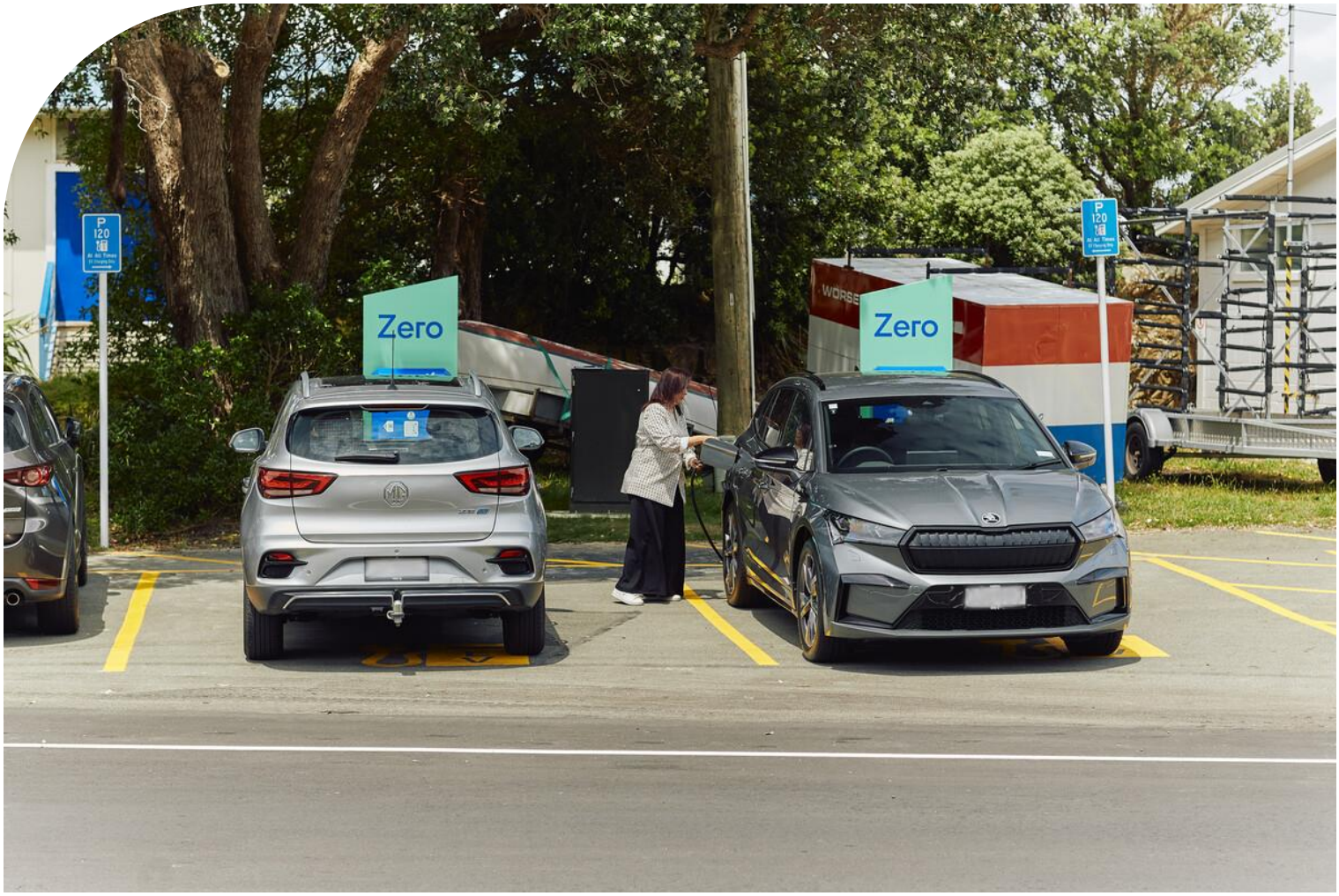

What is needed for an effective and efficient public light-EV charging network?

March 2025

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[1] This research was conducted May 2024 to June 2024.

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Abbreviations and acronyms

BEV	battery electric vehicle
CPO	charge point operator
DC	direct current
EDB	electricity distribution business
EECA	Energy Efficiency and Conservation Authority
EV	electric vehicle
ICE	internal combustion engine
MBIE	Ministry of Business, Innovation and Employment
NEVI	National Electric Vehicle Infrastructure
NREL	National Renewable Energy Laboratory
OCPI	Open Charge Point Interface
PHEV	plug-in hybrid electric vehicle
PMC	pole-mounted charger
RCA	road controlling authority
RUC	road user charges

Contents

Executive summary

This project set out to provide information that could aid in the establishment of a comprehensive public electric vehicle (EV) charging network in New Zealand.

A key part of our approach has been to examine the context for EV charging services and their supporting infrastructure as this provides a foundation for understanding who might need what information and for what purpose.

From our examination of context, we developed a framework with four components:

- Economic framework: This provides a way of thinking about the benefits that may flow from intervention in the market for EV charging services both directly and through influencing the uptake of EVs (which in turn delivers various benefits).
- Service types: This highlights how journey charging, which is the type of charging service that is both most analogous to petrol stations and most commercially challenging, is a relatively small but important part of the charging ecosystem alongside private (including at home) and destination charging.
- Supply chain components: This identifies three key service layers (sites, chargers and digital services) that differ markedly in their economic characteristics and potential commercial models.
- Market functions: This sets out key functions in the market for charging services, highlighting the importance of consumer preferences and the mix of centralised and decentralised planning and investment activities involved in charging services.

We complemented the framework components with literature surveys and case studies that reinforce key points, including:

- a mix of commercial investment and public co-funding is prevalent internationally
- the market for charging services is at an early stage of development, with technologies, business models and consumer behaviours all evolving
- consumers, including potential purchasers of EVs, are learning and it is common for people to misapply mental models from liquid refuelling, which can lead to an overemphasis on availability of public charging and on battery range and charging speed
- from the points above, consumer research is vitally important and useful – both for informing policy (including funding priorities) and for supporting public education (as a complement to infrastructure provision)
- there are a variety of distinct rationale for public investment in EV charging services that could motivate specific programmes of co-funding or other regulation – for example, transport system resilience, services for remote areas, accelerating near-commercial rollout (to reduce congestion) and bolstering services in low-income areas are all distinct and different investment cases.

With the above context in place, we systematically examined potential information requirements from a top-down perspective. We then compared our long list of requirements to information that is available in New Zealand. From this exercise, we were able to develop a prioritised list of information gaps.

We prioritised information gaps from the standpoint of government and consumer interest in a well-functioning market for EV charging services. The top five priorities we identified are set out below:

- Basic network information: Currently, information is collected on a voluntary basis, which means it is incomplete and lacks quality assurance. There is not a clear home for regulation to make information provision mandatory (given charging services span transport, electricity sector and consumer domains). If this hurdle were overcome, comprehensive and high-quality information would inform market monitoring, policy (including funding), consumers and suppliers.

- Dynamic network information: Information on utilisation of existing charging facilities is valuable for guiding investment to expand charging services. Currently, this information is only available to incumbent providers who have generally benefited (directly or indirectly) from public co-funding. We think there is a case, building on a platform of basic network information, to make utilisation information publicly available.
- Consumer research: Information on preferences and perceptions of EV owners, EV drivers and potential EV purchasers is highly valuable in the context of a new and evolving market. EECA already commissions some consumer research. This should be continued and expanded to inform charge point operators, vehicle sellers and government funding programmes and consumer-facing information.
- Consumer-facing information: Building on consumer research, we think the next priority is consumer-facing information for vehicle purchasers and EV drivers. This recognises that consumers' perceptions rest on the actual state of EV charging services as well as assumptions about the importance of charging services. Research shows that novices tend to overestimate the importance of public charging. It is likely that investing in information alongside infrastructure is more cost-effective than investing in infrastructure alone.
- Improved electricity network cost information: Electricity network connections are typically a major cost component for charging services. Costs are difficult to predict, including due to engineering differences and differences between New Zealand's network businesses in how they determine upfront and ongoing charges. This need has been identified previously and is reinforced here for completeness.

We also identified two secondary priorities relating to charger cost information and charging network analysis (such as resilience, blackspot or congestion analysis).

Finally, we contacted nearly 20 organisations across government, academia and industry to assist us to compile an inventory of work relevant to EV charging services policy. We identified more than 50 resources, which we catalogue in Appendix A.

Abstract

This project set out to provide information that could aid in the establishment of a comprehensive public electric vehicle (EV) charging network in New Zealand. This report provides a collation of work that could assist to support effective and efficient charging services for light EVs in New Zealand.

A key part of our approach has been to examine the context for EV charging services and their supporting infrastructure as this provides a foundation for understanding who might need what information and for what purpose. To explore this context, we developed a framework of EV charging infrastructure with four components – an economic framework, service types, supply chain components and market functions. This framework was complemented by case studies that looked at the development process of EV charging infrastructure overseas and a few that drew on examples of other infrastructure development projects from New Zealand.

Using the context provided from the framework and case studies, we identified information requirements from a top-down perspective. An inventory of New Zealand data was used to help identify currently available information in New Zealand. The list of requirements was then compared to the currently available information, which led to a list of information gaps. We then prioritised the information gaps from the standpoint of government and consumer interest in a well-functioning market for EV charging services. The top five priority gaps identified were basic network information, dynamic network information, consumer research, consumer-facing information and improved electricity network cost information.

1 Introduction

This report provides a collation of work that could assist to support effective and efficient charging services for light electric vehicles (EVs) in New Zealand. It takes a top-down approach with these key strands:

- Framework: We develop a framework to introduce key concepts and help organise discussion of charging services.
- Case studies: We present case studies that illustrate a range of approaches and their applicability to New Zealand charging services. This includes international and domestic case studies relating to charging and other infrastructure-based services.
- Information survey: We identify information that could support effective and efficient charging services, identify key gaps and identify options for closing highest-priority gaps.
- Inventory: We provide a summary of work currently under way that could assist policy makers and other stakeholders with next steps in charging development in Appendix A.

The report focuses on public charging services for light EVs, noting the following:

- Light vehicles are those with a gross vehicle mass of less than 3.5 tonnes (Ministry of Transport, n.d.a) and include commercial and passenger vehicles and motorcycles. In practice, this means light vehicles include motorcycles, cars, vans, utes and light trucks. They also include privately owned vehicles and work vehicles such as courier vans, light delivery trucks and car fleets.
- Light EVs include plug-in hybrid electric vehicles (PHEVs) and fully battery electric vehicles (BEVs), noting that PHEVs may have relatively limited need for public charging and typically cannot make use of high-speed direct current (DC) charging.
- There is not always a clean demarcation between public and private services. Examples of semi-public services can include supplier-locked charging (such as the Tesla super-charger network) and services only available to paying customers (such as at hotels, attractions or carparking buildings). Also, demand for public charging depends on the portion of total demand served by non-public charging (such as at home or at work).
- Charging services for heavy vehicles such as heavy trucks and buses is out of scope as is charging services for other forms of transport such as aviation and shipping.

1.1 Research context

We prepared this report during May and June 2024. We note the following about the EV market and wider environment at that time:

- New Zealand's vehicle fleet included around 110,000 light EVs, making up 2.9% of the light passenger fleet and 0.3% of the light commercial fleet (Ministry of Transport, n.d.b).
- Monthly registrations peaked at over 6,100 in December 2023, which was 27% of light vehicle sales. Following removal of the clean car discount, registrations have since reduced to 600–1,000 (3–5%) per month over the quarter ended March 2024.
- BEV and PHEV exemptions from road user charges (RUC) ended from April 2024, with plans to eventually transition all vehicles from fuel levies to RUC.
- Two hundred models of light EV are available as new vehicles, making up 17% of available models. The lowest list price for a new light BEV is $46,990 for an MG4, which is the same price as an entry-level VW T-Roc internal combustion engine (ICE) vehicle. The lowest list price for new light PHEV is $58,990 for a Mitsubishi Eclipse Cross, which is approximately the same price as a top-of-the-range Kia Sportage ICE vehicle (autocar.co.nz, n.d.).

- The carbon price was $64 per tonne at the most recent auction, with a growing surplus of emissions units connected with the way forestry is incorporated into the New Zealand Emissions Trading Scheme (Climate Change Commission, 2024a).
- The average delivered cost of electricity to households is $0.35 per kWh when including fixed and variable charge components for peak and off-peak usage.[2] The marginal cost (the cost of using more electricity) is typically much lower. For example, in recent analysis, the Electricity Authority assumed a rate of $0.18 per kWh for a typical retailer (Electricity Authority, 2023c).[3] There is growing availability of low off-peak rates, especially for households with EVs, which further reduces the cost of charging EVs at base. For example, at least two retailers offer half-price energy overnight (Bingham, 2023).
- The Energy Efficiency and Conservation Authority (EECA) dashboard (EECA, 2024c), which uses data from NZ Transport Agency's EVRoam database (NZ Transport Agency, n.d.c), presents a snapshot of charging units[4] and charging sites (Figure 1.1). EECA plans to add estimated charging points[5] to the dashboard and advises that it records 1,259 charging points, 1,188 charging units and 531 charging sites as of 19 August 2024 (W. Catton, personal communication, September 5, 2024).[6]
- On 30 April, the government announced plans to develop a new model to support investment in EV charging infrastructure and develop a cost-benefit framework for government co-investment. Decisions on the new model are to be confirmed in late 2024 (Brown, 2024).
- EECA has completed 23 co-funding rounds using the Low Emission Transport Fund and the Low Emission Vehicles Contestable Fund that preceded it. This activity has committed around $87 million of government funding and $176 million of applicant funding across 331 projects (W. Catton, personal communication, September 5, 2024). Of the government funding, approximately $40 million has been allocated towards public charging infrastructure development across 141 projects.

[2] Based on March 2024 quarter figure for quarterly residential sales-based electricity cost reporting (Ministry of Business, Innovation and Employment, 2024).

[3] Based on $1,969 per year bill for 8,000 kWh consumption of which $511 is fixed charges, leaving ($1,961 - $511 / 8,000 =) $0.18 per kWh variable rate (averaged across peak and off-peak).

