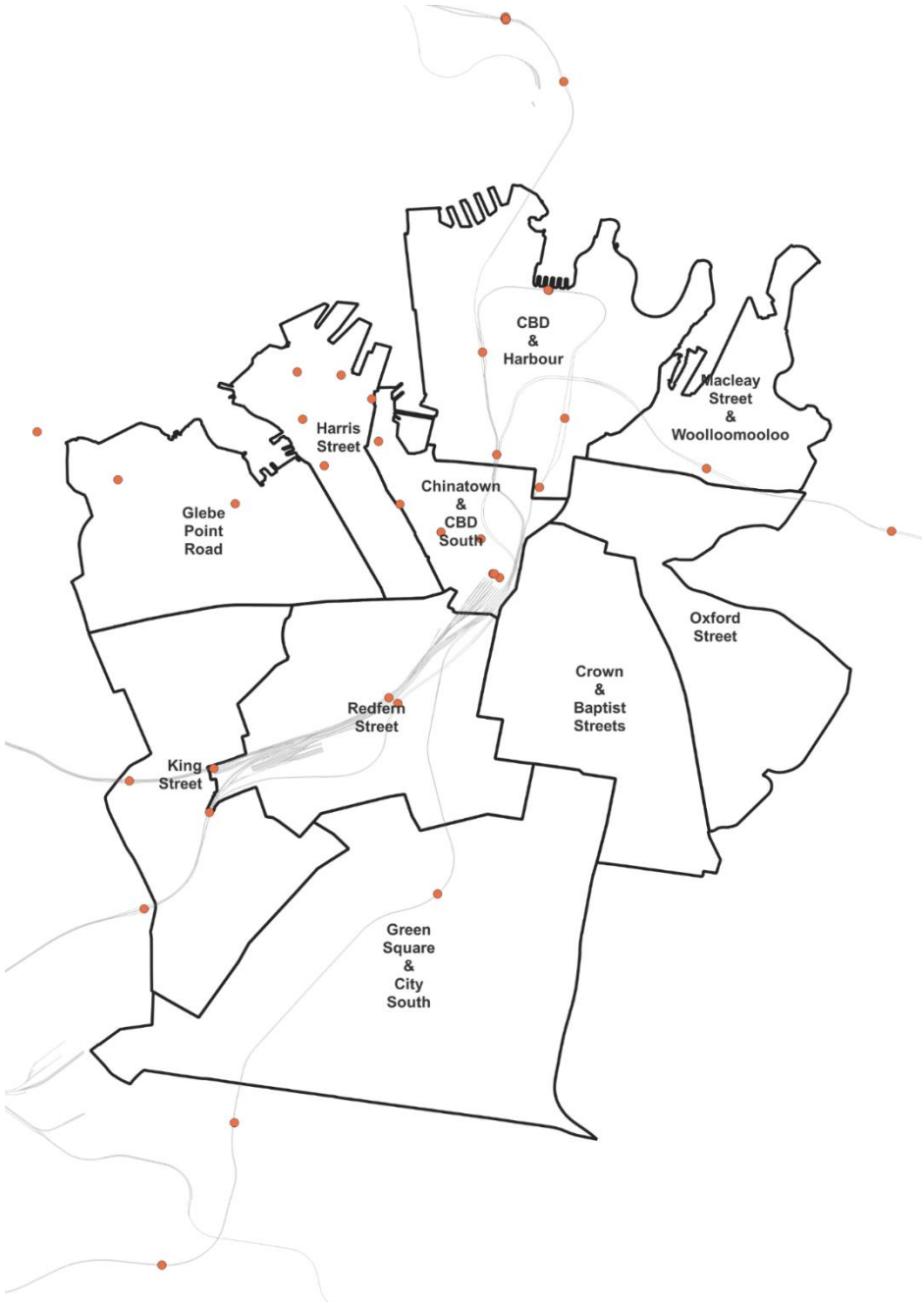
Fleet type	2020	2035 Baseline	2035 Medium	2035 Optimised
Residential	5% (3,400)	25% (17k)	45% (30k)	100% (70k)
Commuters	< 1%	20% (2-5k)	40% (5-10k)	100% (10-15k)
Buses (across Greater Sydney)	2% (70)	100% (4k)	100% (4k)	100% (4k)
Service vehicles	<1%	20%	20%	100%
Car share	<1%	20%	20%	100%
Taxis	<1%	20%	20%	100%

[29] Based on Labor policy announcements from May 2022 during Federal Election campaign. It should be noted that this analysis was conducted during the change of government. Federal Government policies had been released but implementation was not yet fully understood.

4.4 Geography used in the modelling

The modelling has considered spatial variations in EV charging requirements across the City of Sydney's villages. The modelling considered nuances in land use as well as associated vehicle parking and use characteristics (e.g., terrace houses without off-street parking). The villages are shown in Figure 10.

FIGURE 10: CITY OF SYDNEY VILLAGES



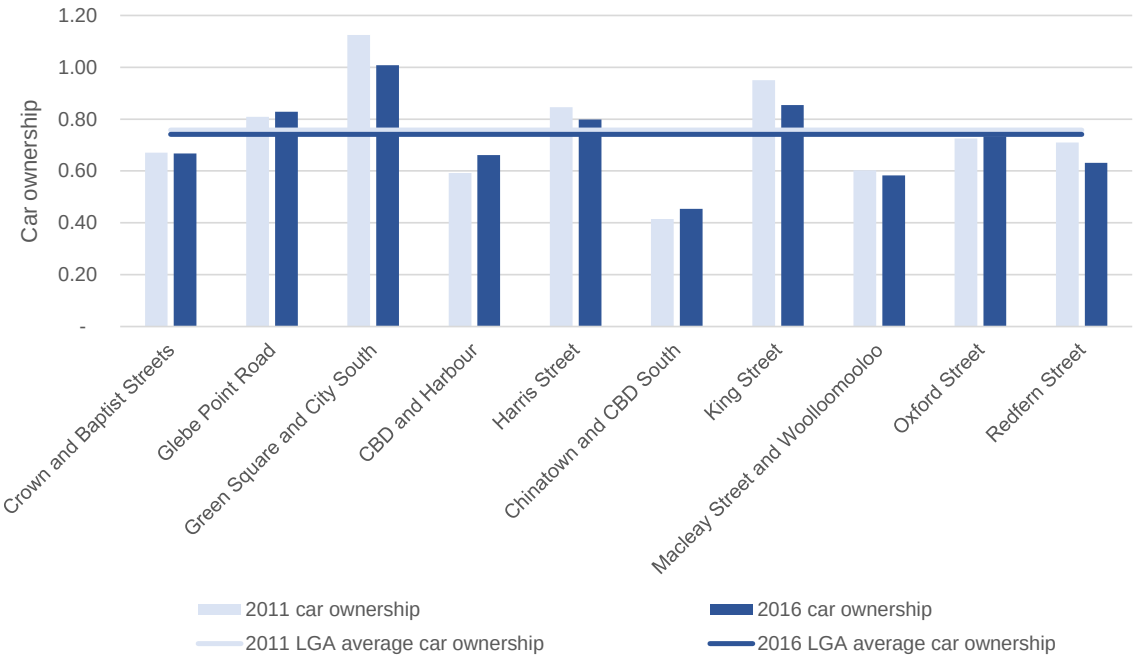
5. Charging needs for different fleets

5.1 Residential vehicle fleet

Current car ownership

Historical car ownership rates across different villages in 2011 vs 2016 is illustrated in Figure 11 below, noting that 2021 Census data was not available at the time of the analysis:

FIGURE 11: HISTORICAL CAR OWNERSHIP IN THE CITY OF SYDNEY (CARS PER DWELLING)



Source: Profile ID (parent source: ABS Census)

While overall car ownership per dwelling did not increase in the period between 2011-2016, there were changes within the individual villages of the city, in line with development patterns. NSW vehicle registrations within the city decreased by 13% between 2019 to 2021 (NSW vehicle registrations data). It should be noted that while estimating total resident cars in the City of Sydney in the future, expected growth in dwellings will offset decreases in per dwelling car ownership rates.

In 2021, approximately 3% of all new light passenger vehicles registered in NSW were EVs[30]. Within the city itself, takeup has been higher, with 5% of resident vehicles being EVs. Between FY19 and FY21, 1,400 new electric vehicles were registered in the City of Sydney.

[30] New registrations by fuel type by vehicle type (2021 calendar year) https://roads-waterways.transport.nsw.gov.au/about/corporate-publications/statistics/registrationandlicensing/tables/table126_2021.html

Car use

The typical city resident uses their car to travel 9-10km per day. In general, the average resident travels short distances for most purposes (Table 11).

TABLE 11: AVERAGE RESIDENT CAR USE

	Average Distance (km per day)
Average daily resident car use	9.4 km
Commute	7.1 km
Education/ childcare	3.0 km
Personal business	3.1 km
Serve passenger	4.2 km
Shopping	1.9 km
Social/ recreation	3.0 km
Work related business	11.2 km
Other	1.1 km

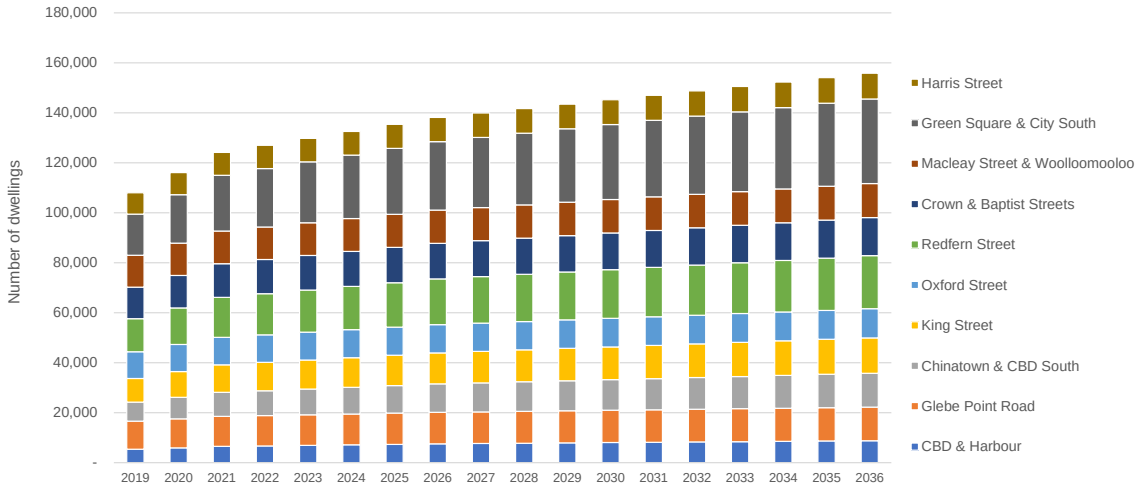
Source: TfNSW household travel survey[31]

[31] TfNSW household travel survey https://www.transport.nsw.gov.au/data-and-research/passenger-travel/surveys/household-travel-survey-hts/household-travel-survey-1

Car ownership projections

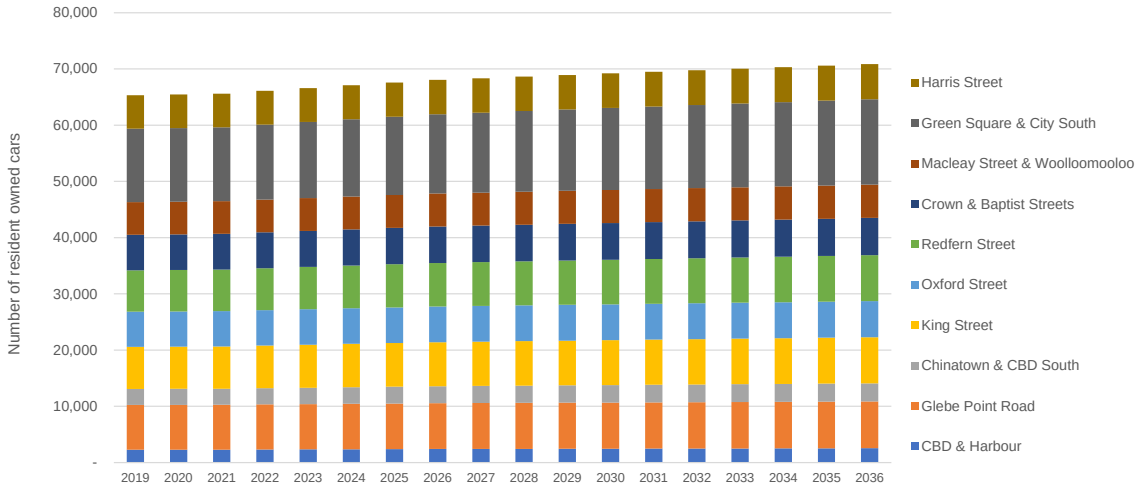
Observed trends in car ownership rates amongst the City of Sydney's residents over the past 6 years and the expected growth in dwellings (Figure 12) have been used to project the number of resident owned vehicles across different villages in the City of Sydney LGA as shown in Figure 13.

FIGURE 12: DWELLING PROJECTIONS BY CITY OF SYDNEY VILLAGE (NUMBER OF DWELLINGS)



Source: City of Sydney LSPS projections

FIGURE 13: NUMBER OF RESIDENT CARS - PROJECTIONS BY CITY OF SYDNEY VILLAGE

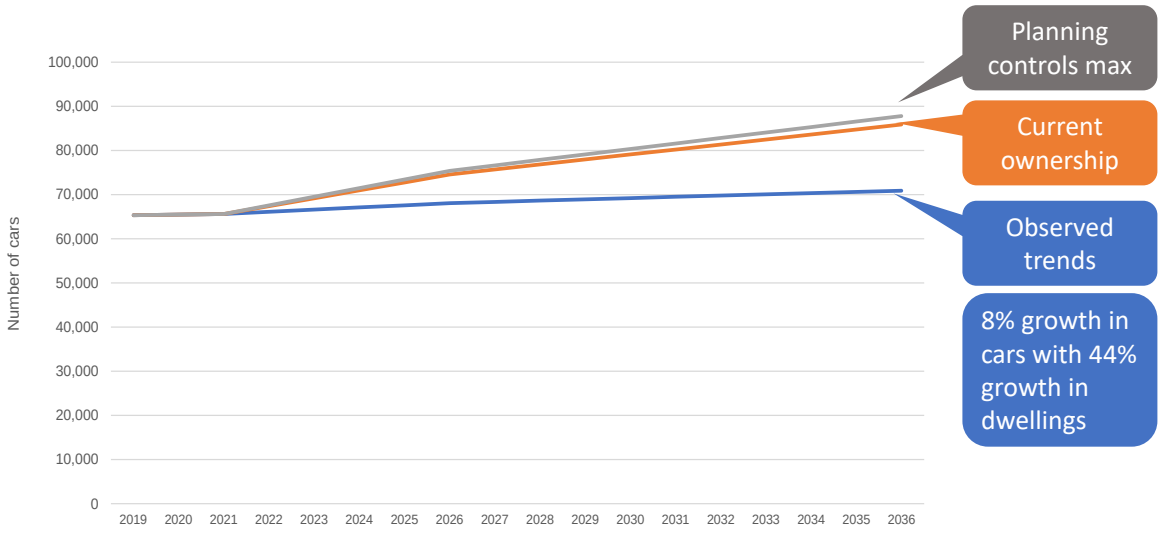


Source: Profile ID (ABS Census) and NSW Registrations, City of Sydney LSPS projections

To understand the scale of the challenge, number of resident cars in the City of Sydney LGA were projected under three different settings.

1. Planning controls max: If all new development was built to provide the maximum parking rate under the City of Sydney LEP 2012 controls and these off-street residential car parks were filled.
2. Current ownership maintained: If current car ownership extends into the future without any change.
3. Observed trends: If observed trends in car ownership continue into the future.

FIGURE 14: CITY OF SYDNEY RESIDENT CAR GROWTH PROJECTIONS (NUMBER OF RESIDENT CARS)



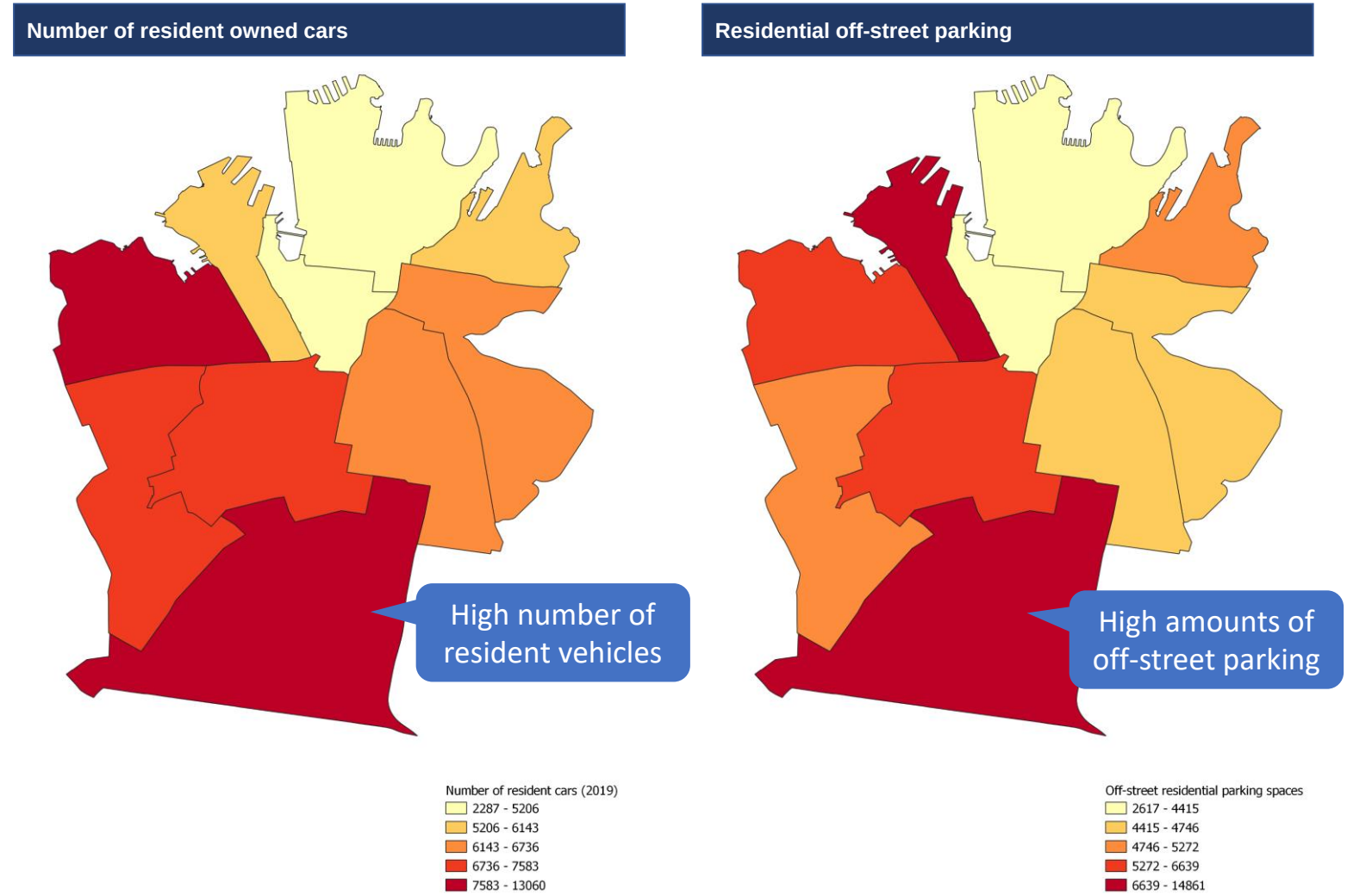
Source: Profile ID (ABS Census), NSW Registrations, City of Sydney DCP and LEP, City of Sydney LSPS

Car parking

From an equity perspective, we sought to understand the constraints to EV takeup on a village-by-village level:

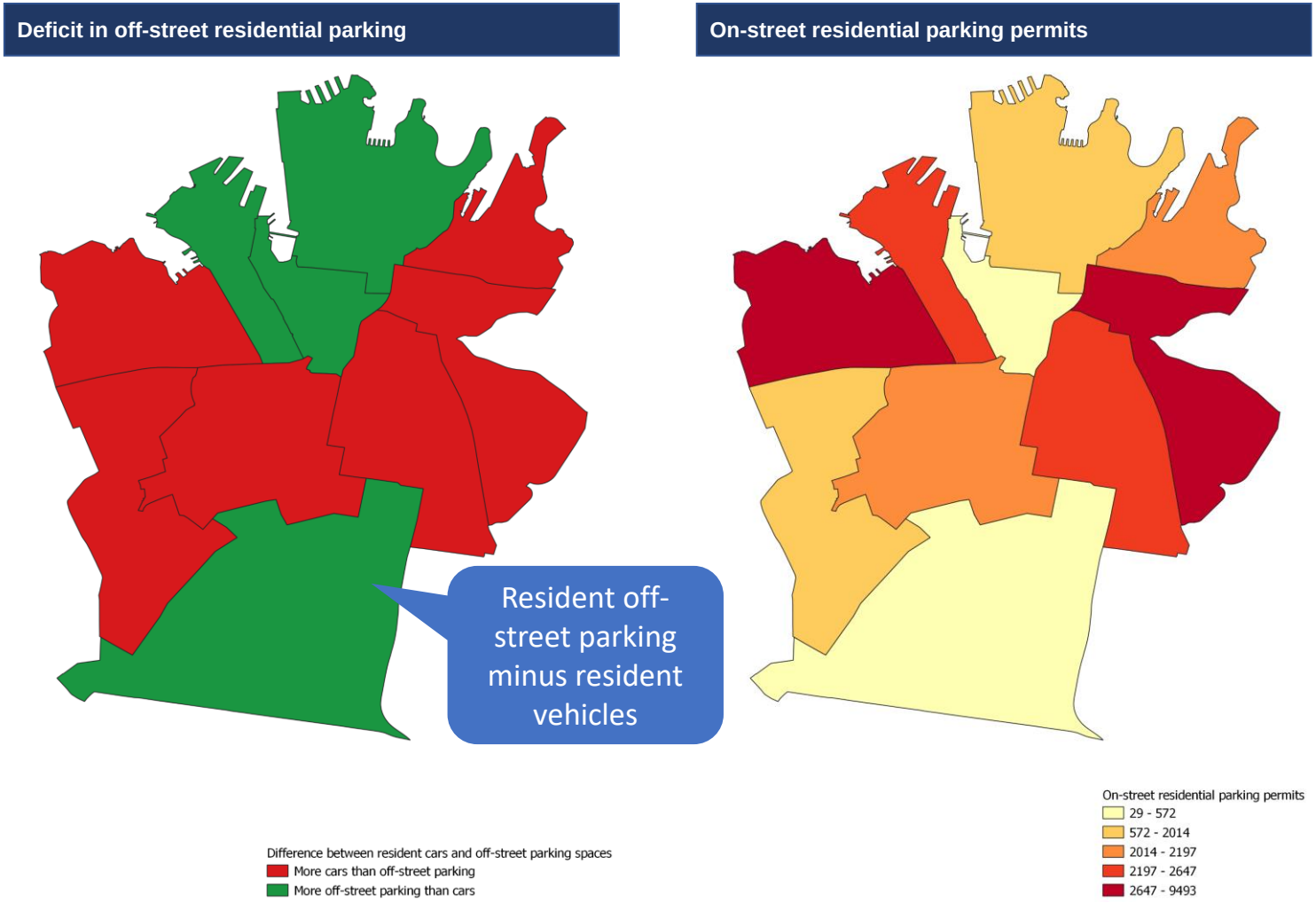
- Where are residents reliant on on-street parking?
  - Figure 15 shows the number of resident-owned cars and resident off-street parking.
  - Figure 16 shows the difference between resident off-street parking and resident vehicle numbers with areas of deficit in residential off-street parking highlighted as red areas which includes residents in inner city areas, typically in terrace houses with limited residential off-street parking park on-street. Residents in Green Square, Pyrmont and the CBD areas, have sufficient off-street residential parking indicated by green.