[4] The EECA dashboard uses the term 'units', which relates to the number of charging appliances. This differs from the Open Charge Point Interface (OCPI) protocol definition 'EVSE port', which represents the number of vehicles that can be charged simultaneously. Elsewhere in this report, we use the term 'charging port' to refer to this metric. To be clear, the number of charging ports will be larger than the number of units recorded on the EECA dashboard as some appliances are capable of charging more than one vehicle at a time.

[5] Charging points is an estimate of EVSE ports, based on analysis of EVRoam 'type' data. For example, a unit with two connectors of the same type is assumed to have two charging points (ie, it is capable of charging at least two vehicles simultaneously). This likely understates charging ports but provides the best estimate currently available given the data collected in EVRoam.

[6] The number of units and sites is lower than previously indicated in the EECA dashboard. This is due to improvements in processing data from the EVRoam database (rather than indicating how many charging sites or units have been removed from service).

Figure 1.1 EECA dashboard indicates 1,248 charging units at 605 charging sites in June 2024 (reprinted from EECA, 2024c)

Note: ‘Units’ refers to a device separate to an electric vehicle that has a mains electricity input (230V or 400V, 50Hz) and provides either a DC or AC electrical output to charge an electric vehicle.

2 Literature survey – framework and case studies

This section surveys literature relevant to the framework and case study components of this report. We cover literature relevant to information needs in a second survey in Chapter 5.

2.1 Overview

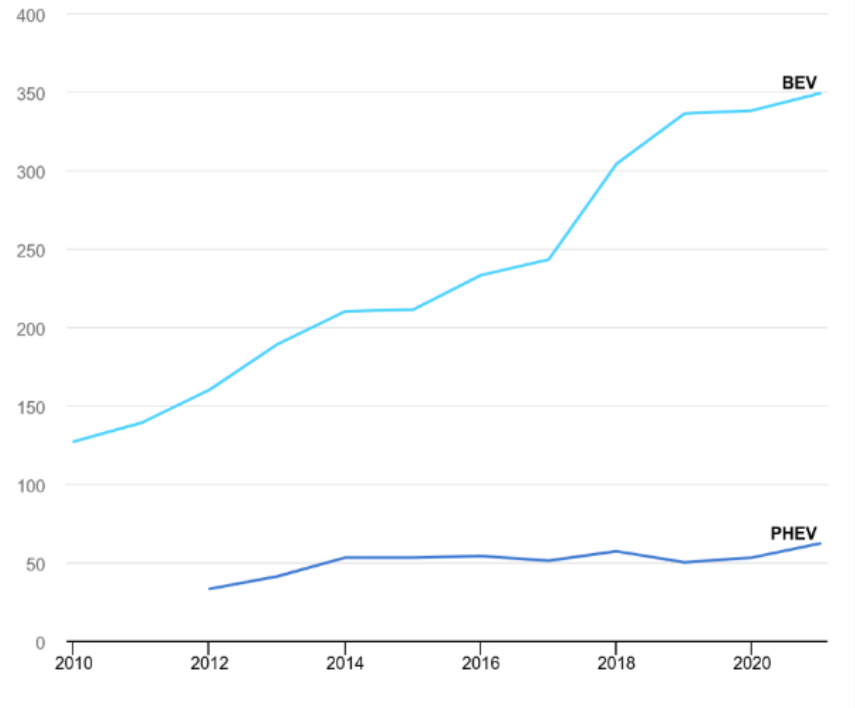
For our initial survey, we focused on four broad categories of literature:

- Network optimisation – material focused on quantitative models for optimising charging services.
- Business models – material exploring commercial models for charging services.
- Country-specific literature – resources from (or about) activities in specific countries.
- Evaluation – reviews and comparative studies focused on barriers or approaches to charging services.

Not all literature strictly falls into one of these categories but they are useful nonetheless for characterising the broad types of relevant literature.

Across all the literature, we found that material dates quickly because EV markets and charging markets are at early stages in their evolution. Technologies are evolving quickly, consumer bases are maturing, service models are developing and policy makers are learning. For example, IEA (2022) estimates the average range for new EVs increased more than 60% between 2014 and 2021.

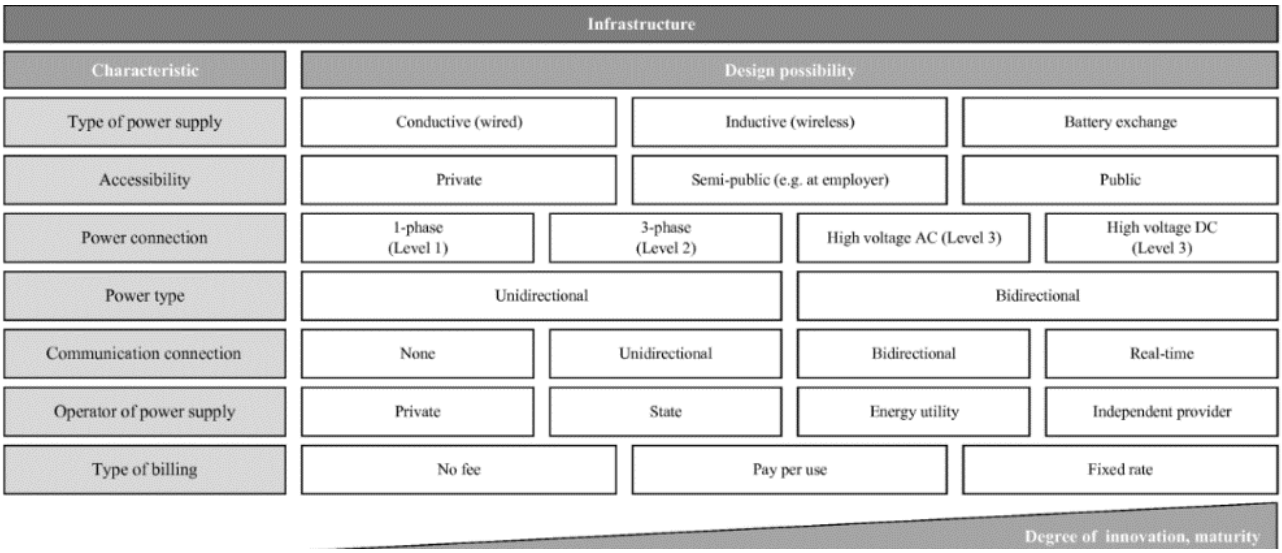
Figure 2.1 Average range for new EVs increased from 210 km in 2014 to 349 km by 2021 (reprinted from IEA, 2022)



Note: Range is sales-weighted and normalised to the Worldwide Harmonized Light Vehicle Test Procedure for all regions.

We have adopted a cut-off date of 2014, with exceptions where earlier papers remain relevant. For example, some early papers established frameworks that have remained relevant and are still cited today. A good example is Kley et al. (2011), which articulated a framework for characterising charging infrastructure (Figure 2.2) that remains relevant today.

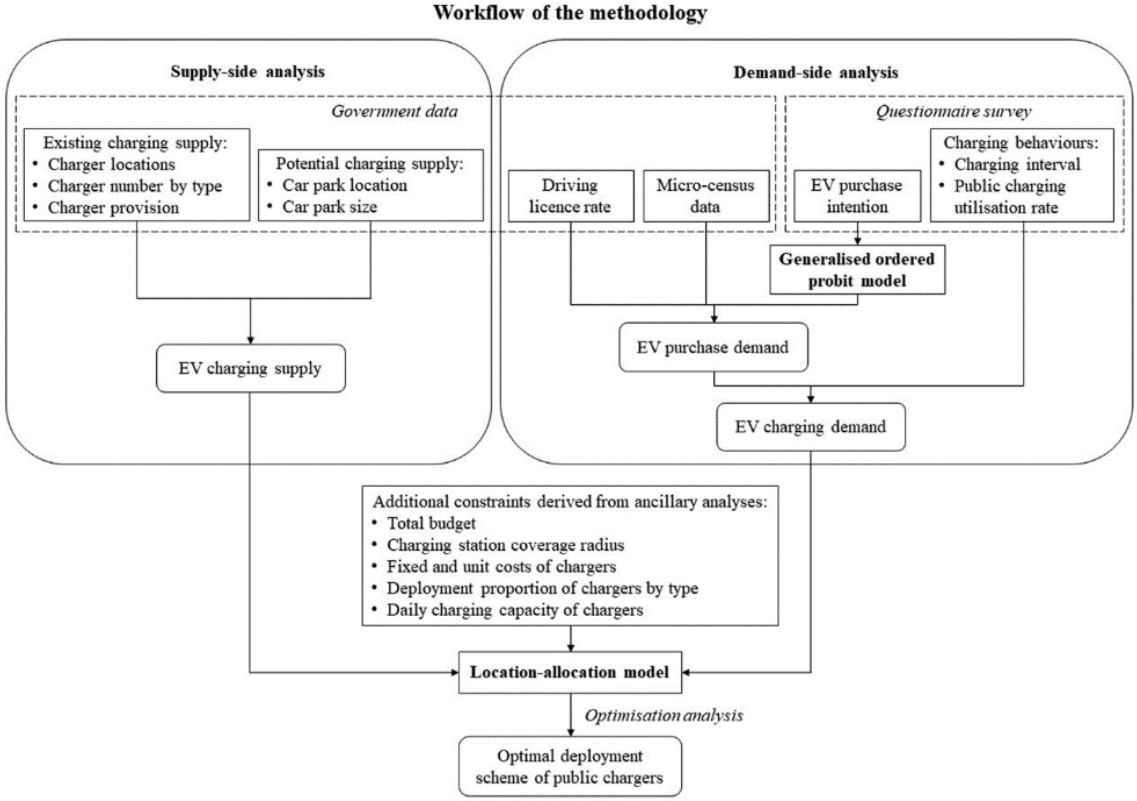
Figure 2.2 2010 infrastructure characteristics breakdown still cited today (reprinted from Kley et al., 2011, p. 7)



2.2 Network optimisation

There is a significant literature base that looks at creating quantitative models for optimising rollout of charging infrastructure. The literature is typically academic, and often charging infrastructure has been chosen as a topical application for general optimisation techniques. Typically, the optimisation objective is to select public charging locations that minimise travel cost and facility supply cost. An example of a network optimisation paper is He et al. (2022), which used Hong Kong supply and demand data to model an optimal location allocation (Figure 2.3).

Figure 2.3 Example of a location allocation optimisation methodology (reprinted from He et al., 2022, p. 24)

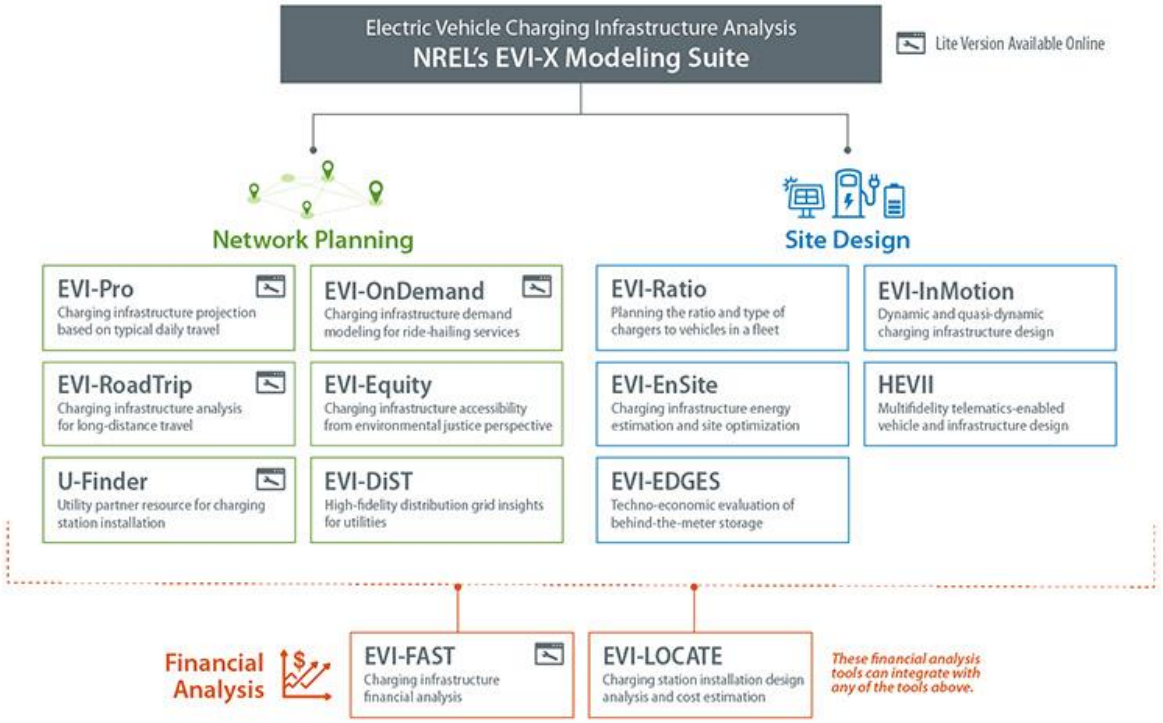


Optimisation solutions implicitly assume a central planner is responsible for charging infrastructure, which can limit their real-world application – as can lack of real-world data to inform the models and real-world uncertainty over how charging markets will evolve.

Nonetheless, optimisation models can provide a useful reference point against which to measure actual charging services or can provide a tool if segments of the charging services market are centrally planned.

The United States (US) Department of Energy's National Renewable Energy Laboratory (NREL) provides a key example of a holistic, real-world application of optimisation modelling with its EVI-X modelling suite and associated reports (Wood et al., 2023). Figure 2.4 illustrates the input assumptions and models that NREL used to project US charging infrastructure needs for 2030.