FIGURE 15: CAR OWNERSHIP (TOTAL RESIDENT CARS) AND OFF-STREET PARKING (PARKING SPACES)



Source: Profile ID (ABS Census), NSW Registrations, City of Sydney Floorspace and employment survey

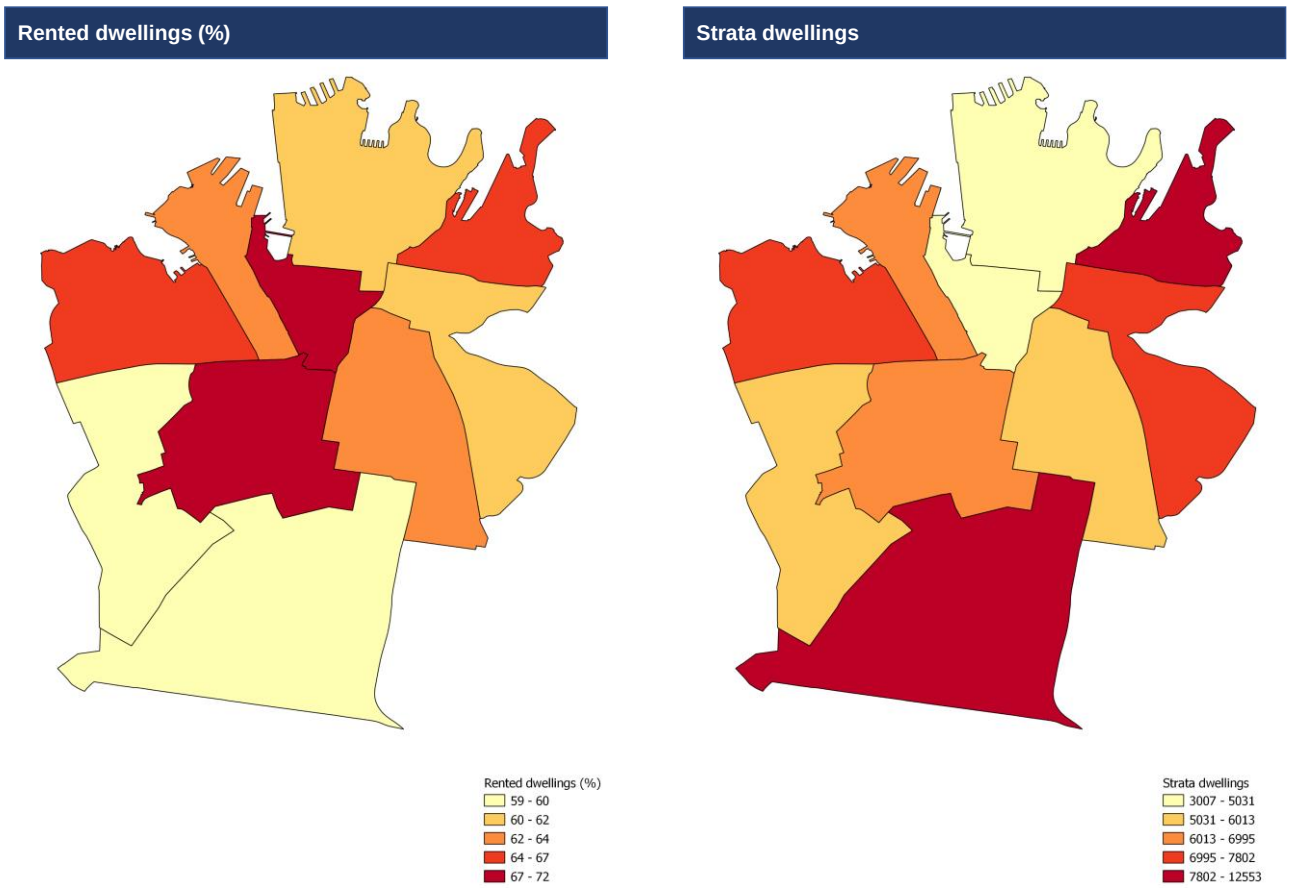
FIGURE 16: ALIGNMENT OF OFF-STREET PARKING TO CAR OWNERSHIP



Source: Profile ID (ABS Census), NSW Registrations, City of Sydney Floorspace and employment survey, City of Sydney residential parking permit data
In the chart on the left, green areas have more residential off-street parking than resident vehicles. Red areas have more resident vehicles than residential off-street parking

- Rented and Strata Dwellings
  - Figure 17 shows that over 50% of dwellings in most parts of the city are rented.
  - Split incentive between owners vs renters as well as EV vs non EV owners in stratas are hurdles to the takeup of off-street residential charging.
  - Based on information from the City, it is understood that there are additional issues for stratas including a lack of information and guidance, metering issues and potential grid capacity constraints from Ausgrid.

FIGURE 17: RENTED DWELLINGS AND STRATA DWELLINGS



Source: Profile ID (ABS Census), City of Sydney Floorspace and employment survey

Key Insight

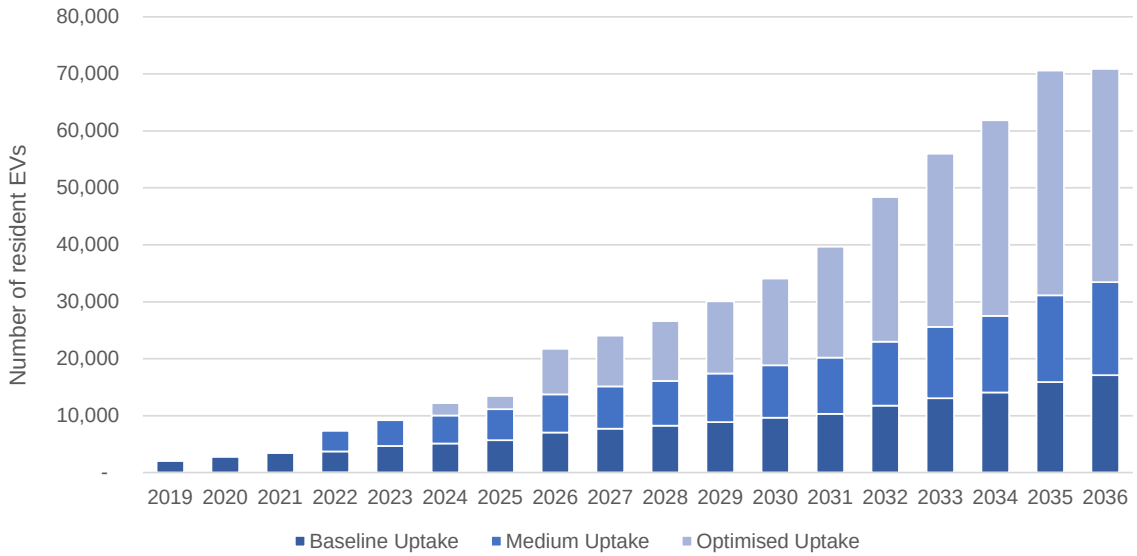
- The average resident in the city travels approximately 9-10km per day. Given that EVs have a range of 300-400km on a full charge, a typical resident in the city would need to recharge their electric vehicle once or twice a month.
- There were an estimated 65,000 resident owned vehicles in the LGA in 2019. By 2035, resident-owned vehicles in the city will grow to around 70,000 to 90,000 based on different uptake projections. Under current trends residential vehicle ownership will be around 70,000 vehicles. This is about 8 per cent growth.
- Residents in the CBD, Pyrmont and Green Square have good access to residential off-street parking and can have good access to private off-street charging.
- Residents in inner city villages (Oxford St, Crown & Baptist St, Redfern St, King St and Glebe Point Rd) are more reliant on on-street parking and therefore will not have the same level of ability to charge at home. However, parking can be decoupled from charging and residents can use publicly accessible off-street charging.

EV take up projections

We projected three scenarios for EV takeup in the City of Sydney as mentioned above.

The three scenarios quantify the range of potential EV takeup outcomes amongst the city's residents. The following sections identify what would be required to enable these outcomes.

FIGURE 18: EV TAKE UP PROJECTION SUMMARY (CUMULATIVE NUMBER OF RESIDENT OWNED EVS) BY SCENARIO



Source: Profile ID (ABS Census), NSW Registrations, City of Sydney LSPS, NSW EV Strategy, Labor Election Policies

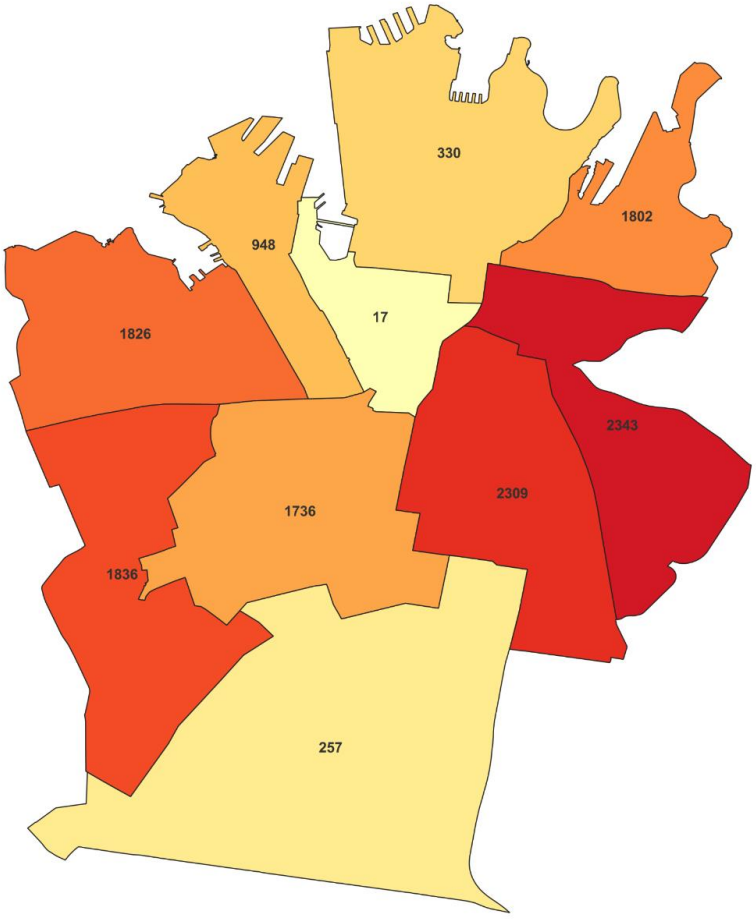
By 2035,

- Close to 30,000 additional dwellings would be built in the City of Sydney.
- Under a baseline scenario – there will be approximately 17,000 resident EVs at 2035.
- If the new Labor government delivers on its election policy, there would be approximately 31,000 resident EVs at 2035.
- At 100% EV takeup, there would be approximately 70,000 resident EVs at 2035.

How many publicly available EV charging points are required to support residents who park on-street?

There are over 13,000 residential parking permit holders across the city. Spatial analysis of these residential parking permit holders shows that about 2,000 residents park on street in each of the inner-city villages of Glebe Point Road, King Street, Oxford Street, Redfern Street, Crown and Baptist streets and Macleay Street and Woolloomooloo as shown in detail in Figure 19.

FIGURE 19: NUMBER OF RESIDENTIAL PARKING PERMIT HOLDERS BY VILLAGE



Source: City of Sydney residential parking permit data

Parking can be decoupled from charging meaning that residents who park on-street and indeed, off-street can charge in off-street public charging locations. To estimate the number of publicly available chargers needed to service residents in the city, the modelling considered:

- The number of EVs expected under each scenario
- Their expected use (less than 10km per day per resident) and as such, frequency of charging (once or twice a month)

Diversity in charging behaviour: on average, utilisation of EV chargers in public car parks is expected to be 10%. While the analysis has assumed average utilisation of 10%, it should be noted that there is likely a spread in utilisation with popular chargers expected to be utilised 70% of the time[32].

Based on this modelling, the number of publicly available chargers required is:

1. Baseline Uptake: 50-100 public chargers.
2. Medium Uptake: 100-150 public chargers
3. Optimised Uptake: 200-350 public chargers

There were 118 public EV charging stations in the City of Sydney LGA at June 2022. This level of charging provision is adequate to already service the modelled EV uptake under the baseline setting, and potentially the medium scenario, note some of these chargers exist in places such as Hotels for guest only.

The combination of new publicly available chargers in retail and off-street parking assets, NSW government roll out of public chargers and future chargers in petrol stations could potentially service the additional EV charging requirement under the Optimised uptake scenario.

The City can work with commercial, retail and public parking asset owners to interrogate a commercial opportunity for these asset owners to support residential parking permit holders to charge EVs in their assets.