Figure 2.4 NREL provides a holistic suite of real-world simulation tools for the US market (Thomas, 2024)

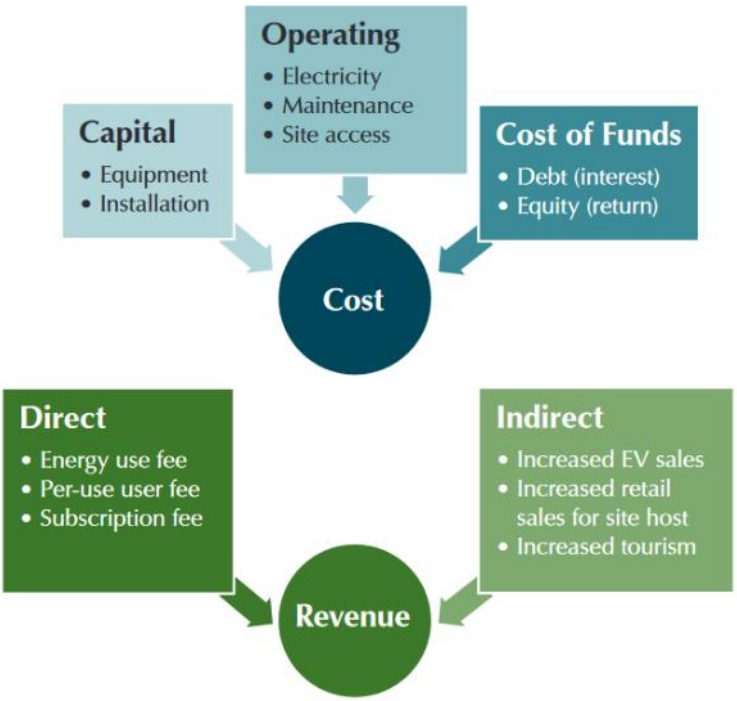


2.3 Business models

At the other end of the spectrum (from centralised to decentralised planning), there is a literature base dealing with business models for charging services – typically considering how (or whether) a private firm could profitably deliver fast-charging services. This literature includes material on quantitative modelling (for example, to support placement decisions) plus explorations of consumer demand, service design, pricing and financing.

An example of a paper focused on business models is Nigro and Frades (2015), which developed and tested three business models for closing charging services gaps in Washington. The paper includes generally applicable insights and analysis as well as detailed demand, siting and financial analysis specific to Washington. The authors note that Figure 2.5 shows private, market-based costs and returns, stating that, while most if not all of the costs must be paid by the owner-operator, some of the revenues (particularly the indirect revenues) are received by other businesses.

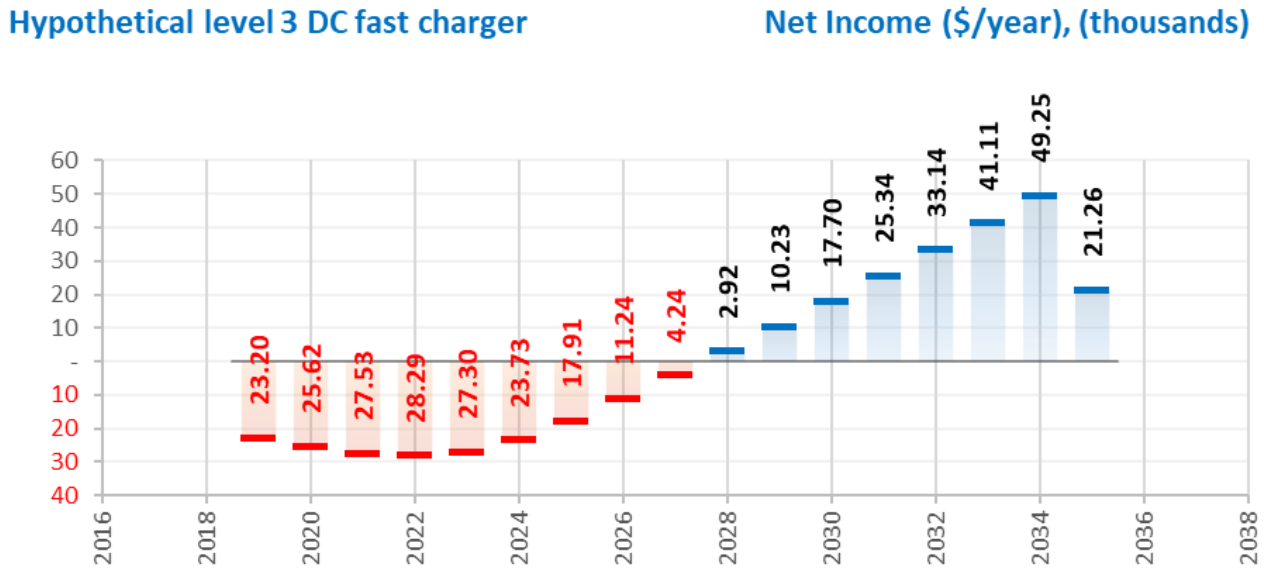
Figure 2.5 Example of business model analysis (reprinted from Nigro & Frades, 2015, p. 38)



Business model literature is helpful in identifying the challenges of a fully commercial model for infrastructure services and for understanding those parts of the market that may operate on a fully commercial basis.

The NREL model suite includes the EVI-FAST spreadsheet tool (Figure 2.6) for in-depth financial analysis for EV charging infrastructure (Penev et al., 2020).

Figure 2.6 Sample output from EVI-FAST financial analysis spreadsheet



2.4 Country-specific literature

Country-specific literature encompasses a wide range of sources, including academic papers, news articles and government policy documents. These documents provide source material for case studies plus elements of our framework.

Policy documents include material such as goal setting and context descriptions, analysis of policy options (including cost-benefit analysis) and artefacts such as funding documents or laws and regulations. Often jurisdictions have relevant policy documents from multiple levels of government.

The United Kingdom (UK) provides a good example of a country with extensive published material across a variety of sources, including:

- academic papers such as Chen et al. (2020), which reviews charging infrastructure development in the UK and discusses context, incentives, standards, designs and business models
- newspaper articles such as Jolly (2024), which reports on chargers installed in the first 3 months of 2024 and discusses some relevant market dynamics
- central government papers such as the Department for Transport's (2022) strategy, which provides comprehensive information on current state, vision, challenges, strategy (Figure 2.7) and action plan
- local government papers such as Birmingham City Council's (2021) strategy, which sets out how it intends to support and facilitate development of charging services (Figure 2.8)
- regulatory papers such as a Competition and Markets Authority (2021) report on competition in the market for EV charging services, which describes the state of the market and includes policy recommendations to enhance competition.

Figure 2.7 UK strategy for EV charging includes clear strategic pillars (reprinted from Department for Transport, 2022, p. 54)

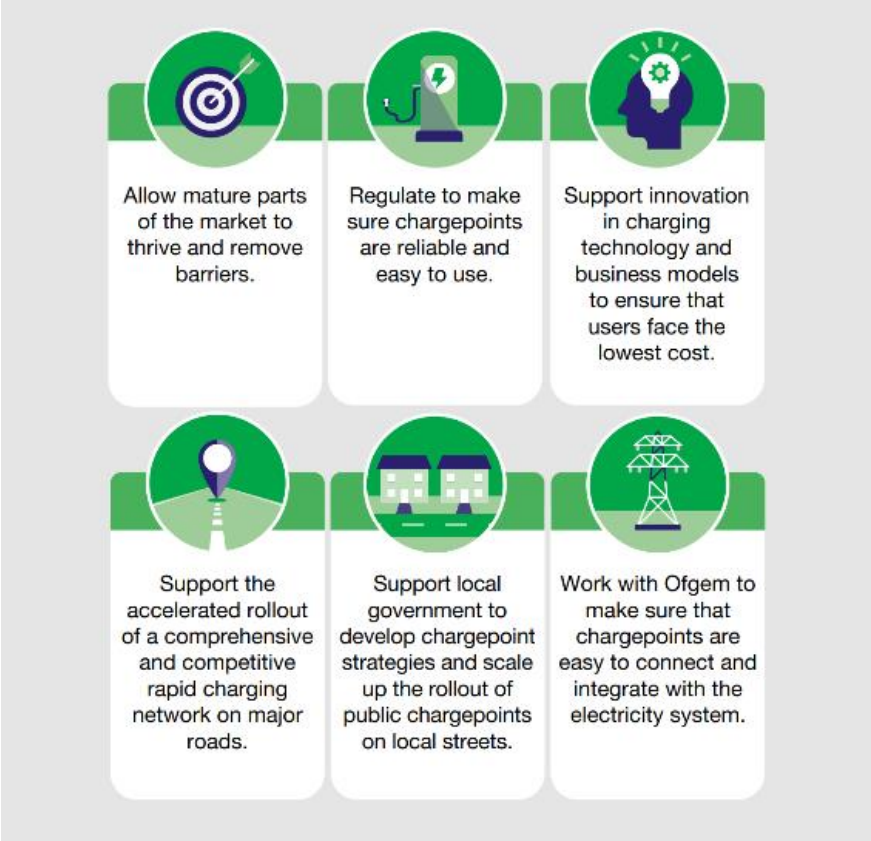


Figure 2.8 Birmingham City Council has identified where it has a role supporting or facilitating EV charging development (reprinted from Birmingham City Council, 2021, p. 12)

Charging type	Home charging	Residential charging		En-route charging	Destination charging	Workplace charging
		On-street	Charging hubs			
Use case	Charging at home in a private driveway / garage / allocated space, typically overnight	Charging at public on-street EVCP close to driver's house, typically overnight	Charging at public EVCPs in the drivers local areas. In the rapid hub case, quick turnaround means a similar model to petrol refuelling.	Charging along major arterial routes or main roads in urban areas. Quick turnaround times.	Charging in car parks at the end of an outward journey. "Top up" charging model.	Charging while parked at workplace. Predictable + long dwell times. Not strictly public charging.
EVs per EVCP	1 EV per EVCP	Small number of EVs per EVCP	Many EVs per EVCP			Small number of EVs per EVCP
Key user groups	Residents with off-street parking	Residents without off-street parking	Residents without off-street parking, taxis, car clubs etc.	All residents, visitors, commuters and commercial vehicles.		Employees (particularly those without off-street parking)
Typical location	Driveway, garage, private residents car park	Along residential pavements	Along urban roads, public car parks, forecourts, dedicated development on public land	Service station / petrol forecourts plus other sites near main roads including hotels, retail parks etc.	Range of car park types e.g. public car parks, supermarkets, shopping centre	Employee car park
Typical charging speed	Slow, 3-7kW	Slow to fast 3-22kW	7-150kW but more likely to be 50-150kW (rapid and ultrarapid)	Rapid to ultrarapid (50-350kW)	Slow to fast 3-22kW with some sectors moving towards rapid	Slow, 7kW
Led by	Residents/building owners	**Council**	**Council or private sector**			Private sector (unless for council employees)

Not council led – not a focus of this strategy | Main focus of strategy

Another example is Germany, which has published its charging infrastructure masterplan (Federal Ministry for Digital and Transport, 2022). This overarching strategy consolidates federal government activities aimed at boosting the expansion of EV charging infrastructure and contains 68 measures across a wide range of themes and challenges.

The European Union (EU) Sustainable Transport Forum (European Commission, 2024) has published several reports that provide guidance, recommendations and best practices to help states establish EV charging infrastructure. Reports include topics such as:

- permitting and grid connection procedures
- governance and architecture frameworks
- standards and protocols for communication exchange
- procuring, awarding concessions and licences and granting support.

These reports often contain multiple examples and case studies from various jurisdictions in the EU and around the world.

2.5 Evaluation

Finally, we have reviewed papers that provide cross-jurisdictional assessments of charging services markets, barriers or policies. These are typically academic papers usually with a focus on public policy decisions and the quality of policy implementation.

An example of an evaluation paper is LaMonaca and Ryan (2022), which surveys key features of markets for charging infrastructure, summarises private and public roles and makes high-level policy recommendations.

Evaluation papers can provide a useful synthesis across topics covered in the other categories of papers, help identify useful case studies and highlight key trends or themes.

2.6 Key papers

Table 2.1 lists a selection of key papers from this literature survey that we have found most useful in preparing this report.

Table 2.1 Key papers from our survey of literature relevant to framework and case studies

Paper	Summary
Department for Transport, 2022	Comprehensive central government strategy paper from the relatively mature UK market with useful points of comparison to New Zealand.
Wood et al., 2023	Reports on comprehensive simulation of near-term (2030) infrastructure needs, addressing interplays between driving needs, charging types, physical constraints and financial support.
Sprei & Kempton, 2024	Highlights how novice EV drivers misapply mental models from liquid refuelling to EV charging, resulting in an overemphasis on the importance of fast journey charging and vehicle charging speed and range.
LaMonaca & Ryan, 2022	Surveys key features of markets for charging infrastructure, summarises private and public roles and makes high-level policy recommendations.
Voxlin et al., 2024	A UK-based research report that breaks down barriers to EV purchasing using survey data from new-car buyers and explores ways for policy makers and industry to mitigate these barriers to change consumers' EV purchasing behaviour.

3 Framework

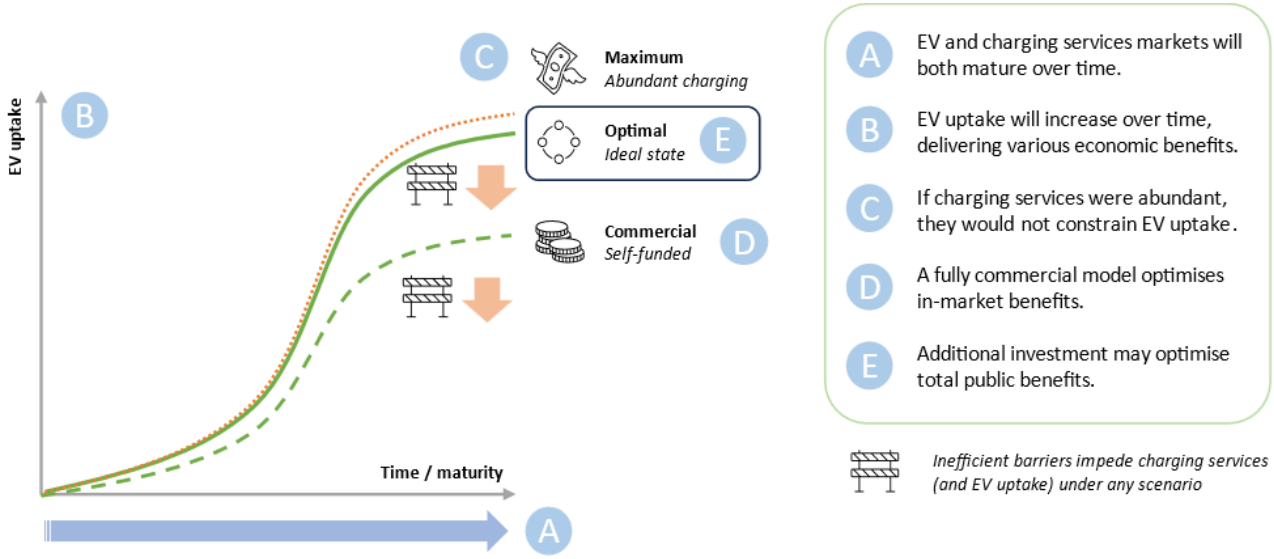
We have developed a framework to help organise discussion of charging services and to introduce key concepts. The framework has four components:

- Economic – relationship between charging services, EV uptake and economic benefits.
- Services – charging services ecosystem.
- Supply chain – inputs to charging services.
- Market functions – functional breakdown for charging services delivery.

3.1 Economic

We have developed an economic framework that centres around the uptake of EVs (Figure 3.1).

Figure 3.1 Our economic framework is summarised with an EV uptake diagram



S-curves are commonly used to characterise the uptake of new products or technologies (Rogers et al., 2019), reflecting that growth tends to accelerate as a technology gains acceptance and taper off as it reaches market saturation. These dynamics are applicable to EVs, with the following relevant considerations:

- Battery technology is improving, which means EVs are becoming cheaper to purchase, their range is improving and charging speeds are increasing.
- Vehicle manufacturers are investing heavily in EVs, driving further improvements and expanding the range of models. For example, two models of plug-in hybrid utes are entering the New Zealand market in 2024 (TransportTalk, 2024) – the BYD Shark (Cassidy, 2024) and GWM Cannon Alpha (Alvrez, 2024).
- EVs are already a lower total cost of ownership option than ICE vehicles for many consumers, and this cost advantage will strengthen over time (EECA, 2022a).[7]

[7] Since April 2024, EVs have been subject to RUC, which weakens their cost advantage. However, this one-off change is countered by continuing reductions in upfront purchase costs and changes in the structure of residential electricity prices (higher fixed and lower variable rates plus lower off-peak rates, leading to lower running costs).

- Light vehicles have a relatively low turnover rate[8] and imported second-hand cars typically make up a sizeable portion of new supply, which both limit the rate of EV diffusion (Denne, 2021). Japan is our primary source market for used vehicle imports (Beattie, 2022) and a relative laggard in EV uptake (Matsuoka, 2024).

EVs also have markedly different fuelling requirements to ICE vehicles. In many ways, EVs are superior:

- Electricity supply is near ubiquitous in New Zealand, including at homes and workplaces (Ritchie & Roser, 2024).
- Many consumers can meet all (or most) of their charging needs at home, which is typically more convenient than travelling to a petrol station (Cassidy, 2021).
- Electricity is a lower-cost fuel source than petrol or diesel, largely because EVs have much better energy conversion efficiency than ICE vehicles (Westbrook, 2022). This cost advantage is strengthened by the carbon price applied to fossil fuels and by changes in the structure of electricity network prices. Key changes in the structure of electricity prices include the following:
  - Regulations that constrained the structure of network and retail charges for residential consumer are being phased out, resulting in rebalancing towards higher fixed charges and lower usage charges. This results in household energy bills being less sensitive to overall energy usage (Concept Consulting, 2023d).
  - Increasing penetration of intermittent renewable generation is expected to produce more volatile energy prices, which is advantageous for storage loads (such as EVs) that can charge opportunistically when prices are low (Market Development Advisory Group, 2023).
  - The Electricity Authority is encouraging more cost-reflective network pricing, including moving usage charges towards zero for off-peak loads and for loads that can be controlled to manage peaks. The Electricity Authority has observed significant progress already, with several electricity distribution businesses (EDBs) offering zero-rated off-peak usage and with a sector weighted average off-peak rate of $0.019 per kWh (Sparks, 2024).
  - Low-cost off-peak or overnight retail rates are becoming more common, especially for households with EVs (Electricity Authority, 2023c).

However, charging can also act as a brake on EV uptake for many consumers because:

- at-base charging is not sufficient for all journeys
- some consumers do not have access to private (at-home or at-work) charging
- away-from-base charging is unfamiliar and can be slow, and charging services are not widespread and can be congested (adding waiting time) or unreliable.

These factors mean there is a relationship between the availability of charging services and the rate of EV uptake (and likely the level of penetration at which the market will saturate).

Curve C in Figure 3.1 represents the EV uptake curve in a hypothetical market in which charging services are so abundant that their availability does not impede EV uptake at all.

The growing attractiveness of EVs means there is growing demand for charging services, which creates a growing commercial opportunity to provide those services. Without any government funding, various private sector actors would deliver a growing level of charging services under a fully commercial model – with a resulting EV uptake rate indicated by Curve D in Figure 3.1. This curve has a slower rate of uptake and a lower saturation level than the unconstrained case (Curve C).

[8] In 2022, average vehicle ages were 14.9 years for light passenger vehicles and 12.5 years for light commercial vehicles (Ministry of Transport, n.d.b).

Funding for services under a fully commercial model can include direct revenue from users of the service plus indirect sources of value such as:

- supporting EV sales volumes – for example, Tesla was an early investor in charging infrastructure to support vehicle sales
- hosting advertising – for example, JOLT has an advertising-supported business model for destination charging (RNZ, 2022)
- attracting customers to nearby businesses – for example, The Warehouse was an early investor in destination charging (Shaw, 2017)
- increasing consumer loyalty or demand for related services – for example, Meridian Energy's Zero service is deploying hundreds of destination chargers nationwide (Zero, n.d.).

These related sources of value can bolster the level of commercially funded charging services but are unlikely to deliver a socially optimal level of EV uptake – indicated by Curve E in Figure 3.1. This curve sits between the unconstrained and the fully commercial cases.

Reasons that the fully commercial case may deliver more constrained charging services and less EV uptake than the socially optimal case are set out below:

- Consumer hesitancy: EVs are a new and unfamiliar technology, which can suppress demand. Anxiety regarding the adequacy of charging services is a key contributor to consumer hesitancy (Fischer et al., 2024), including in New Zealand (EECA, 2023a). New Zealand has basic coverage (at least one fast/rapid DC charger every 75 km on state highways) as a first plank in addressing this anxiety (NZ Transport Agency, 2024).[9] This leaves reliability (whether the charger will be working), congestion (whether the user will have to queue), performance (how fast the charger is) and customer experience (how pleasant it is to use) as remaining planks.
- Market maturity: The charging services market is small and at an early stage of development so supply-side response to demand for charging services may be patchy. This is especially likely for segments of the market where supply increments are large relative to demand or where demand is more uncertain.
- Financial preferences: Private vehicle purchasers tend to favour lower upfront purchase costs rather than lower lifetime costs, leading to a higher cost for the New Zealand economy. This is referred to as hyperbolic discounting and is common for private individuals and less-sophisticated businesses (Gowdy et al., 2013).
- Carbon emissions: If carbon emissions are priced below cost, the benefits of reductions are under-signalled to vehicle purchasers and transport decarbonisation will not meet New Zealand's targets or obligations. The Treasury (2023) recommends emissions values for public sector cost-benefit analyses materially higher than the current prices of emissions units.[10] Supporting charging services is one option for mitigating the impact of underpriced carbon emissions. Even if carbon emissions were fully priced, we also note there is debate as to whether that would be sufficient on its own to drive optimal outcomes given the pace and scale of transition required and the barriers involved (Hall & McLachlan, 2022).
- Air pollution: The health cost of pollution caused by ICE vehicles is not signalled in vehicle or fuel prices (Timilsina & Dulal, 2011) and is material. In 2016, the social cost to New Zealand of NO_2 pollution from motor vehicle exhausts was estimated at $9.5 billion (Metcalfe & Kuschel, 2022).

[9] As of June 2024, there were two remaining North Island coverage gaps and four remaining South Island coverage gaps (including Milford Sound and Haast).

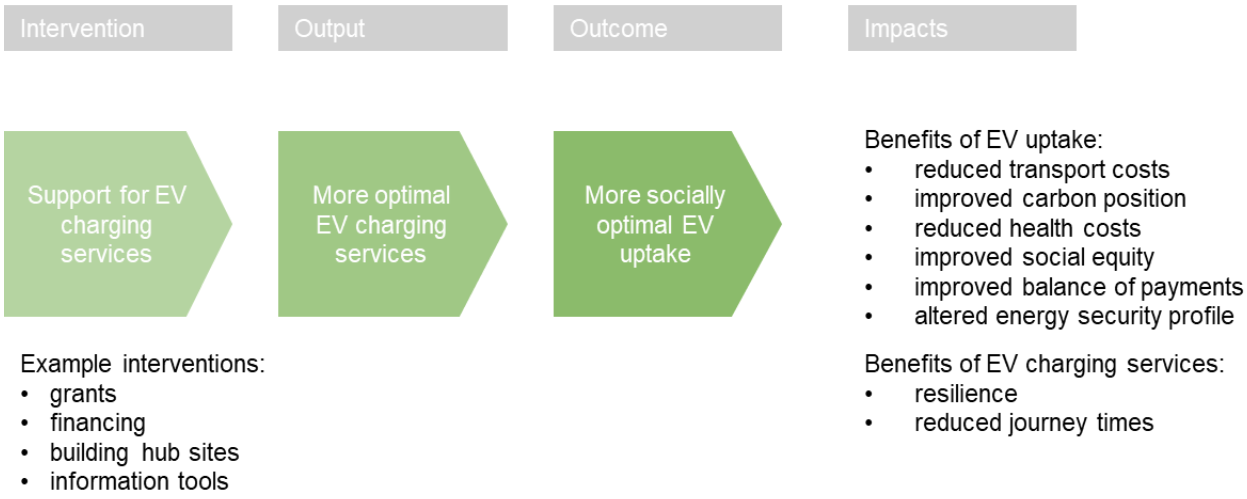
[10] A 'central' value for 2024 of $105 per tonne CO_2e compared to the clearing price for the March 2024 emissions trading unit auction of $64 (Ministry for the Environment, 2024) and secondary market prices at $48 as at 19 June 2024.

- Social equity: A fully commercial model is likely to under-serve lower-income communities and communities with high costs of supply (including many rural or remote communities). As the cost advantage of EVs improves over time, this could drive growing social inequity.
- Transport system resilience: A resilient system requires diversity (availability of alternatives such as charging services on lightly travelled alternative routes) and site resilience (availability of backup power supplies and communications links) (Speidel, 2023). Socially optimal levels of transport system resilience are unlikely to be delivered under a fully commercial model as resilience is a poorly and unreliably remunerated service attribute.
- Energy security and geography: Electricity is produced domestically, with limited reliance on imported fuels. This means EVs have more favourable long-term impact on balance of payments than ICEs, which rely entirely on imported fuels. In addition, electricity has a different energy security risk profile to imported fuels, which may be favourable overall.

Any of these considerations may mean government intervention to increase charging services can deliver a net public benefit compared to a commercial model. These interventions would achieve this by potentially improving the charging services market by stimulating or sustaining competition, improving network resilience or supporting urban/rural equity, which in turn may support a more socially optimal level of EV uptake. This generic intervention logic (Figure 3.2) can be applied to a range of EV charging services support measures. For example, government may wish to:

- accelerate expansion of charging services to deliver greater reliability and less congestion, mitigating these sources of consumer hesitancy
- expand coverage of charging services to further mitigate hesitancy, reduce inequities, improve resilience or expand the range of journeys for which people use an EV – this can involve targeting locations that are under-served by commercial services, for example, due to low incomes, low volumes or high costs
- support market entry and expansion to mitigate market power risks.

Figure 3.2 Intervention logic for supporting EV charging services



We note there may also be a balance to be struck between investment in EV charging services and investment in education. This is because perceptions of inadequate charging can be driven by a mix of:

- actual deficiencies in coverage, capacity or quality of EV charging services
- overestimation of the importance of public charging based on misapplying existing mental models for petrol refuelling to EV charging (Sprei & Kempton, 2024).

Education may provide a cost-effective way to boost the efficacy of any investment in EV charging services.

Charging services depend on a complex chain of inputs, and there is scope for inefficient barriers to raise the cost of supply and slow the rate of deployment. It is important to note that not all costs and hurdles are inefficient. For example, there should be some level of charge for connecting to an electricity network as the alternative is for existing users to bear the cost of building new connections. However, EDBs can set charges for new connections that are higher than they need to be to protect existing consumers. This can inefficiently suppress new connections to the detriment of all consumers (Electricity Authority, 2024).

Examples of costs and hurdles (that are not necessarily inefficient) include:

- electricity network connection costs
- ongoing electricity supply costs (including network, energy and risk management costs)
- planning, building and safety regulations (including road and electrical safety)
- access requirements for public roads and land.