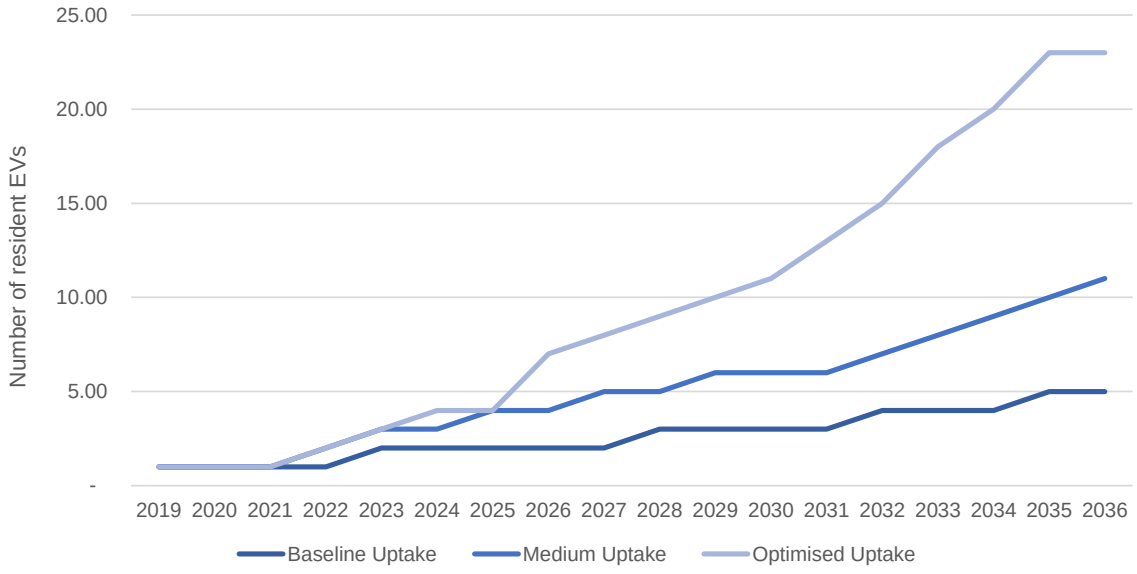
[32] https://www.virta.global/blog/how-are-we-charging-a-deep-dive-into-the-ev-charging-station-utilization-rates

How many EV charging points are required in a residential strata building?

At 2035, between 5-25 EVs are expected in an average strata building under the three scenarios. This was estimated based on the number of EVs projected under each scenario, the number of current strata buildings and projected growth in dwellings from the City of Sydney LSPS.

It should be noted that there is a large spread in the scale (size, age and parking) of strata buildings. A good rule of thumb is to enable one charging space per 10 EVs[33]. As such, 15-20% of the car parks in a strata building can be enabled with EV charging to support all residents taking up EVs.

FIGURE 20: AVERAGE NUMBER OF EVS PER RESIDENTIAL STRATA BUILDING



Source: Profile ID (ABS Census), NSW Registrations, City of Sydney LSPS, NSW EV Strategy, Labor Election Policies, City of Sydney Floorspace and Employment Survey

Resident energy demands

To estimate the EV charging demand from city residents, we need to answer the following:

- How many EV's will be owned by resident?
- How will residents use their EVs and how often will they need a charge?
- What will be the increased demand from EV charging on the electricity grid?

By 2035, close to 30,000 additional dwellings would be built in the city with the number of resident EVs modelled under the three different uptake scenarios as shown in Figure 18 above.

[33] Mckinsey & Company, 2022, Building the electric-vehicle charging infrastructure America needs https://www.mckinsey.com/industries/public-and-social-sector/our-insights/building-the-electric-vehicle-charging-infrastructure-america-needs

How will residents use their EVs and how often will they need a charge?

- At 2035, 20% of resident vehicles are expected to be EVs under the baseline scenario[34]. Under the medium scenario with Labor policy settings, this would be 25%. The City can be enabled so 100% of its residents can transition to EVs at 2035.
- The average city resident travels under 10km per day[35].
- Most EVs can drive 200km when fully charged. Range is increasing with new models able to travel 400 km in single charge[36].
- Effectively, on average residents would need to charge once a fortnight/ month. Note that this is representative of average every day car use and excludes destination/ long trips.
- As at 2022, 118 public EV stations exist in the city[37].
- Residents that charge at home would increase their energy use by 10%.
- As such, residents that charge at home would add $100 per year in electricity costs but this is offset by over $800 of savings in fuel costs.
- Residents charging in public charging stations could pay $200 per year in charging costs under 2022 EV charging pricing structures. Compared to over $900 per year in petrol costs if they were using a petrol vehicle.

[34] NSW EV strategy
[35] TfNSW household travel survey
[36] TFNSW Electric Vehicles Webpage
[37] TFNSW Electric Vehicles Webpage, plugshare.com

What will the increased demand from EV charging be on the electricity grid?

The increased electricity demand from charging of EVs is represented Figure 21.

2019-20 electricity demand from the residential sector is roughly 425 GWh per annum. The projected growth in dwellings would increase building or stationary electricity demand by 170 GWh. The impact of EV charging on the 2019-20 residential electricity demand would vary based on takeup and range between 10% to 40% increase.

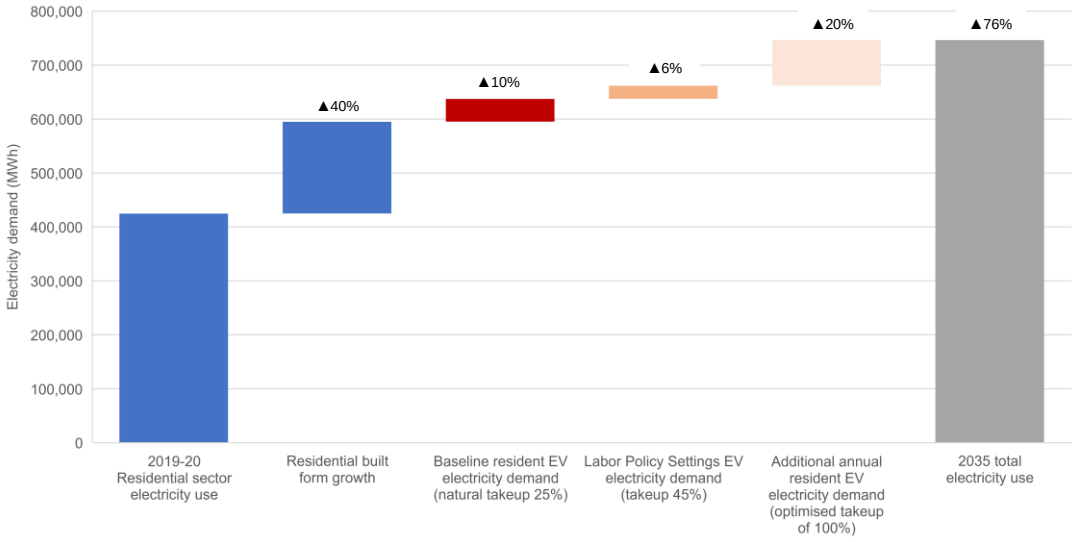
The expected EV charging electricity demand would vary under the three scenarios. The increase on 2019-20 residential electricity use is described below.

1. Baseline Uptake: 10% increase on 2019-20 residential electricity use.
2. Medium Uptake: 16% increase on 2019-20 residential electricity use
3. Optimised Uptake: 36% increase on 2019-20 residential electricity use.

To put this into perspective, new residential buildings are expected to increase the current residential electricity demand by 40% in 2035.

The impact on aggregated LGA-wide electricity load profiles would be minimal. Resident EV charging is expected to increase peak demand across the LGA by under 5%, as most residential charging at home will occur overnight, and publicly accessible charging will mostly occur during the day. However, the localised impact, for example, on individual substations, will need to be further understood with Ausgrid.

FIGURE 21: ENERGY DEMAND FROM RESIDENTIAL EV CHARGING (ELECTRICITY DEMAND IN MWH)



Source: City of Sydney ESP, Kinesis Modelling for Net Zero by 2035 Strategy, Kinesis modelling of EV takeup, usage and associated energy demand.

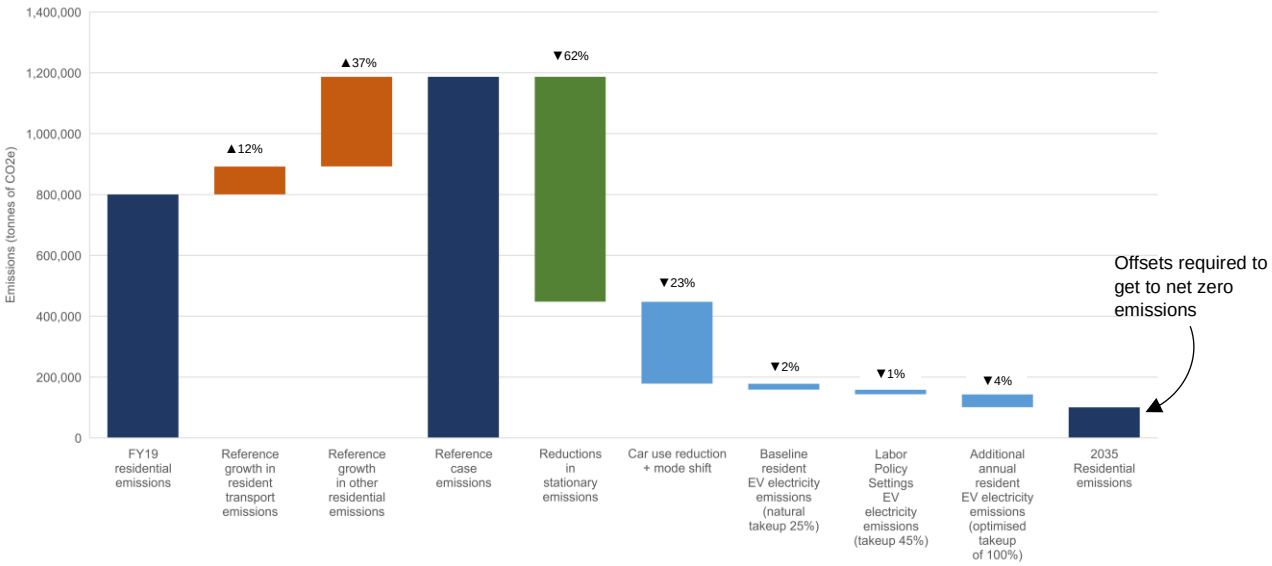
What will the impact be on emissions?

This work has been contextualised in terms of the City's commitment to net zero emissions by 2035. To get to net zero emissions, we have considered the transport and stationary emissions modelled for the City of Sydney's Environmental Strategy. The impact of the takeup of EVs by city residents under the three scenarios has been quantified on the city's residential sector. This is represented as a waterfall chart in Figure 22.

At a high level, relative to the modelled reference emissions:

- Reductions in stationary emissions particularly from decarbonisation of the electricity grid will deliver over 60% of the pathway to net zero emissions by 2035.
- The City's programs and policies directed at reducing car use and encouraging mode shift to public and active transport will deliver 23% of the pathway to net zero emissions by 2035.
- The City's residents transitioning to electric vehicles will contribute to 2-7% of the pathway to net zero emissions by 2035, depending on the EV takeup rates. EV takeup under the baseline settings described by the NSW EV strategy would deliver 2% emission reduction at 2035. Medium uptake under Labor policy settings would deliver 3% emission reduction at 2035 and a full resident transition to EVs would deliver 7% emission reduction at 2035.
- Carbon offsets will be required to cover the remaining emissions and get to net zero emissions by 2035 in the residential sector.

FIGURE 22: SOURCES OF CHANGE IN RESIDENTIAL EMISSIONS IN THE CITY OF SYDNEY (EMISSIONS IN TONNES OF CO2E) 2035



Source: City of Sydney ESP, Kinesis Modelling for Net Zero by 2035 Strategy, Kinesis modelling of EV takeup, usage and associated energy demand.

Going from left to right in Figure 22, each bullet point below relates to a column or bucket in the waterfall chart:

- The 2019-20 emissions from the residential sector is roughly 800,000 tonnes of CO2e.
- If current travel patterns continue, the projected growth in the residential sector would increase resident transport emissions by 12%
- If current energy use patterns continue, the projected growth in the residential sector would increase 2019-20 residential emissions by 37%.
- At 2035, under a reference case, where 2019-20 travel patterns, resource use and emissions patterns continue, residential emissions are expected to be nearly 1.2 million tonnes of CO2e.