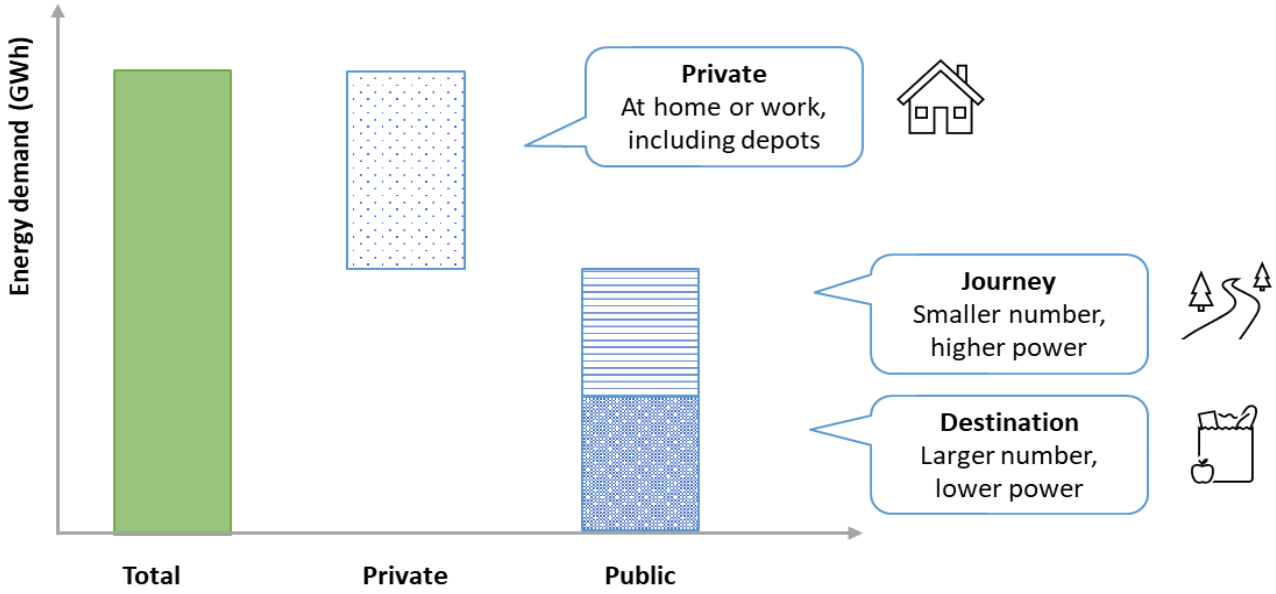
In addition to their direct impact on the cost of supply, inputs can present barriers relating to:

- uncertainty, including if cost information is difficult to access, pricing methodologies are complex, pricing levels vary or pricing risks are not able to be managed such as through fixed-price contracts
- delays, including if processes are lengthy and time consuming.

3.2 Services

Figure 3.3 summarises our services framework.

Figure 3.3 Demand is met by a mix of private charging and public destination and journey charging services



In energy terms, a substantial portion of charging needs should be met through private charging, including at-home and workplace charging. Private charging is typically the first choice, including because it is:

- convenient – making use of vehicle downtime removes the need to make a special effort to refuel
- low cost – the incremental cost of supply is low, including because private charging does not need to be high-speed (due to long dwell times) and can typically make use of existing network connections and capacity, and charging can be timed to target periods when energy and network prices are lowest
- battery friendly – higher-speed charging has a mildly detrimental impact on battery life, accelerating loss of capacity (Gao et al., 2017).

Around 75% of light passenger vehicle journeys in New Zealand are less than 75 km, well within the range that can be added to a typical car from an 8-hour session charging from a standard three-point connection.[11] However, private charging is not able to meet all charging needs:

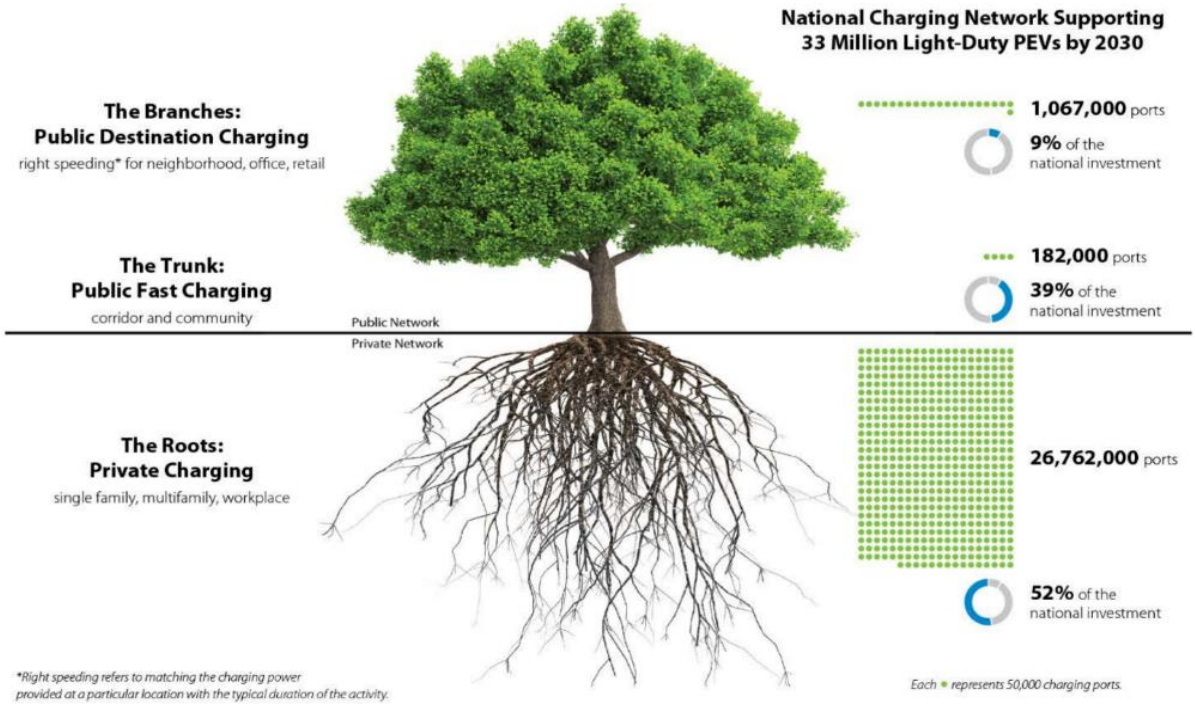
- Some people cannot charge at home or work. This includes people who live or work at premises without off-street parking or live in a rental property where the landlord is unwilling to provide a charge point (or where inability to isolate charging costs from a shared bill is a barrier). This can also include people renting a car while away from their home base.
- Some journeys are beyond the range that can be fuelled from at-home charging alone. EV ranges have been improving as battery costs fall and technology improves, but there will always be journeys that are beyond the range of most or all EVs.

As such, there is a role for public charging services to meet this residual demand and hence expand the utility of EVs. Public charging services are typically broken into two distinct types:

- Journey charging – designed to provide fast, while-you-wait charging at locations that are convenient for extending vehicle journey range. These services are often located along highways or at journey end points (to support return travel) or rest points (to support onward travel). They are analogous to petrol stations and may include complementary while-you-wait services such as a café or convenience store.
- Destination charging – designed to provide convenient charging during vehicle downtime. These services include kerbside and carpark charging for people without at-home charging and charging facilities at shopping areas, libraries and other destinations. Charging speed may be right sized to suit vehicle dwell time, meaning destination charging is typically slower and lower cost than journey charging.

The optimal mix of private, journey and destination charging will depend on a range of factors, vary by country and across New Zealand and evolve over time as EV and charging services markets mature. NREL provides a useful model for the balance between private, journey and destination charging (Figure 3.4).

Figure 3.4 NREL illustration of US charging infrastructure needs (reprinted from Wood et al., 2023, p. ix)



[11] We assume 16 kWh of stored energy added in 8 hours. Vehicle efficiency of 0.2 kWh per km adds 80 km of range.

While the optimal mix for New Zealand is unlikely to be exactly that same as the US, this model highlights some salient features, including that:

- the three parts of the charging ecosystem are important and mutually reinforcing
- journey charging is expensive per port – it is likely to make up the smallest part of the overall ecosystem while consuming a large share of investment
- destination charging is the most cost-efficient form of public charging and has a key role to play in cost-effectively expanding EV charging services availability
- the charging ecosystem is more varied than the ICE fuelling infrastructure that we are used to, with the most analogous service (journey charging) having a much smaller (but still important) role to play.

The optimal mix can vary across vehicle segments, for example:

- many privately owned vehicles can meet most of their charging needs from private at-home charging
- rideshare vehicles may benefit from good availability of lower-cost, lower-speed public chargers (that enable recharging during downtime)
- commercial vehicles (including courier vans and delivery vehicles) may have a comparatively high need for fast charging to top up range during the day.

3.2.1 Public journey (fast) charging

Public journey charging sites provide high-speed recharging to support long journeys.

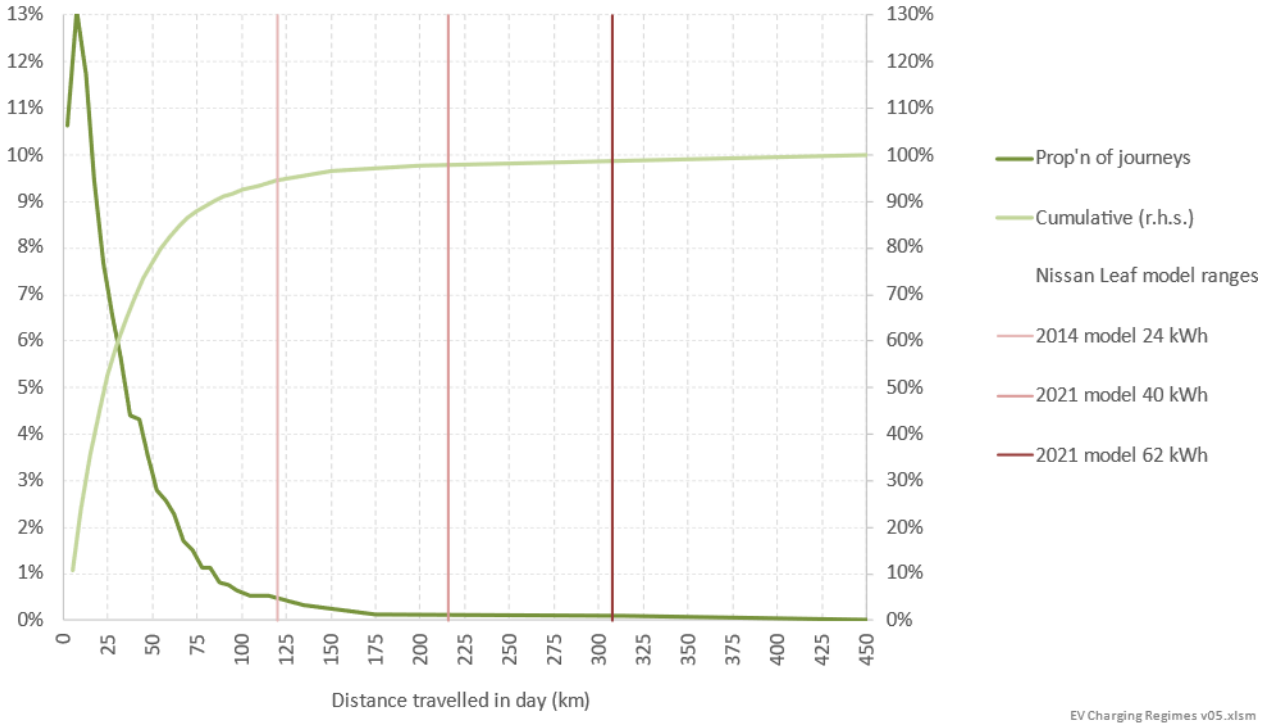
They are analogous to petrol stations though differ in many respects:

- Recharging is not as fast as refuelling. A petrol pump transferring 30 litres per minute to a vehicle with a fuel efficiency of 7 litres per 100 km can add 400 km of range in around 1 minute. This compares to a claimed time of 15 minutes for New Zealand's fastest journey chargers (ChargeNet, 2021) and around 1.5 hours for a typical 50 kW fast charger.[12]
- Given the difference in speed, a traveller would need to spend longer at a journey charger than they would at a petrol station for the same amount of range extension.
- The difference in speed also means a charge point will serve fewer customers in a day than a fuel pump and will deliver less transport energy.
- Charge points and charging sites are less intrusive than fuel pumps and petrol stations.
- Charge points can be added to existing parking spaces or rest areas relatively easily provided there is a suitable electricity network connection. This contrasts with petrol stations, which typically require dedicated underground storage tanks and space for a fuel truck to safely refill the tanks.
- Public journey chargers fulfil a much smaller role for EVs than petrol stations do for ICEs because EVs can more conveniently recharge at private charging facilities (including at home or work) or public destination chargers.

Figure 3.5 shows that even EVs with modest batteries have enough range to cover the distance travelled in a day for at least 95% of the time.

[12] Assuming a vehicle efficiency of 0.2 kWh per km.

Figure 3.5 Even modest EVs can cover most journeys without charging (Concept Consulting analysis of July 2011 to June 2014 New Zealand Household Travel Survey data)



Despite their relatively limited real-life role, journey chargers do expand the utility of EVs and have a disproportionate impact on reducing consumer hesitancy. They can also play an important role in some segments such as domestic and international tourism.

Two factors help explain disproportionate emphasis on journey charging:

- Consumers tend to buy vehicles suitable for their ‘every now and then’ travels rather than their common travel needs (Voxlin et al., 2024). This also contributes to consumer choices around (ICE and EV) vehicle size, seating capacity, power and off-road capabilities.
- Novice EV users (and policy makers) tend to misapply their existing mental models for petrol refuelling to EV charging (Sprei & Kempton, 2024). More-experienced EV owners develop new mental models appropriate for the realities of EV charging. Misapplication of liquid refuelling mental models has detrimental impacts such as heightened anxiety regarding recharging, buyer choice of EV characteristics mismatched to need (too much focus on range and charging speed), manufacturer oversizing of batteries and policy overemphasis on fast public charging.

In common with many other countries, New Zealand has had an early focus on ensuring basic coverage of journey chargers, typically with 50 kW capacity. As the EV market has matured, more higher-power chargers have entered the New Zealand market. The first time EECA awarded funding for a public charger above 50 kW was in August 2019, whereas funding round 9 (in 2023) awarded funding for 20 150 kW chargers and 11 chargers with capacities ranging from 160 kW to 200 kW (EECA, n.d.a).

The advance in EV capability is neatly illustrated by the Nissan Leaf:

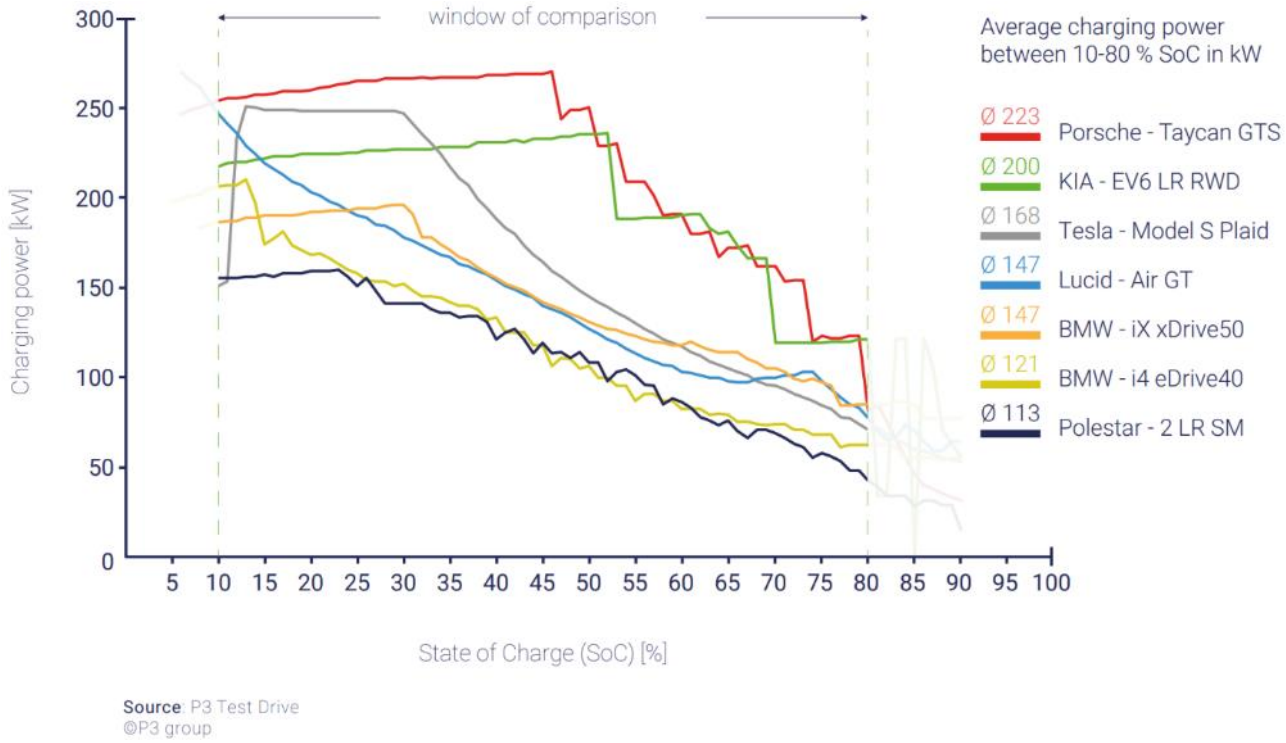
- The first-generation Nissan Leaf, manufactured from 2010, was limited to a 44 kW charging rate and had a maximum range of 200 km (Pod Point, 2024c).
- The second-generation Leaf, manufactured from 2017, could charge at 50 kW and had a maximum range of 270 km (Pod Point, 2024d).

- In 2019, Nissan introduced a variant that can charge at 100 kW and had a maximum range of 380 km (Pod Point, 2024b).
- Nissan's new Ariya, coming to New Zealand in 2024, can charge at 130 kW and has a maximum range of 400 km (Pod Point, 2024a).

The fastest-charging light vehicle sold in New Zealand is the $265,000 Lotus Eletre with a claimed peak charging rate of 350 kW (EVDB, n.d.b) and the (comparatively) more affordable $99,990 Kia EV6 Earth has a claimed peak charging rate of 239 kW and range of around 500 km (EVDB, n.d.a).

Charging speed is also a common focus for EV batteries research (alongside weight and cost). For example, CATL claims to have developed a battery than can add 400 km of range in 10 minutes, which is equivalent to a sustained charging rate of 360 kW (Crownhart, 2023). This would provide significantly better real-world performance than existing batteries, which cannot sustain their advertised peak charging rates (Figure 3.6).

Figure 3.6 Real-world charging rates vary from advertised peak rates (reprinted from Buderath et al., 2023, p. 9)



There is also some concern whether battery degradation will occur due to overcycling from fast charging. However, studies show that, where fast chargers are used infrequently, impact on battery capacity loss is not material – less than 10% over 10–15 years' vehicle ownership (Pesaran et al., 2015).

Public journey charging can be commercially challenging for several reasons:

- High upfront site costs: The cost of connecting to electricity distribution networks has been an area of particular concern for New Zealand charge point operators (CPOs) (Electricity Authority, 2024). CPOs report that costs vary considerably across EDBs and installations and are often much higher in New Zealand than in other jurisdictions. In addition, the process of obtaining a connection can be lengthy, extending the overall timeframe for delivering new charging facilities.
- High uncertainty: EV charging is not a mature market, and there are multiple sources of uncertainty:
  - EV uptake, which drives the overall size of the market for charging. EV uptake is impacted by vehicle market developments and EV and climate change policies.

  - Consumer preferences, which drive the share of charging carried out at public journey chargers, as well as preferred types of journey charging (including preferred providers).
  - Market dynamics, including competitor strategies – for example, in the early stages of market development, providers were competing with EDBs who provided free charging (Wade, 2024).
  - Equipment performance – for example, poor uptime performance for early charging equipment has been a source of frustration for EV drivers and cost for equipment providers and operators (Parkinson, 2023).
  - Obsolescence risk – as EV capabilities evolve, there is a risk of earlier facilities no longer being fit for purpose. For example, the North American market is now converging on a new SAE J3400 North American Charging Standard (NACS), which combines Tesla's charging port design with the ISO 15118 communications protocol used in the Combined Charging System (Choksey, 2023).
- Low utilisation: To address EV purchaser hesitancy, charger capacity may be added ahead of demand and in low-volume locations. This keeps congestion low and coverage high but translates to low utilisation (and hence revenue from charging) for suppliers. Methods for spreading demand (and consumer attitudes to congestion management) are also relatively immature.

At least some journey charging is likely to be provided at hubs where common site infrastructure, including public amenities and a high-capacity network connection, is shared by multiple competing CPOs.

3.2.2 Public destination (slow) charging

Destination charging is not analogous to liquid refuelling. It takes advantage of the fact that lower-powered charging is a low-cost and unobtrusive way to provide pervasive and convenient access to EV charging facilities.

Examples of destination charging:

- Carpark charging at malls, shopping centres, commercial streets, libraries, swimming pools, parks, attractions, airports, hotels, restaurants, public carparks and other destinations where people park while carrying out some activity. This type of charging can attract EV-owning customers to a destination, meaning facility owners have an incentive to support CPOs – for example, through providing an electrical supply, providing space free of charge or providing incentives to operators or their customers.
- Advertising-supported charging in areas with high vehicle or pedestrian volumes. This type of service can provide a convenient free charging option in places with high visitor numbers (Schulz, 2022).
- Kerbside charging on residential or commercial streets. Residential kerbside charging can provide an alternative to at-home charging, making it easier for people without off-street parking to own an EV. Commercial kerbside can provide an away-from-base charging option for couriers, rideshare vehicles, taxis and delivery vehicles.
- Community charging, including at housing developments and at community centres, parks and other similar facilities. This can provide another option for people who cannot otherwise charge at home plus another option for light commercial vehicles such as couriers, rideshare vehicles and taxis.
- Workplace charging for visitor and employee-owned vehicles (as opposed to private charging for employer-owned fleets).

NREL projects that destination charging provides 85% of public charging ports while consuming less than 20% of national investment in public charging in the US (Wood et al., 2023).

In New Zealand, destination charging has been an area that has attracted early investment from a range of operators – both with and without direct government support.[13]

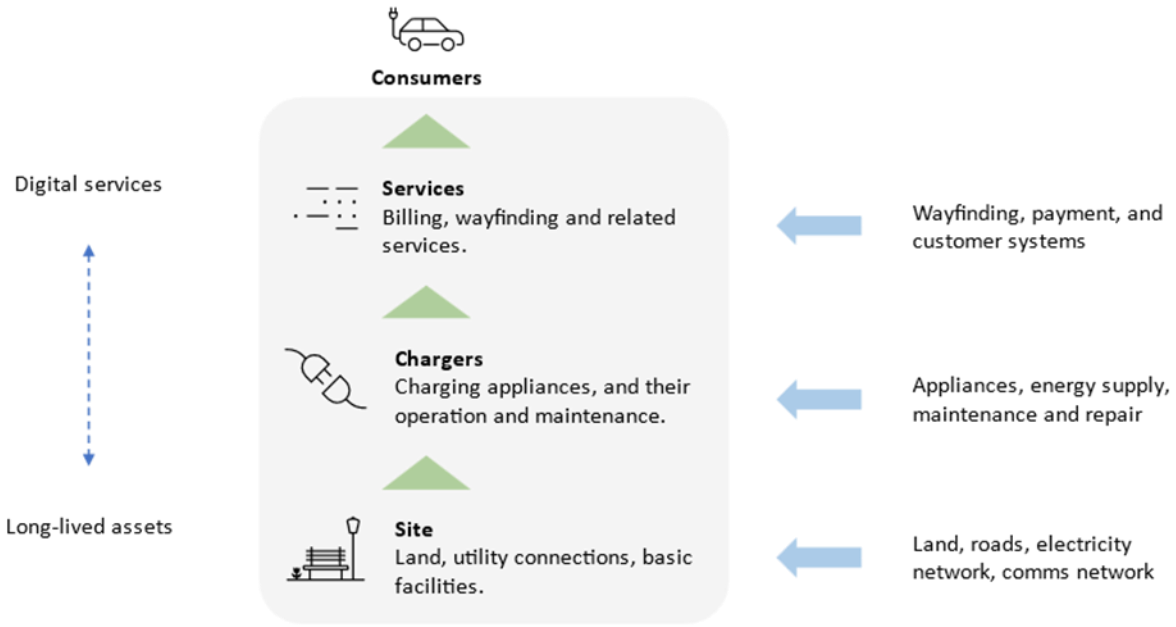
At the time of writing, EECA's dashboard (EECA, 2024c) reports 318 charging units (or 25% from a total of 1,248) owned by four destination-focused providers (Meridian, JOLT, Hikotron and The Warehouse).

This likely under-reports the significance of investment to date in destination charging, including because other providers own a mix of journey and destination charging and because destination chargers are less likely to be recorded in the EVRoam database used by EECA's dashboard.

3.3 Supply chain

As illustrated in Figure 3.7, the supply chain is made up of multiple inputs to provide a charging service to consumers, including site infrastructure, chargers and (digital) services.

Figure 3.7 A mix of inputs is needed at each layer of the charging services supply chain



The different parts of the supply chain can be developed, owned and operated by a range of different market players, including public, semi-public and fully private companies.

The different market players may be organised around only one or up to all three of the key inputs shown in Figure 3.7.

3.3.1 Site infrastructure

Charging infrastructure is relatively flexible in where it can be located compared to petrol stations. This is because it does not require a big footprint for underground tanks or fuel tanker movements and does not involve storing and handling hazardous liquids.

[13] This is evidenced by the number of public chargers in New Zealand significantly exceeding the number of co-funded chargers. However, all private investment in public charging services indirectly benefits from the charging ecosystem that co-funding has helped to establish and the EV uptake that has occurred as a result.

Site options can include the following:

- Greenfield – a dedicated development specifically for EV charging. This can involve establishing road access, pavement, stormwater management, electricity network connection, lighting and other safety features and telecommunications connection.
- Brownfield – repurposing or augmenting an existing development to provide EV charging. This can include upgrading an existing electricity network connection, extending electrical cabling and modifying infrastructure such as crossings and pavement.
- Serviced – a site developed for EV charging with existing infrastructure ready to accommodate new providers or additional charge points. Serviced sites may be operated by a site host or may simply have been enabled with passive infrastructure when established.

Site needs vary by charging type and CPOs may vary in their thesis as to what kind of sites will best meet consumer needs. For example, sites may be located:

- where vehicles already dwell such as shopping areas, community facilities, workplaces or residential areas
- where vehicles already travel such as along busy transit corridors or inter-regional connectors
- in locations that are convenient for drivers to access even if not heavily frequented such as near recreation reserves or scenic locations.

Sites may vary significantly in their revenue potential (direct and indirect) and their cost. A key cost driver is the cost of establishing (or upgrading) an electricity network connection. This is most acute for high power connections but can also be material for otherwise low-cost destination charging.

Factors that influence electricity network costs:

- Proximity to existing network infrastructure (of a suitable voltage) and type of environment: For example, a site adjacent to a busy metro road and located far from a suitable network connection point may incur significant traffic management, civil works and cabling costs compared to a site directly adjacent to a suitable network connection point.
- Network upgrade needs: Networks vary in the amount of headroom they have available to accommodate new loads. If headroom is limited, expensive upgrades or reconfigurations may be needed to accommodate charging loads.
- Connection charging policies: There are 29 EDBs and each network has its own connection pricing arrangements, which can vary significantly in how they allocate the above costs between parties. This diversity adds cost and uncertainty for CPOs operating nationwide and can influence how they prioritise their expansion plans. Key considerations for connection charging policies (Electricity Authority, 2023c) include:
  - allocation of costs between upfront charges paid by the access seeker and ongoing charges recovered over time across all network users (including new and existing users)
  - treatment of upgrade costs, including whether they are recovered solely from the party who triggers an upgrade or spread across all the parties who consume available headroom
  - balance between cost reflectivity (and other drivers of complexity) and simplicity.
- Options available to lower costs by opting for a flexible connection: For example, a supply that can be interrupted or throttled (potentially in conjunction with an on-site battery to maintain the charging service) may be less costly than supply with firm capacity.
- On-site reticulation needs: For example, a site will have lower cabling costs if charging appliances are located near the point where the site connects to the electricity network.

For much of the charging market, sites are unlikely to be strongly strategic assets – the market can be efficiently served by a large number of sites controlled by competing providers with site access not forming a significant barrier to entry.

However, there may be some parts of the charging market where sites are a strategic, bottleneck asset that would benefit from being developed and shared with multiple CPOs. This is most likely for:

- charging in areas with low demand such as tourism spots or remote locations where the number of sites needed to satisfy all demand is low – such locations may also have high network costs, further exacerbating their bottleneck nature
- areas where road access is tightly controlled and/or there are limited suitable sites (especially if they are publicly owned) such as motorway service areas
- areas where charging demand is large enough to require significant electricity network reinforcement – for example, hubs that provide inter-regional journey charging for both light and heavy vehicles.

Where sites have the potential to become bottleneck infrastructure, there can be value in an open-access, vertically separated industry structure (where the site owner is not also a CPO).