From this reference case, we have modelled reductions in stationary and transport emissions as outlined below:

- The expected decarbonisation of the electricity grid as well as smaller impact interventions across building efficiency and waste would reduce residential emissions by 62%.
- Existing programs and policies to drive car use reduction and mode shift to public and active transport would result in a 23% reduction in reference case residential emissions.
- Baseline uptake of EVs as projected under the NSW EV strategy would reduce emissions by 2%
- Medium uptake of EVs as projected by Labor's policy settings would reduce emissions by a further 1%
- Optimised uptake of EVs by residents would reduce emissions by a further 4%.
- At 2035, the city's residential sector is expected to generate 100 thousand tonnes of CO2e emissions.

Key insights

EV takeup under each of the three scenarios would reduce the reference case emissions at 2035 by:

1. Baseline: 2% reduction on 2035 reference case residential emissions.
2. Medium: 3% decrease on 2035 reference case residential emissions
3. Optimised: 7% decrease on 2035 reference case residential emissions.

To put this in context:

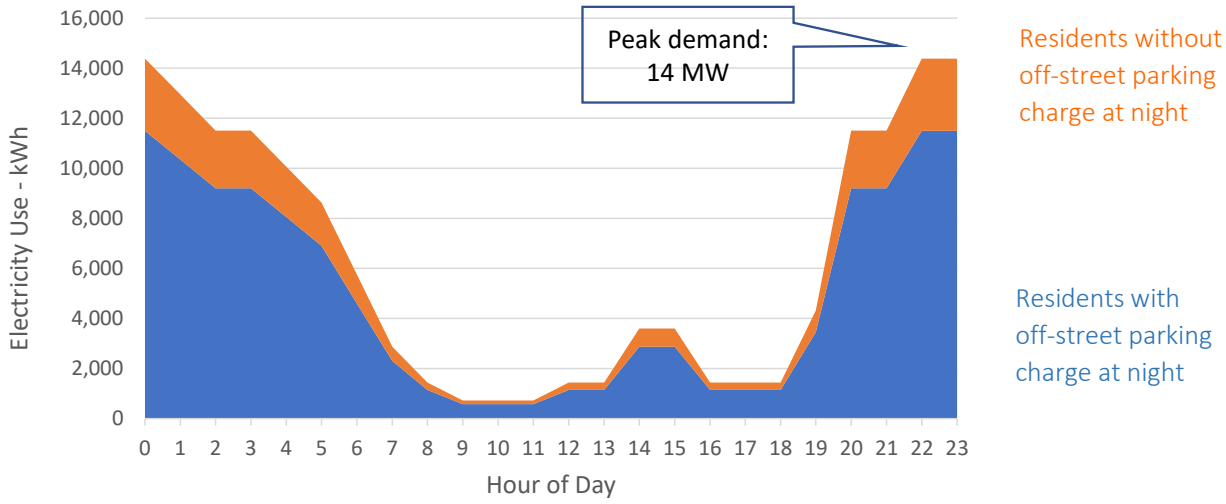
- Electricity grid decarbonisation would significantly decrease residential stationary emissions. It would decrease 2035 reference case residential emissions by over 60%.
- Current programs to reduce car use and mode shift to public and active transport would reduce 2035 reference case residential emissions by over 20%.

What is the impact on energy load profiles?

The impact on energy load profiles and peak demand would vary based on how residents charge their vehicle.

Based on current user behaviour, over 80% of charging happens at home but residents in the city have options for public EV charging. The diversity of charging behaviour and technologies from exercising these options would impact daily energy load profiles overleaf show indicative daily load profiles from resident EV charging. They show what the maximum demand would be if all residents charged at night (14 MW) (Figure 23) and if residents used a mix of public chargers and off-street charging in their homes (10MW) (Figure 24). Aggregating all substations that roughly service the city, the peak electricity demand is roughly 700 MW. As such, resident EV charging would add less than 5% to the peak demand. However, the impact should be considered on a granular geography/ substations through discussions with Ausgrid.

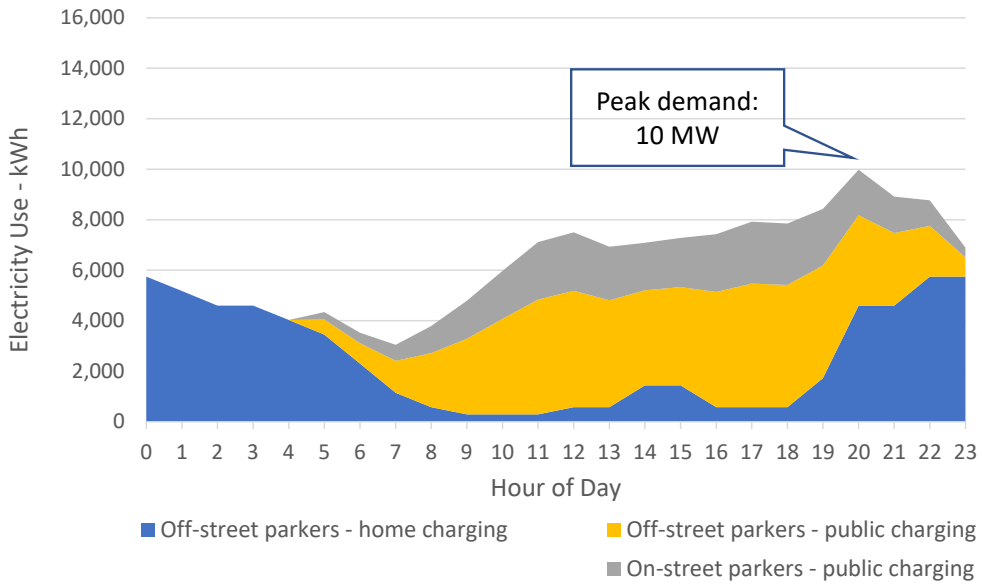
FIGURE 23: ELECTRICITY DEMAND PROFILE FOR OPTIMISED SCENARIO (100% EV TAKEUP) WITH MOST CHARGING AT NIGHT



Source: Kinesis modelling of home and public charging profiles. Charging profiles obtained from a Danish study have been calibrated to City of Sydney EV charging demand based on resident car use extracted from TfNSW Household Travel Survey[38]

[38] https://www-sciencedirect-com.virtual.anu.edu.au/science/article/pii/S0142061521001400X#s0015, https://www.transport.nsw.gov.au/data-and-research/passenger-travel/surveys/household-travel-survey-hts/household-travel-survey-1

FIGURE 24: ELECTRICITY DEMAND PROFILE FOR 100% EV TAKEUP SCENARIO WITH CHARGING AT DIFFERENT TIMES (DAY AND NIGHT)



Residents who park on-street or park off-street charge in public off-street charging points through different times (at day and night)

Residents who park off-street, charge off-street mostly at night

Source: Kinesis modelling of home and public charging profiles. Charging profiles obtained from a Danish study have been calibrated to City of Sydney EV charging demand based on resident car use extracted from TfNSW Household Travel Survey[39]

GRID IMPACTS

The impact on aggregated LGA-wide electricity load profiles would be minimal but localised impact in individual substations and distribution networks would need to be explored by Ausgrid on a case-by-case basis.

To understand this impact, the following steps were followed:

- Identified 14 zone substations that service the City of Sydney LGA.
- There isn't a clear mapping between these zone substations and the City's villages. As such the electricity load profiles from the 14 substations that service the LGA was aggregated to understand the impact of EV's across electricity demand for the City of Sydney LGA as a whole.
- Under an Optimised Scenario simulating 100% EV takeup within the city, the incremental impact on the peak electricity demand was under 5%. Note that resident charging demand is expected to be the most material of all fleets based on the fact most EV charging has been assumed to occur at home.
- While the impact on LGA wide electricity load profile is expected to be minimal, impacts on localised substations and distribution networks should be investigated further with Ausgrid. This will likely be done on a case-by-case basis by Ausgrid.

[39] https://www-sciencedirect-com.virtual.anu.edu.au/science/article/pii/S0142061521001400X#s0015, https://www.transport.nsw.gov.au/data-and-research/passenger-travel/surveys/household-travel-survey-hts/household-travel-survey-1

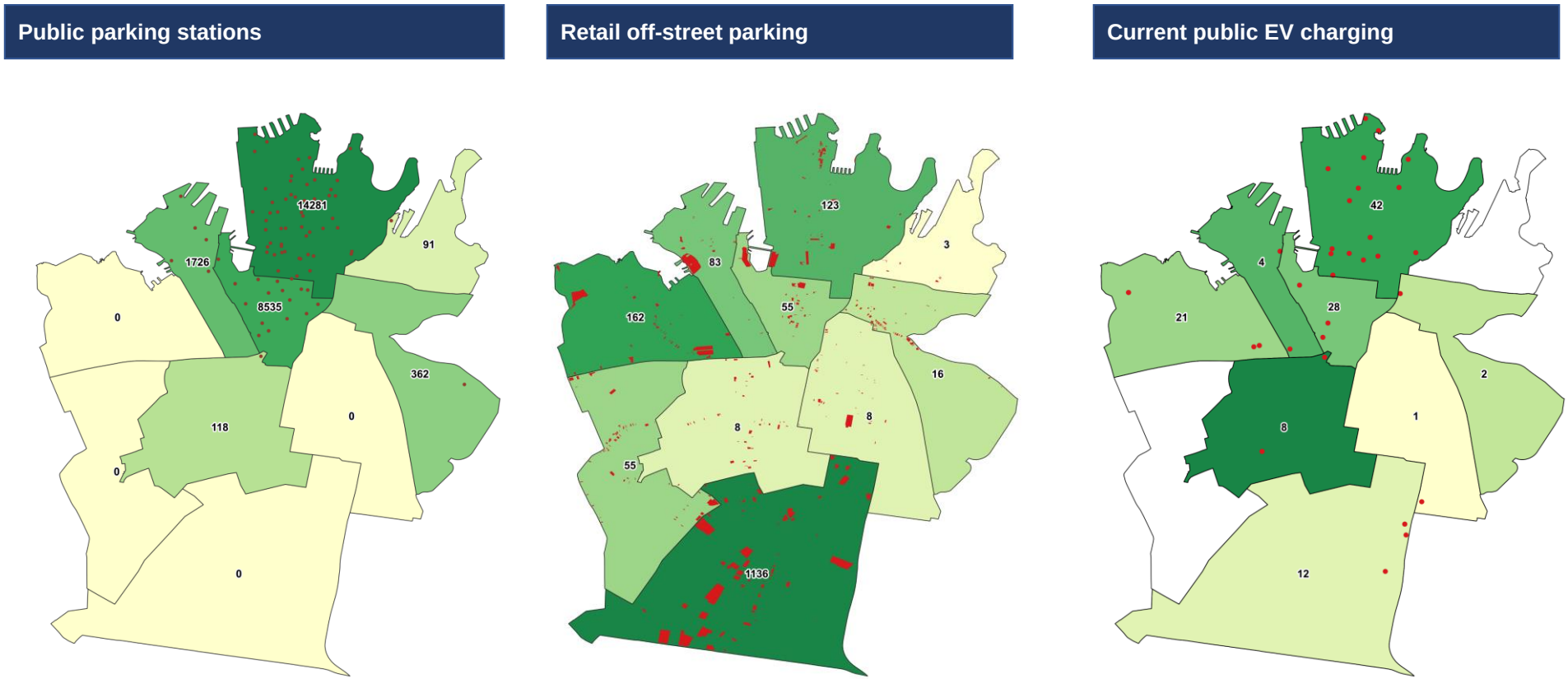
Options to charge

City role

Given that most residents would typically only charge 1-2 times a month, it is possible to decouple where residents park from where they charge. That is, EV users in the city can consider options outside of home charging. The following would support this.