3.3.2 Chargers

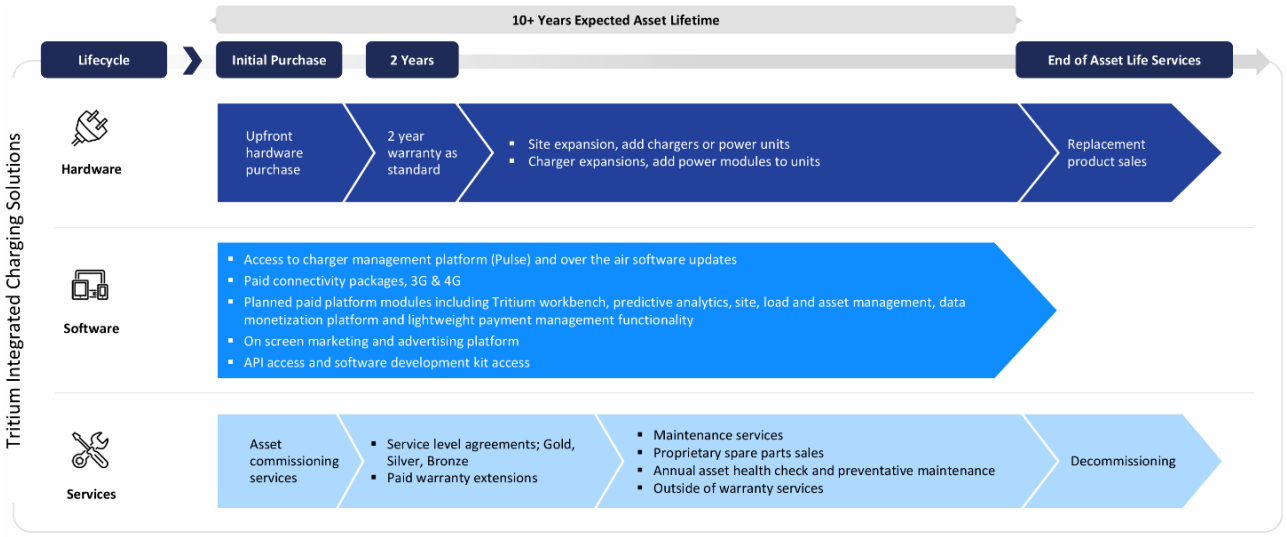
The charger layer includes the following:

- Charging appliances (upfront capital cost or ongoing lease cost): These vary in their performance, appearance, durability and functionality. For example, there may be differences in their peak power, number of simultaneous charging sessions they can serve, ability to load balance between appliances (to manage overall site demand), type of connectors, remote communications and control capabilities, upgradeability and resilience to wet, hot, cold and dusty conditions. Charger end of life may be prompted by equipment failure, technical obsolescence or end of manufacturer support. Tritium (2023) reports an expected life of 8–10 years for DC fast chargers. Charger capabilities are influenced by international standards and regulations for vehicles and vehicle charging, which in turn influence the capabilities of vehicles imported into New Zealand. For example, European regulatory requirements can influence capabilities of vehicles sold in New Zealand, which in turn influences how well charging appliances meet the needs of our vehicle fleet.
- Appliance maintenance and repair (ongoing operating and periodic capital cost such as for life-extension works): Maintenance typically includes scheduled work (inspections and servicing), reactive work (repairs) and proactive work (such as firmware upgrades or part replacements). Cost can be driven by equipment performance, environmental conditions and factors such as vandalism or customer behaviour. Work may be carried out by a third party, the CPO or the appliance supplier.
- Energy supply (ongoing operating cost): Arrangements for ongoing energy supply may include metering, lines charges, energy purchases and price risk management (such as financial hedges). CPOs may purchase all of these as a bundled service through an electricity retailer or may purchase all or some inputs directly.

Figure 3.8 shows how appliance manufacturer Tritium[14] based its business model on securing after-sales revenue associated with maintenance and repair as well as services such as charger connectivity and management. In 2023, Tritium claimed to have the second-highest global market share of fast chargers, with only five “true competitors” (Tritium, 2023, p. 12).

[14] Tritium entered receivership in April 2024. Its receivers report that they have stabilised the business and are hopeful of finding a new owner (Thomsen, 2024).

Figure 3.8 Appliance manufacturers such as Tritium offer warranty, maintenance and repair services (reprinted from Tritium, 2023, p. 33)



As with connection charges, EDBs vary considerably in how they structure ongoing lines charges, including:

- the balance between fixed (such as $ per day or $ per installed kW) and usage-based charges (such as $ per kWh or $ per peak kW)
- whether charges are structured to incentivise efficient usage (such as with lower off-peak rates)
- whether charges differentiate between firm demand and flexible demand that can be throttled at times of system stress
- how different types of non-residential consumers are grouped together for pricing purposes – for example, according to capacity bands or some other characteristic.

The Electricity Authority has been encouraging EDBs to adopt more cost-reflective charging structures, although its focus to date has mostly been on residential consumers (Electricity Authority, 2023c). More cost-reflective charging generally ought to entail a high fixed-to-variable ratio and lower usage charges for flexible demand and off-peak usage.

At a wholesale level, the electricity market sets spot prices in real time at hundreds of nodes across the country, with the price reflecting current supply and demand balance. Spot prices can be volatile, with higher prices occurring when demand is very high or when supply is tight – for example, during extended dry periods (impacting hydro generation), when plant is out of service or (increasingly) when wind and solar production is low.

Retailers typically transform lines charges and energy charges into a retail tariff, which typically provides a more predictable usage charge. As with EDBs, retailers can offer charges that are structured to incentivise efficient usage at times when networks are generally less stressed and wholesale prices are lower.

3.3.3 Services

The digital services layer supports use and management of charging appliances and can include:

- telecommunications – fixed, wireless or satellite-based communications to support remote monitoring, reporting and control
- customer information systems – apps or interfaces to supply information such as location, features and status (available, in use or out of service)

- operator information systems to support management of a network of charging sites – for example, including technical and commercial management such as commissioning and configuration management, fault reporting and diagnostics, maintenance management, pricing management and security
- electrical load management systems for balancing load between charging ports to stay within site limits or throttling site demand to manage network limits, optimise energy purchase costs or earn electricity revenues such as demand control payments – these can work alongside integrated or on-site batteries
- payment systems for controlling usage and collecting payment – these can range from point-of-sale systems to app-based or bundled (with home electricity billing) systems, including with features such as subscriptions or provider roaming.

As the charging services market matures, there is likely to be ongoing evolution in customer-facing digital services:

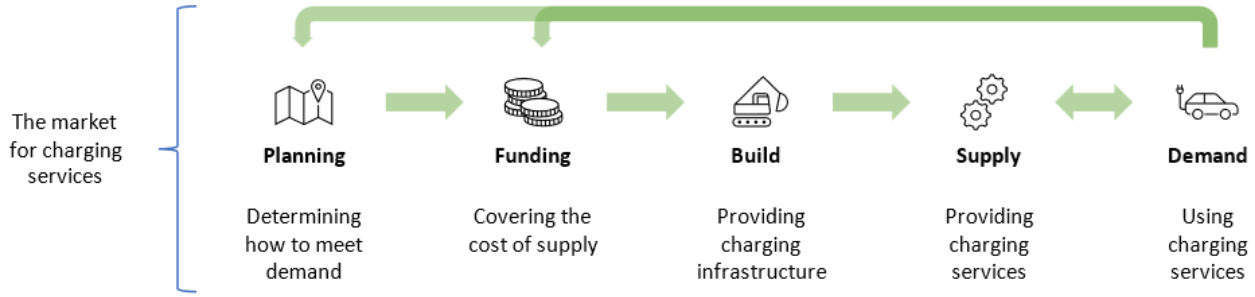
- Interoperability: Operators typically have varying incentives as a market matures to favour a walled garden, limited interoperability or fully open model. The ability and incentive to move towards more open models can be influenced by the availability of standards and by regulatory oversight.
- Market structure: Digital services can be integral to site, appliance or CPO or can operate as stand-alone businesses or as part of a wider services business. The breadth of business models, the scope for innovation and the ease with which services businesses can scale up means there is relatively high potential for market structure to evolve.
- Pricing models: Pricing tends to evolve as suppliers experiment with options for trading off between cost reflectivity (matching revenue to costs), price discrimination (basic and premium pricing tiers) and simplicity. How pricing evolves can be influenced by the structure of input prices and various market dynamics. For example, fixed-line broadband services in New Zealand have evolved from using monthly data allowances as a pricing metric to providing unlimited data and differentiating by speed and technology. This pricing model is used by Chorus for wholesale fibre services and adopted by retailers for their retail plans.

In a survey of 21 charging companies located across more than 10 countries, about one-third included a fixed fee, 50% included some form of volumetric charge, 20% included a time-based charge and 10% included a flat fee to connect. Other companies used other forms of fee structure such as free charging or charging rates set by individual station owners (LaMonaca & Ryan, 2022).

3.4 Market functions

Figure 3.9 summarises our functions framework, which sets out the key steps involved in supplying charging services to meet demand.

Figure 3.9 The market for charging services has five key functions



3.4.1 Demand

Because there is demand for EV charging services, there is a market to supply those services – demand is the fundamental driver for supply. To meet that demand, suppliers need to carry out functions that are common across any infrastructure-based service.

While demand is the fundamental driver, it is common for suppliers to invest in stimulating demand. Initially, suppliers focus on finding early adopters, then growing early and late mainstream adopters, then encouraging laggards and shifting market share. These are some examples from other services:

- For many years, Powerco used its Gas Hub brand to promote natural gas as a product and offered zero-cost connections to its gas network (Powerco, 2013, p. 3.). With gas networks facing a heightened stranding risk due to electrification, it is now phasing out this policy for new connections (Powerco, 2023, p. 170).
- The government's ultra-fast broadband contract with Chorus required Chorus to invest in marketing fibre services (Crown Infrastructure Partners, 2011). Chorus also provides zero-cost installations for new premises and has invested in incentive programmes to encourage retailers to promote fibre services (Chorus, n.d.).
- Spark, One NZ and 2degrees invest heavily in brand marketing and promoting specific services such as 5G-based services, satellite-backed services, international roaming and wireless broadband. Wireless broadband marketing is aimed at stimulating demand rather than upselling or shifting market share (Chorus, 2023).
- Microsoft has developed its Copilot brand to promote services supported by artificial intelligence, including new services and enhancements to existing products and services. This investment aims to stimulate demand, including by addressing consumer hesitancy regarding artificial intelligence (Warren, 2024).
- Car manufacturers direct a portion of their advertising at educating consumers about new technologies or features such as hybrid drivetrains to overcome hesitancy and stimulate demand.

Information about demand is valuable to suppliers:

- Projections of future demand and insights into the factors that may impact demand: The more suppliers are confident that demand will grow, the further ahead they can plan to meet new demand. For EV charging services, factors that influence demand include factors that influence whether people purchase EVs and how they choose to charge their vehicles – for example, the balance between at-home and public charging or between journey and destination charging.
- Utilisation of existing infrastructure: High utilisation is a key indicator of where there may be value in adding more capacity. This indicator only becomes available where there is some existing supply so is more useful for guiding capacity additions (new sites near existing sites or extra chargers at existing sites) than coverage extensions. Utilisation information can also indicate what types of charging services consumer prefer and how much they are willing to pay for various attributes (such as speed, customer experience and convenience). Utilisation of various classes of charging services such as at remote tourism locations can indicate whether there is demand for more of that class of service.
- Profitability of existing infrastructure: Profitability encapsulates information about utilisation as well as willingness to pay and the cost of supply. In mature markets with efficient pricing, low barriers to entry and no externalities, profitability is the prime indicator of where and how to expand services (OpenStax, 2023).
- Consumer research: Consumer research, which is typically survey or interview based, can provide richer information on consumer preferences and barriers to uptake. For EV charging services, it is useful to understand preferences for consumers who have not switched to EVs as well as EV owners.

3.4.2 Planning

In most markets, planning is a decentralised activity with individual suppliers competing to meet demand and carrying the financial risk as to whether the supply they add will be profitable. Benefits of this dynamic are:

- allowing a diversity of views as to how best to meet demand – suppliers will have differing views on how best to meet demand and will be incentivised to learn quickly from the relative success of different offerings, which can be particularly valuable for immature markets where consumer preferences and options for meeting those preferences are evolving rapidly
- allocating investment risk to the parties best placed to manage the risk
- promoting efficiency because suppliers are incentivised to deliver the best services at the lowest costs and in the best locations with the best timing (Cheng, 2019).

However, there are many markets where fully decentralised planning may not be socially optimal:

- Where services have strong monopoly characteristics such that it is efficient to have a single supplier: Electricity transmission is a classic network infrastructure example in contrast to electricity generation, which does not have strong monopoly characteristics and benefits from largely decentralised planning. In transmission markets, there is often regulatory oversight of planning, which is carried out by the supplier. Oversight can include regulatory standards (such as for reliability), process requirements, revenue caps and related incentive mechanisms and prescribed cost-benefit analysis methods. In addition, regulators typically constrain the scope of the regulated service and promote contestability where possible (such as for building new connections to the network, electricity generation and retail).
- Where services have strong public good characteristics and there are benefits to society that will not be reflected in market prices: Examples include public schooling, public health, public roads, fire services, national defence and flood control.
- Where services depend on access to bottleneck infrastructure: This can introduce a need for or benefit from some degree of coordination between the supplier of the bottleneck infrastructure and competing access seekers. There is typically a trade-off in such circumstances between the benefits of decentralisation and the benefits of coordination – sometimes the inefficiency of uncoordinated access is outweighed by the efficiency benefits of decentralised planning.

Findings for EV charging services in overseas markets:

- Some degree of decentralised planning and commercially led investment is common, especially in the most commercially viable segments of the market. These can include destination charging (which is relatively low-cost and has complementary value streams) and journey charging in areas with the highest revenue potential.
- Centralised planning by government agencies is also common, including to:
  - inform market monitoring or policy design (by providing a baseline view of efficient investment)
  - guide public funding decisions
  - inform or coordinate development of centrally planned infrastructure such as roads and electricity networks
  - provide information that will assist charging services suppliers, investors or EV purchasers.