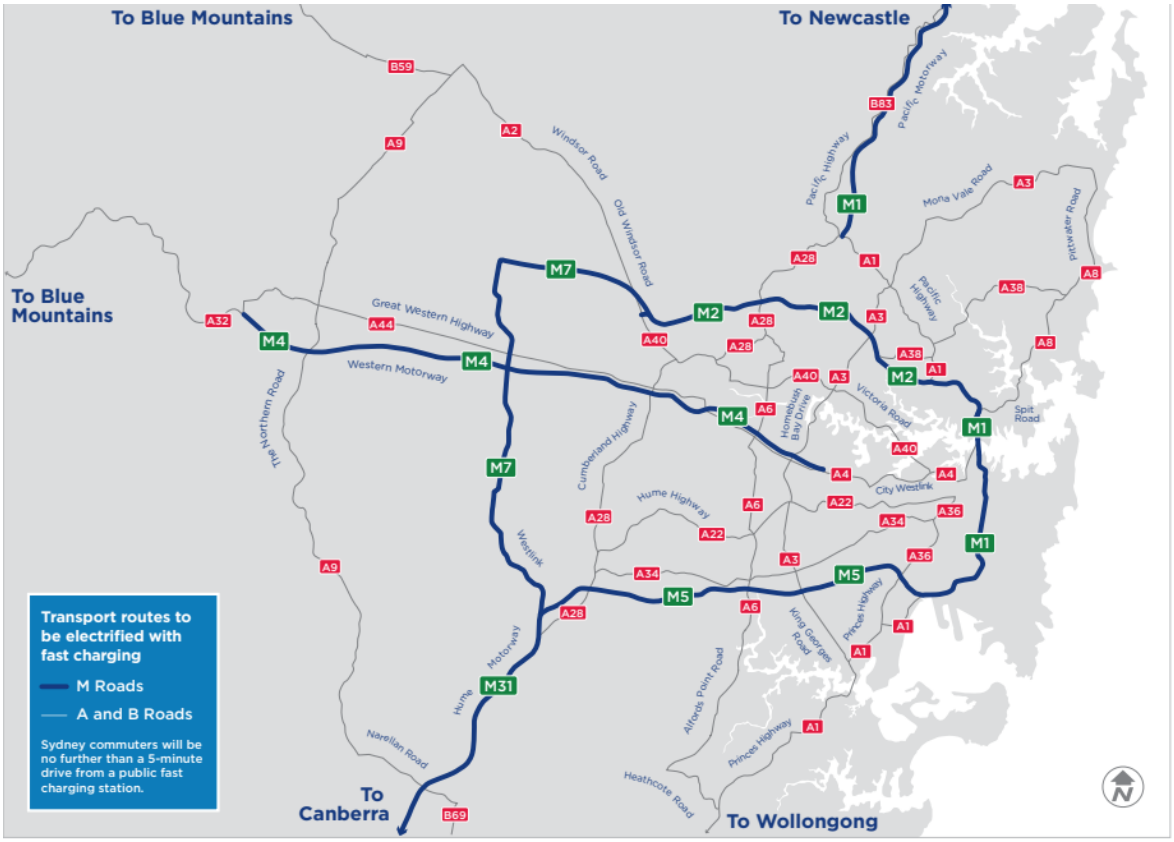
- As at July 2022, there are 118 public EV charging stations in the City of Sydney.
- City can work with retail asset owners to increase fast EV chargers in retail centres.
- The City can work with public parking asset owners/operators to provide publicly available EV charging as a commercial opportunity that benefits both the asset owner as well as EV users.
- Private sector establishing publicly accessible charging stations i.e. converting petrol stations.
- NSW Government has plans to deliver an EV charging network along the M1 and A4 roads within the LGA as shown in Figure 26.

FIGURE 25: OPTIONS FOR PUBLIC EV CHARGING (NUMBER OF CAR PARKS/ EV STATIONS)



Source: City of Sydney Floorspace and Employment Survey, TfNSW Electric Vehicles Webpage (plugshare).

FIGURE 26: NSW STATE PLANS FOR EV CHARGING



Source: NSW EV Strategy

5.2 Commuter/ worker vehicle fleet

The EV charging requirement to service commuters into the city was understood by answering the following key questions:

- How many commuter car trips are made now and how many are expected in 2035?
- What is the average distance of these trips? Does this vary across the LGA?
- Would commuters need to charge in Sydney? Or can they drive back home and charge?
- Would there be any benefits in providing charging for commuters?

How many commuter car trips are made now and how many are expected in 2035?

- There are currently approximately 90,000 journey to work car trips each day into the LGA.
- An additional 200,000 jobs are expected in the City of Sydney by 2036
- The City has mode shift targets. Currently, 85% of commuters to the city centre and 62% of commuters to the rest of the LGA use public and active transport. By 2050, the target is for 90% of commuters to the city centre and 66% of commuters to the rest of the LGA to use public and active transport.
- As such, approximately 150,000 journey to work car trips are expected in the City of Sydney LGA by 2035.

What is the average distance of these trips? Does this vary across the Sydney LGA?

- The typical car commute of workers travelling to the City of Sydney LGA is between 5 to 10 km (see Figure 27).

This is consistent across different parts of the City of Sydney LGA. That is, both a car commuter to green square and one to the CBD travel 5-10km (Figure 28).

Would commuters need to charge in Sydney? Or can they drive back home and charge?

- Given that EVs have a range of 300-400km per charge, it is unlikely that commuters who drive into work in the Sydney LGA will need to charge their EV in the LGA.
- Councils where the commuters live need to ensure their residents to have charging opportunities, for all their purposes including work trips to the Sydney LGA.

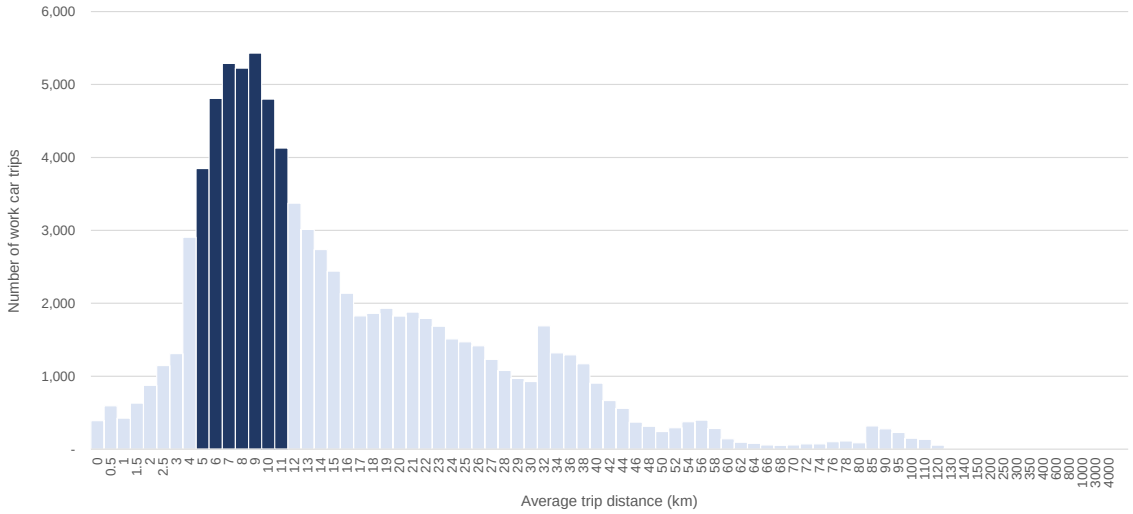
Would there be any benefits in providing charging for commuters?

- However, there is a commercial opportunity for commercial and public parking asset owners to provide EV charging for their employees and customers. Figure 29 shows the location of publicly accessible car park and commercial car parks.

City Role

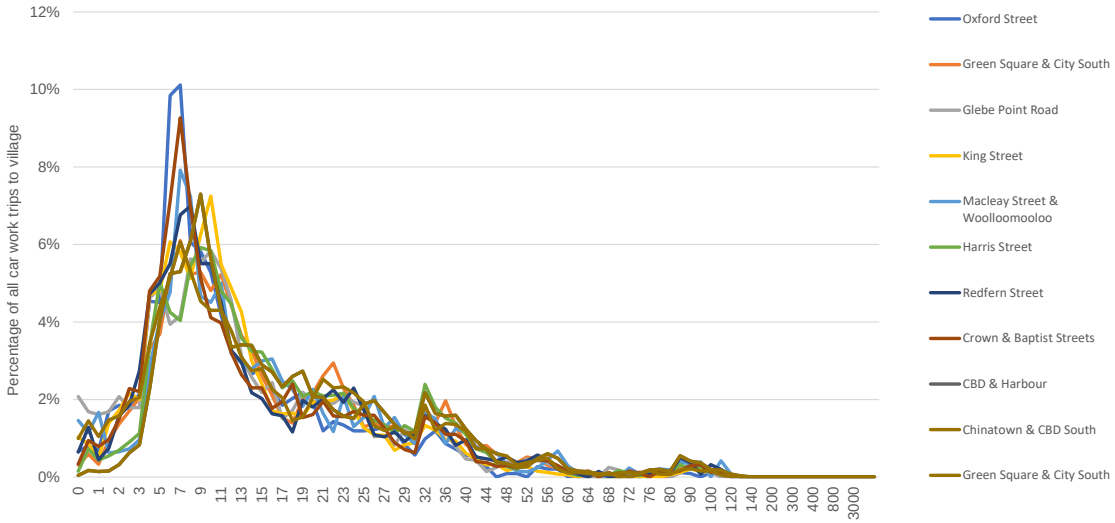
People car commuting to commercial or public parking assets in the City of Sydney LGA would generally not need to charge EVs at their destination (as they would generally charge at or near their homes. While the City would discourage owners of parking facilities in commercial buildings or public car parks to provide charging in the CBD (with very low rates of car commuting), there might be advantages to provide charging in locations outside the City Centre.

FIGURE 27: COMMUTING TRIP DISTANCE TO THE CITY OF SYDNEY (NUMBER OF CAR COMMUTER TRIPS BY DISTANCE)



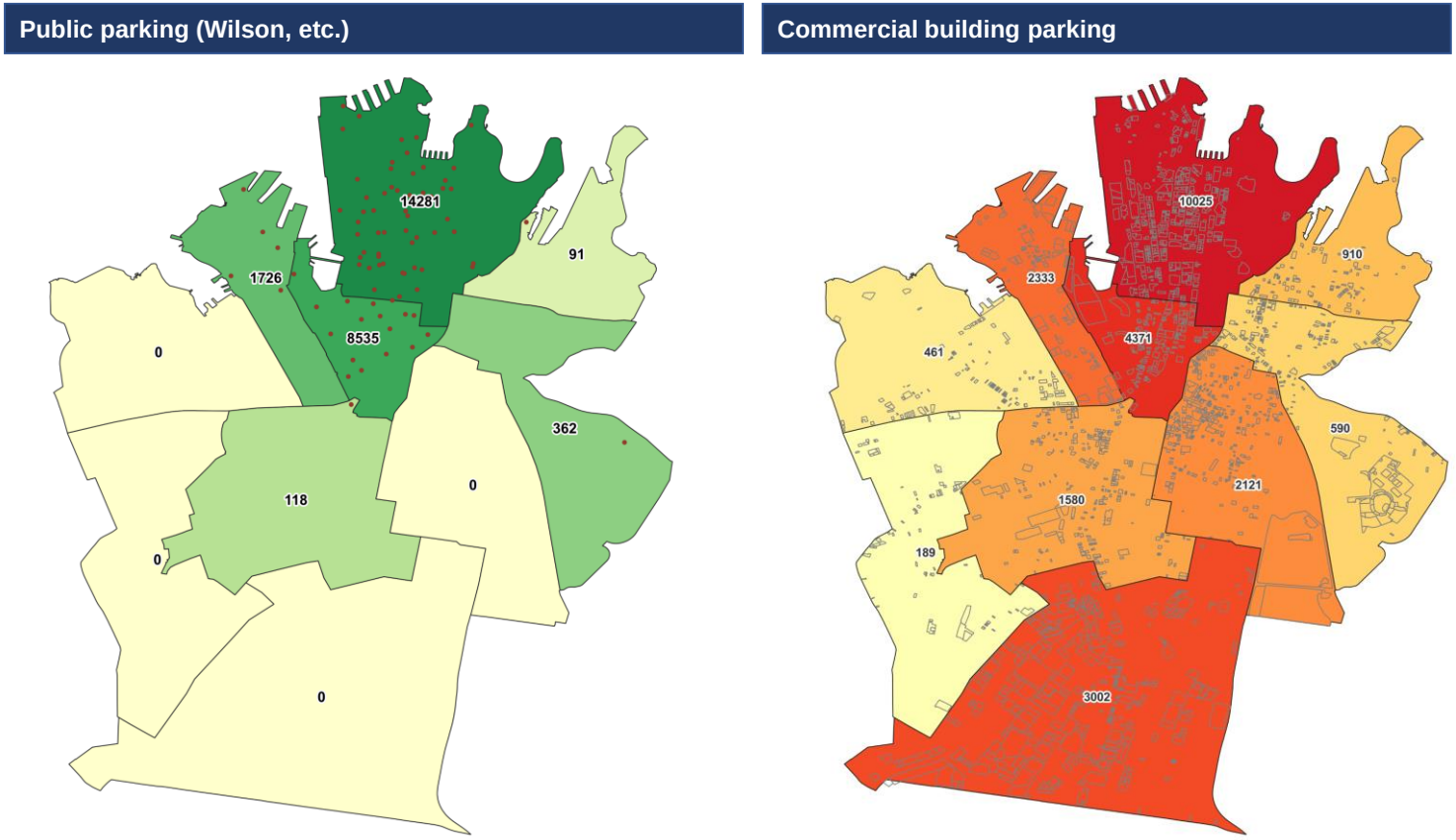
Source: ABS Census Journey to Work

FIGURE 28: COMMUTING TRIP DISTANCE BY CITY OF SYDNEY RESIDENTS (% OF CAR COMMUTER TRIPS BY DISTANCE BY VILLAGE)



Source: ABS Census Journey to Work

FIGURE 29: COMMUTING PARKING LOCATIONS (NUMBER OF SPACES)



Source: City of Sydney Floorspace and Employment survey, City of Sydney public parking data

5.3 Car share fleet

- There are approximately 850 car share vehicles across the LGA.
- The average use of a car share vehicle in the Sydney LGA is 35 km per day. This does vary across the year as shown in Figure 30.
- Typically, car share vehicles are in use for 5 hours per day. That is, for 19 hours of the day, the car would be idle.
- For this level of use, the average car share vehicle will require 1 to 2 charges every 2 weeks

City role

- Set obligations to car share providers for 100% fleet transition by 2030.
- Monitor car share charging requirements as these demands become known.
- The City does not need to provide on-street charging for car share vehicles. There is a limited business case for operators to install on-street charging at their cost.

FIGURE 30: CAR SHARE USAGE (CAR SHARE VEHICLE KM PER DAY)

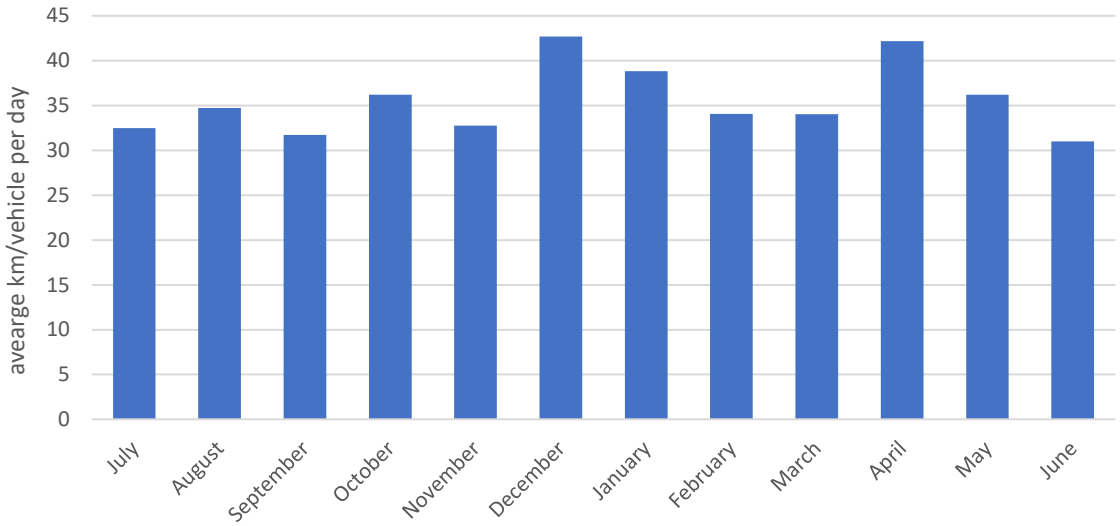
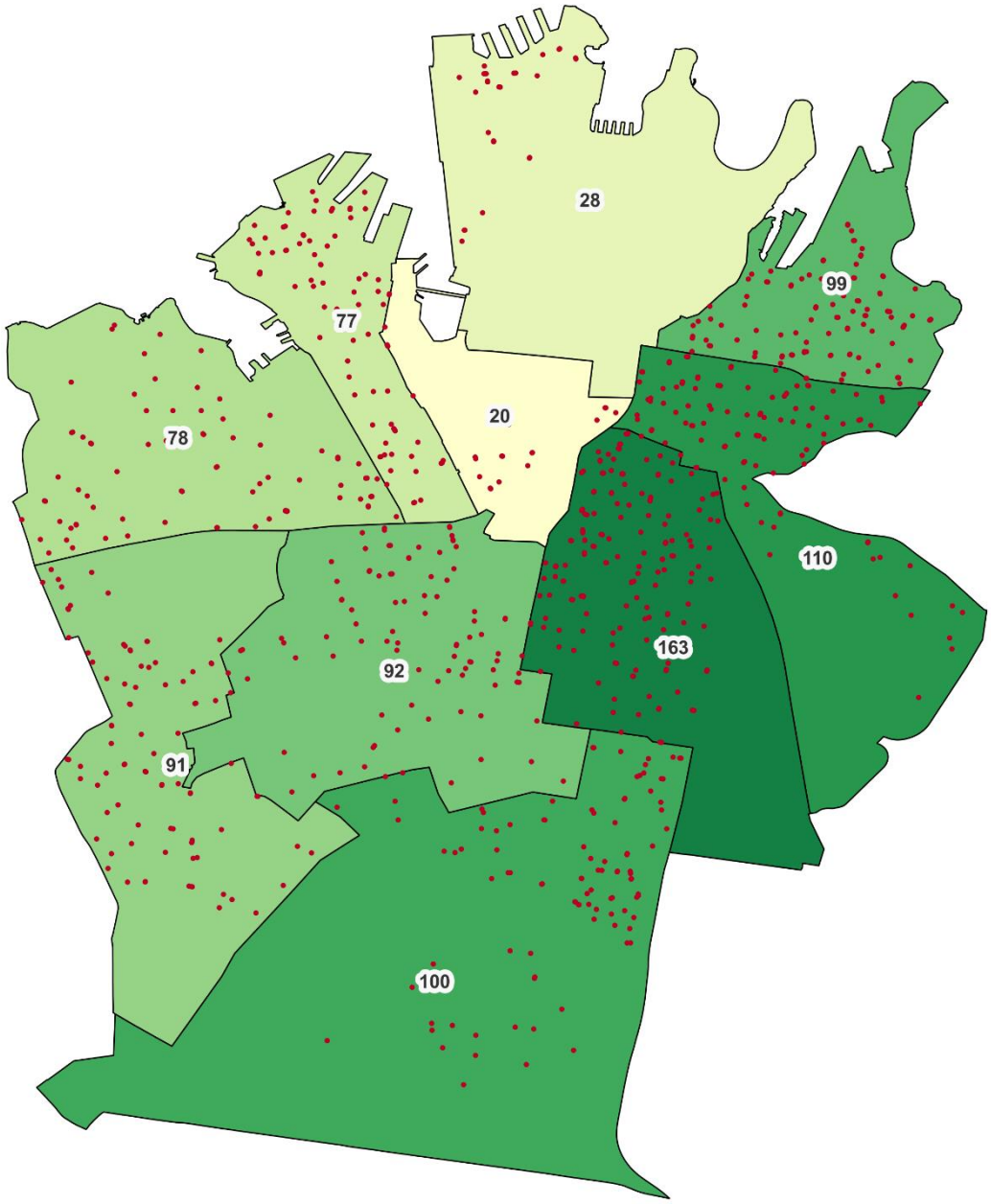


FIGURE 31: CAR SHARE PARKING LOCATIONS

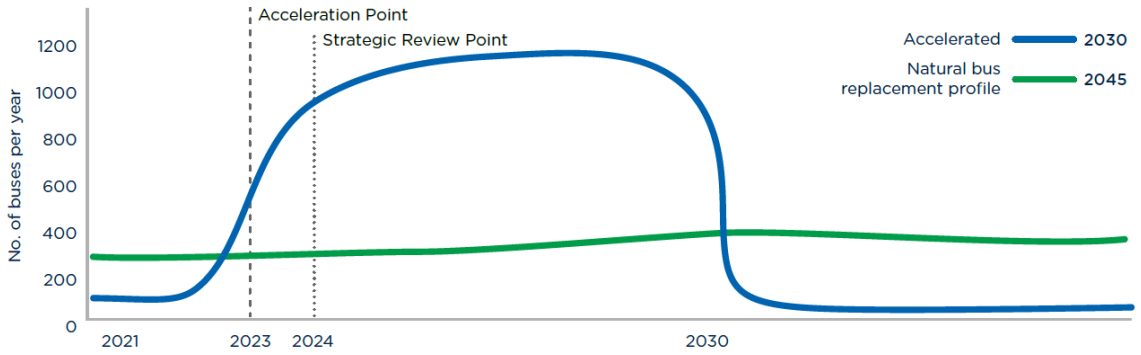


Source: City of Sydney transport team

5.4 Public transport fleet

- Electrification of public transport is a key priority for the City.
- There are 4,090 buses operating in Greater Sydney area. 90% of these are the standard bus types which has an electric version.
- There are currently 70 electric buses operating in the network.
- TfNSW has a transition strategy with a potential target to transition the Greater Sydney bus fleet by 2035.
- The deployment of electric buses is projected to accelerate after 2023.
- Electric buses are charged at the depot.

FIGURE 32: NSW ELECTRIC BUS PROGRAM SUMMARY



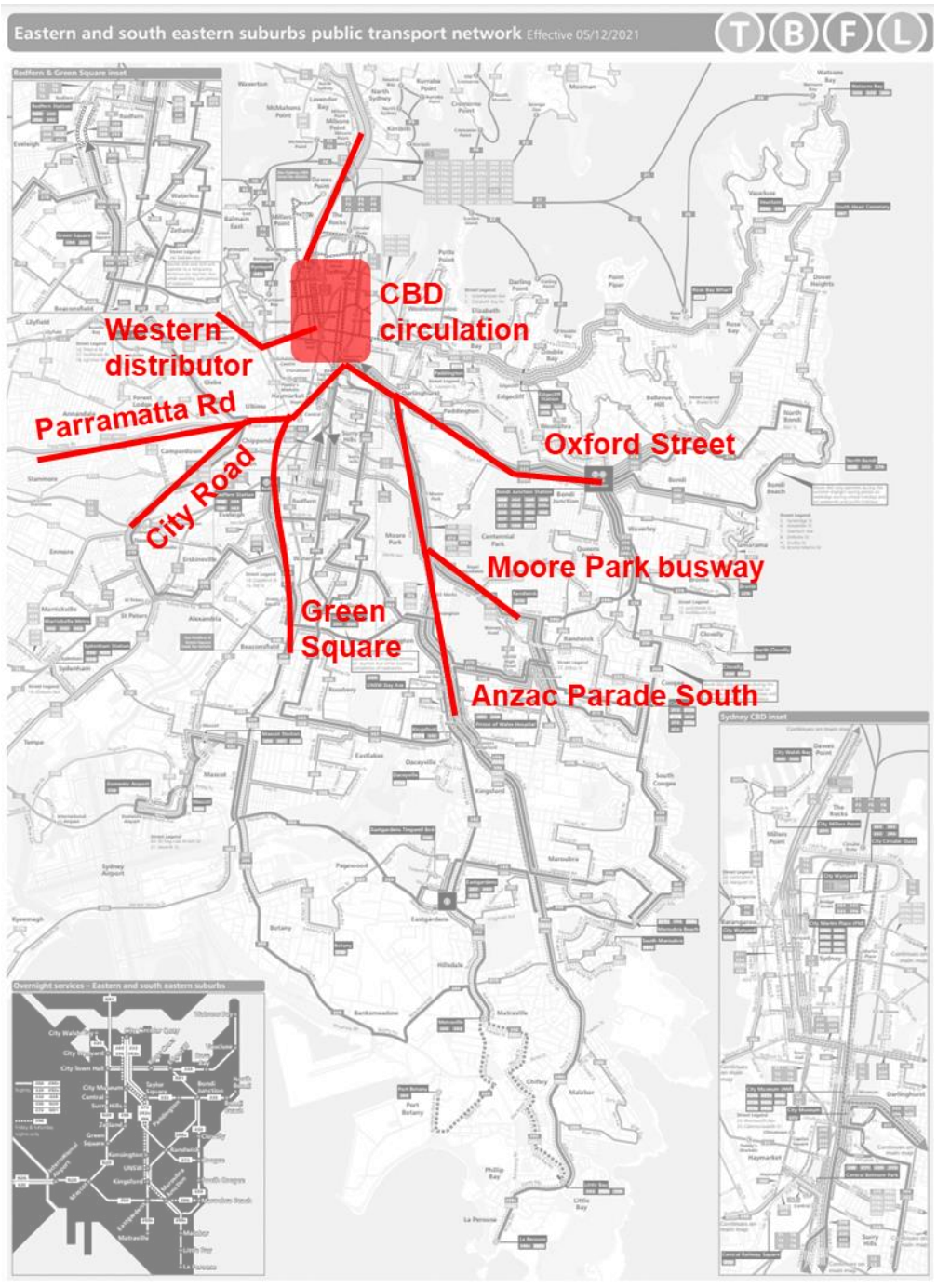
Source: NSW Zero Emission Buses – Our Transition Strategy

City role

The City can identify priority routes and depots for electrification and advocate to the state government. This prioritisation should be based on:

- Major bus routes into the city. The key ones are identified in Figure 33 overleaf.
- Major areas of idling (e.g. Clarence, York St)
- Major residential areas affected (noise, local pollution)

FIGURE 33: MAJOR BUS CORRIDORS SERVICING THE SYDNEY CBD



5.5 Point to point (taxi/ ride share)

- On average, a taxi travels 200-300 km each day[40].
- Some taxis may charge at a depot or point of origin overnight on a dedicated charger to meet their range needs.
- A proportion of taxis may be driven around the clock and will likely require a rapid charge through the day at a dedicated off-street charger.

City role

- Establish a low emissions zone in the CBD to accelerate the transition of the taxi fleet as part of a broader fleet transition.
- Enable fast charging in dedicated off-street locations for taxis. Opportunity to coordinate with NSW Government roll out of rapid charging.
- Understand taxi depots and usage patterns through collaboration with the TfNSW point to point commission and taxi industry.

5.6 Service and loading vehicles

- 35,000 service vehicle movements in the city each day (independent operators and dedicated fleets)[41] with approximately 1,400 on street loading zones in the city[42].
- Majority of loading and service vehicles are likely to charge at point of origin.
- A proportion of these vehicles will likely require a rapid charge through the day at a dedicated off-street charger.
- There is an opportunity to work in conjunction with the provision of shared loading facilities to offer micromobility options (e-bikes) for smaller freight deliveries and provide charging facilities on-site for these fleets.

[40] Global Taxi benchmarking study
[41] TfNSW data and Michael Stokoe, Space for Freight – Managing capacity for freight in Sydney – a CBD undergoing transformation (research paper)
[42] Sydney CBD Loading Zone usage data

City role

- Align EV charging provision with off street loading facilities
- Conduct surveys/ consultation with loading / service vehicle operators to understand average daily distances and charging requirement.
- Low emissions zone in the CBD to accelerate the transition of the service vehicles as part of broader fleet transitions.

5.7 Charging need insights for different fleets

- Most vehicles (all fleet types) will predominantly charge at the point of origin, at home/depots
- Within the City of Sydney LGA, the demand for the vast majority of EV charging will come from residents (connections and electricity demand).
- The main challenge is to cater for residents that are reliant on on-street parking.
- There is no standardized and streamlined approach for stratas to install EV charging in their residential off-street parking spaces. It is a case-by-case decision by stratas and Ausgrid. Clear guidance can resolve these challenges and provide a framework for discussions. This guidance could potentially be led by NSW state government to provide consistent advice across all LGAs.
- Whilst there is significant opportunity for off-street charging to be provided in commercial buildings, the travel data indicates this would not be a major demand/need for the typical user. However, if this infrastructure is provided, it could be utilised as an option for residential parking permit holders for charging outside of office hours and should be limited to locations outside of the city centre, and for people without easy access to EV charging locations
- Car share vehicles will be charged by their fleet owners and users.
- Public transport (buses) will charge at the depot.
- Majority of point-to-point vehicles will charge at point of origin/depot. Some rapid charging at a dedicated off-street charger may be required.
- Majority of service vehicles will charge on point of origin/depot. Some rapid charging at a dedicated off-street charger may be required.
- Across the LGA, the impact of daily vehicle charging would have a limited impact on the aggregated electricity load profile. However, the localised impact, for example on individual substations, will need to be further explored with Ausgrid.

The above is summarised in the below table which indicates key found for an Optimised Scenario with key roles and responsibilities

TABLE 12: FOUNDATIONS FOR AN OPTIMISED SCENARIO

Fleet type	EV charging infrastructure	EV takeup targets
Residential	– 100% of on-street and residential parking permit holders charge in off-street EV charging points.	– 100% of resident cars can be EVs by 2035. – There are no infrastructure limitations to EV uptake.
Commuter/commercial	– Some provision of EV charging spaces in commercial/ public car parks dedicated for residential parking permit holders.	– n/a
Car share	– Managed by car share companies	– 100% of car share fleet electrified by 2030
Public transport (buses)	– Managed by TfNSW depots	– 100% of buses fleet electrified by 2030
Point to point vehicles	– Managed by taxi depots and fleet owners	– 100% of taxis operating in city electric by 2030
Service vehicles	– Managed by fleet and independent operators	– 100% of service vehicles operating in city electric by 2030

Appendix A Data Sources

	Rationale	Analysis performed	What is the number	Data Sources
Residential	Resident EV charging requirements was understood from a supply and demand perspective. What is the future demand for EV charging and how to leverage current off-street parking infrastructure to service this charging? To answer this, we explored the following sub questions: – How many cars are going to be owned by City of Sydney residents by 2035? – How many of these would be EVs based on natural vs 100% take up? – How often would residents need to charge their EV? – Given the low car use and charging requirement, is there an opportunity to decouple where residents park from where they charge? – How many residents park on-street and where can they charge? – How can strata residents charge their cars? – Based on typical charging patterns, what will the impact on electricity demand be? Will this inhibit EV uptake?	– Baseline number of cars owned by City of Sydney residents – Projections for number of cars owned by City of Sydney residents based on dwelling projections and observed car ownership trends – Current proportion of resident vehicles as EVs – Future proportion of vehicles as EVs – Residential car VKT (average car use of City of Sydney residents) – Off-street residential parking – Resident parking permits – Number of strata buildings and associated off-street parking – Charging patterns of residents – Current electricity demand and aggregate LGA load profile – Projected growth in electricity demands from future residential buildings – Projected growth in electricity demands from EV uptake	– 65,000 cars in 2019 – 71,000 cars expected by 2035 – 5% of cars are EVs in 2021 – Under a natural takeup, 45% of all resident cars to be EVs by 2035. City will be enabled for 100% EV uptake. – Average CoS resident only travels 10 km per day. This level of low car use means that residents need to charge their car only 1-2x a month. – 13,400+ residential parking permit holders can charge their car in public EV charging stations already available or made available in their village through recommendations. – 3-10 EV chargers required per strata building. Alternatively, residents in strata buildings can also charge in public EV charging points. – A 100% takeup of EVs would increase residential electricity demand by 36%. To put this into perspective, new residential buildings are expected to increase the current residential electricity demand by 40%. – The increase to LGA wide peak demand would be under 5%. Although this is expected to vary by substation and needs to be understood with Ausgrid.	– ABS Census 2016 car ownership data – Profile ID – 2016 car ownership disaggregated by village – NSW Registrations data – Latest car ownership + Historical trends in car ownership in City of Sydney LGA. – City of Sydney LSPS for dwelling projections – TfNSW registrations data – NSW EV strategy, Labor EV policy – TfNSW – household travel survey – City of Sydney Floorspace and Employment Survey – City of Sydney residential parking permits by village – City of Sydney data – CSIRO EV forecast report – average daily charging profiles for light passenger vehicles – Ausgrid LGA energy consumption data (also available in City of Sydney ESP) and Ausgrid substation data – City of Sydney Net Zero by 2035 modelling (Kinesis) – Modelling based on projected number of cars, EV uptake, average car use and charging load profiles/ behaviour.

	Rationale	Analysis performed	What is the number	Data Sources
Commuter/ Commercial	To understand commercial EV charging requirements, we sought to answer the following key question: Will commuters driving into the City need to charge in the City or can they drive back home to charge? To answer this, we explored the following sub questions: – How many commuters are expected to drive into the City in the future? – How many of these would be EVs based on natural vs 100% take up? – What is the typical commute distance and will they need to charge in the City?	– Journey to work car trips today – Journey to work car trips in the future based on projected jobs growth and mode share targets – Future proportion of car work trips made by EVs (Natural vs 100%) – Journey to work car VKT (average distance of car commutes into the City of Sydney) – Off-street commercial parking and public car parks	– 92,000+ worker car trips in 2019 – 100,000+ worker car trips expected by 2035 – Under a natural takeup, 45% of commuter cars to be EVs by 2035. City will be enabled for 100% EV uptake. – Median car commute distance is under 10 km per day. This level of low car use means that commuters will have more than enough charge to drive back home to charge. – There is an opportunity for public car parks and commercial asset owners to enable EV charging for commuters. Commuter don't need to charge but they can recharge their EV battery and go home to peak shift.	– ABS Census 2016 Journey to Work data – City of Sydney LSPS for dwelling projections, City of Sydney mode shift targets – NSW EV strategy, Labor EV policy – ABS Census 2016 Journey to Work data – City of Sydney Floorspace and Employment Survey – City of Sydney data – CSIRO EV forecast report – average daily charging profiles for light passenger vehicles – Modelling based on projected number of work car trips, EV uptake, average worker car VKT and charging load profiles/ behaviour.

	Rationale	Analysis performed	What is the number	Data Sources
Car share	To understand the charging requirement for car share, – How often do car share vehicles need to be recharged? – Can car share operators manage this as part of their business?	– Number of car share bays in the City of Sydney LGA – Typical car share usage per day in terms of km – Average number of hours a car share bay is booked	– 850+ car share bays in the City of Sydney LGA – Average car share bays have 35 km per day of usage. – Average car share bay is booked for 5 hours (Idle for 19 hours)	– City of Sydney car share locations data – GoGet data

	Rationale	Analysis performed	What is the number	Data Sources
Public transport	The City will largely play an advocacy and lobbying role to electrifying buses For this, we sought to analyse the following: – What is the current TfNSW plan for transitioning to electric buses? – What are the key bus routes to prioritise for electrification?	– Target timeframe for bus electrification – Key bus corridors to prioritise for electrification	– 4,090 electric buses by 2030 – Electric buses are charged at the depot – Prioritisation by depot based on – – Major bus routes into the city – Major areas of idling (e.g., Clarence, York St) – Major residential areas affected (noise, local pollution)	– Eastern and South Eastern Suburbs Public Transport Network, engagement with City of Sydney staff (Peter Warrington) – TfNSW Zero Emission buses – Our transition strategy

	Rationale	Analysis performed	What is the number	Data Sources
Point to point	To understand the City's role in supporting charging for point to point services, – Most taxis will charge at a depot or point of origin overnight on a dedicated charger to meet their range needs. – A proportion of taxis will likely require a rapid charge through the day at a dedicated off-street charger.	– How many taxis are in the city at any given point? – How much do taxis travel each day and what does this mean for charging?	– There are 25,000 taxi movements in the city centre on an average weekday. – Taxis typically travel 200-400 km a day	– Sydney City Centre Access Strategy – Global Taxi benchmarking study – average distance travelled by taxis

MELBOURNE
Level 14, 222 Exhibition Street
Melbourne VIC 3000
+61 3 8616 0331
sgsvic@sgsep.com.au

CANBERRA
Level 2, 28-36 Ainslie Avenue
Canberra ACT 2601
+61 2 6257 4525
sgsact@sgsep.com.au

HOBART
PO Box 123
Franklin TAS 7113
+61 421 372 940
sgstas@sgsep.com.au

SYDNEY
Suite 2.01/50 Holt Street
Surry Hills NSW 2010
+61 2 8307 0121
sgsnsw@sgsep.com.au

SGS Economics & Planning

Certified B Corporation