Planning can be carried out with different levels of granularity and planning horizons, for example:

- setting high-level targets such as:
  - coverage (such as one charger every 75 km)
  - density (such as 10 EVs per public charger)
  - number (such as 10,000 chargers by 2030)

- simulating an optimal nationwide charging mix – for example, NREL's modelling of US light-duty demand in 2030 (Wood et al., 2023)
- high-level planning to support a supplier business plan – this would focus on investment, operating cost and revenue projections with a horizon suitable to financing and delivery planning needs
- detailed planning of optimal sites for segments of the market that benefit from central coordination, funding or delivery such as high-cost sites, low-income areas, rural or remote locations, kerbside charging and motorway layby charging.

3.4.3 Funding

Charging services typically involve high upfront costs that are recovered over time from net income. This means funding can involve a mix of:

- customer income from vehicle charging, which can include some mix of subscription revenue and pay-as-you-go revenue
- ongoing revenue from third parties such as from advertisers or on-site businesses
- upfront contributions from on-site or local businesses or government grants
- financing to cover the timing mismatch between cash outlays and income.

Suppliers and financing providers (investors or lenders) need to assess costs and benefits to test whether investment will pay off. This can include assessment at a high level (for business planning or to assess whether to provide financing) and at a project level (to test whether to commit to a particular site).

Project-level testing involves gathering detailed, project-specific information about costs and revenue potential. This is easier if costs and revenues are predictable and well understood – for example, if a supplier has information from existing sites on which to base revenue projections and if network connection charges are standardised, low or determined via a transparent methodology.

For public funding, government is typically interested in making the smallest contribution needed to achieve a given outcome. This can involve:

- estimating a project's shortfall between income and costs, assessed on a net present value basis, and taking into account a supplier's cost of capital and reasonable hurdle rate
- if government is providing financing (rather than a grant or tax relief), assessing lending or investment risk, which can involve interrogating the capital structure of the supplier and its broader business plans.

This level of project-by-project and firm-by-firm scrutiny can add time and cost and influence the type of supplier and type of infrastructure that is built. As such, it can sometimes be more efficient to provide public funding at a programme level – for example, a fixed contribution on delivery of a given outcome.

In New Zealand, EECA has supported the installation of most of the public journey charging infrastructure across the country with co-funding through the Low Emission Transport Fund (EECA, 2024b). It has co-funded more than 1,400 EV chargers, with over 700 of these already operational (EECA, n.d.a). In the process, EECA has gathered project-level cost information and gained market knowledge.

Overseas, the US National Electric Vehicle Infrastructure (NEVI) Formula Program (Department of Energy, 2021) has made nearly US$5 billion available for states to co-fund the development of EV charging networks (Department of Transportation, 2022). California awards funding to developers with conditions that they install a minimum number of charging stations and charging ports within designated transport corridors (thus incentivising developments of a specific type in these general locations) but awardees remain responsible for locating and securing access rights to specific charging station locations and then designing, engineering, constructing, operating and maintaining the charging stations (O'Dea et al., 2023).

Generally, grants and subsidies only make a proportion of the investment, with co-investment from the private sector still required. EECA's co-funding requires a minimum investment from developers, and NEVI funding is available for up to 80% of eligible project costs.

These grants and subsidies can target specific locations or types of chargers that are not being delivered by the private sector. The NEVI Formula Program ensures that charging infrastructure is built on key routes by requiring them to be located along federally approved alternative fuel corridors. It also ensures that the service provided is widely accessible by requiring charging stations to:

- be non-proprietary
- allow for open-access payment methods
- be publicly available or available to authorised commercial motor vehicle operators from more than one company.

3.4.4 Build

Build involves physical works to enable the provision of charging services. It requires:

- accessing land
- connecting to utilities
- installing other physical infrastructure, including charging appliances.

3.4.4.1 Access to land

To build an EV charging station, a developer must have access to suitable land through ownership or some kind of lease or access agreement with the landowner. Depending on the installation, the developer may also require approval from the territorial authority or road controlling authority (RCA) to use the land for this purpose.

Government interventions that could be used to improve access to land for private developers:

- Reducing consenting barriers to make it easier for developers to build EV charging stations without being impeded by unnecessary costs, bureaucracy or public opposition: For example, a National Party policy highlights plans to eliminate the need for resource consents for EV charge points (National, 2023).
- Mandating that certain types of private developments have or allow public EV chargers: Some planning laws require developments to have a certain number of public carparks to be granted consent. Government could further mandate that a certain number or percentage of these carparks must include EV charge points or enabling infrastructure such as electrical reticulation.
- Regulating exclusivity agreements: Where a party controlling key sites for EV charging infrastructure (such as an airport or local government) establishes an exclusivity agreement with a CPO, this can harm competition in the market for charging services. For example, in the UK, the competition regulator expressed concern regarding exclusivity agreements reached in relation to motorway service areas (Competition and Markets Authority, 2022).
- Central and local government owning land that can be suitable for charging, including road reserves and facilities such as carparks, parks, libraries and other community facilities: Low (or zero) cost access to this land can reduce the cost of supplying charging services.
- In locations where sites are likely to become a bottleneck such as high-cost remote areas and high-capacity journey hubs, government could build or fund the basic site infrastructure and provide open access for CPOs.
- In locations where local government owns the land such as taxi stands, loading zones and other on-street parking, local government could reticulate power supplies and provide open access for CPOs.

3.4.4.2 Connection to utilities

Connection to the roading network and an electricity network are typically essential parts of establishing a charging site. Some sites may also require connection to other utilities such as stormwater, waste and drinking water (for on-site bathrooms) and fixed telecommunications networks.

Electricity networks typically provide reliable, low-cost access to energy compared to self-supply options (such as on-site solar and battery installations). Greenfield sites typically require installation of a new network connection, while brownfield sites can require an upgrade to existing network connection capacity.

EDBs are natural monopolies. They face no competitive pressure to provide new customers such as a CPO wanting to connect an EV charger to their network with an affordable and high-quality service as the CPO cannot choose to engage a different EDB for the same site. Instead, this must be ensured through price-quality regulation, which caps the amount of revenue an EDB may earn from regulated services while also imposing minimum quality standards.[15]

A report by Baringa (2023) for the Ministry of Business, Innovation and Employment (MBIE) found that, despite existing regulation, CPOs still had issues with connecting to distribution networks:

- Network visibility: CPOs need to know where there is spare network capacity to connect an EV charging station so they can make well-informed decisions about where to locate their charging station. Obtaining this information can be difficult or slow and sometimes is not available at all.
- Connection processes: The procedures that are in place for connecting to the network can impede the development of EV charging stations. Timelines can be slow and requirements can be restrictive. In New Zealand, only EDBs can undertake connection works whereas this can be done by a certified provider in the UK (Llewellyn, 2024).
- Connection charges: Upfront charges can vary depending on what is being connected where. This can make it difficult for CPOs to plan projects efficiently as they may not know how much it will cost to connect until they have done so.
- Distribution use-of-system tariffs: Tariffs for the ongoing use of the distribution network tend not to be based on the characteristics of EV charging stations so they may not accurately reflect the costs they impose on the network.

These issues are particularly acute for CPOs looking to build faster, higher-voltage chargers, which require a larger network connection and potentially upstream network upgrades.

There is also a lack of consistency between EDBs across the country, with no standardised visibility tools, connection processes or connection charges. As there are 29 EDBs, this can add considerable complexity for nationwide CPOs and can influence how CPOs prioritise expansion plans.

The sector could collaborate to improve connection arrangements. Alternatively (or as well), government could intervene by amending regulatory settings for distribution networks – for example, to:

- mandate minimum procedural standards such as the timeframes in which an EDB must process a request to connect an EV charging station
- improve the ability for independent connection providers to construct new network connections
- set out processes for dispute resolution
- provide best-practice guidance to EDBs about what good connection processes and charges look like

[15] While most EDBs are subject to price-quality regulation, 13 EDBs are exempt on the basis that they are consumer-owned and assumed to act in the interests of their consumers. Exempt EDBs are still subject to information disclosure regulation and regulation of network access terms and pricing methodologies.

- require clear capital contribution policies (or cost estimates at a minimum) so CPOs know how much they will be expected to pay to connect to the network before they make their final investment decision
- require standard connection charges (predictable cost caps) so CPOs know how much they will pay for ongoing use of network services.

3.4.4.3 Charging appliances

The charging appliance is the most visible and specialised part of the charging service infrastructure. A developer needs to select and order a charging appliance, install and commission the appliance and potentially arrange for warranty and maintenance support.

The market for supply of charging appliances is evolving alongside EV and charging services markets, with appliances evolving in terms of their performance, reliability and features. As the market evolves, standards are evolving for connector design and vehicle communication protocols, remote communications and control protocols, appliance management and payment systems.

Charging appliances offer numerous trade-offs between cost and features such as:

- peak and sustained power output
- simultaneous charging sessions
- information display or communication
- upgradeability
- load balancing and throttling
- vehicle compatibility
- appearance and ergonomics
- expected life, durability, repairability and other lifecycle features.

3.4.5 Supply

Supply involves the ongoing delivery of charging services, including activities such as:

- managing energy costs
- managing other operating and recurring costs, including appliance and site maintenance
- promoting the service and helping drivers to find and access the service
- improving the service over time, including through consumer research
- managing pricing structures and levels
- managing other commercial arrangements such as with partners or other on-site providers
- planning for renewal, capacity expansion or retirement of services
- managing safety
- managing compliance and other risks.

Where government has contributed funding to charging services, it may have a particular interest in supply quality, including matters such as pricing, reliability and provision of dynamic data. For example, Crown Infrastructure Partners required Chorus and other fibre companies to report on a range of network and customer service performance metrics and imposed penalties for poor performance (Crown Infrastructure Partners, 2011).

Government may also have an interest in matters that impact consumer experience, especially if they contribute to suppressing EV uptake. For example, the UK Department for Transport (2022) intends to regulate for various customer experience features, including price transparency and payment roaming.

4 Case studies

In this section, we discuss how EV charging networks are evolving worldwide, with particular focus on policy in jurisdictions that are broadly comparable to New Zealand – Germany, Norway, the Netherlands, the US, the UK, Australia and Canada. We begin by summarising thematic commonalities and notable differences between certain jurisdictions before focusing on illustrative topical case studies we describe in greater detail.

4.1 Setting goals for EV charging rollout

Many jurisdictions have established EV charging goals in line with objectives for EV uptake. For example:

- 300,000 chargers by 2030 in the UK (Department for Transport, 2022)
- 50,000 more chargers/stations by 2029 in Canada (Transport Canada, 2022)
- chargers on major highways at an average interval of 150 km in Australia (Department of Climate Change, Energy, the Environment and Water, 2023).

Some jurisdictions have expanded on these goals to incorporate more qualitative ambitions for the charging network such as spatial coverage, user experience, reliability, energy system integration and pricing. For example, the following qualitative goals apply in the UK (Department for Transport, 2022, p. 5):

- Everyone can find and access reliable public charge points wherever they live.
- Effortless on-street and off-street charging.
- Fairly priced and inclusively designed public charging.
- Market-led rollout for the majority of charge points (where the market is mature and government's role becomes largely one of removing inefficient regulatory hurdles).
- Infrastructure is seamlessly integrated into a smart energy system.
- Continued innovation to ensure users face the lowest cost.

In 2020, the Netherlands Government anticipated a need to triple charge points by 2025 and an eight-fold requirement by 2030 (Netherlands Enterprise Agency, 2020), although this appeared to be more of an indicative aspiration rather than a hard target. Like the UK, the Netherlands' ambitions are quite holistic. For example, the aim is not just for sufficient charger coverage but also:

- strategic and data-driven placement of infrastructure
- accessible information on charger location, availability and rates
- future-proofed integration with the electricity grid to manage capacity constraints
- a good balance of charging infrastructure modalities (fast journey chargers, slower public chargers and private chargers).

It is very important for EV charging goals to be broadly consistent with an efficient mix of private, journey and destination charging, as seen in the UK and Dutch aspirations in particular. The German Government has recently mandated that large petrol station companies operating over 200 locations must offer a fast-charging point at all stations (or in the immediate vicinity) from 2028 (Schaal, 2024). This has led to concerns that not only might this goal be far in excess of EV demand but also that it does not recognise the potential for private charging and destination charging to support EV uptake in a cost-effective manner. The Federal Association of Energy and Water Industries is critical of the legislation, emphasising the difference between EV charging behaviours and refuelling combustion vehicles.

4.1.1 New Zealand context – setting goals

New Zealand does not yet have an all-encompassing numerical target for EV charge points. However, in 2017, NZTA established a vision for nationwide coverage of fast-charging stations every 75 km across state highways (NZ Transport Agency, 2024). This set the scene for co-funding from EECA (via the Low Emission Vehicles Contestable Fund and its successor, the Low Emission Transport Fund) in the subsequent years for nationwide journey charging coverage to reduce range anxiety for EV drivers commuting between centres and eliminate charging blackspots.

More recently, the national EV charging strategy (Ministry of Transport & Ministry of Business, Innovation and Employment, 2023b) set targets to have journey charging hubs every 150–200 km on main highways by 2028 and at least 600 EV charging stations in rural locations by 2028. The current government also campaigned on a goal of 10,000 public EV chargers in New Zealand by 2030 (National, 2023), which is yet to be formalised in policy.

Finally, it is worth noting that New Zealand's national carbon emissions targets imply certain target ranges for EV uptake, which could in turn inform targets for EV charge points. The Climate Change Commission's 2021 demonstration pathway signals significant acceleration in EV uptake is needed to achieve national targets, alongside avoid and shift activities such as increased use of active and public transport. It implies that 13% of the national light vehicle fleet will need to be EVs by 2030 (Climate Change Commission, n.d.).

4.2 Funding support for EV charging

Funding support from governments often goes hand in hand with goal setting. For example, Canada's government has committed CA$376 million in funding for 35,000 chargers/stations and CA$400 million for a further 50,000 (Transport Canada, 2022).

Not all funding support is in the form of grants. Some governments have taken the view that some funding for EV charging could also become a profitable investment for taxpayers:

- "Canada's Infrastructure Bank will also invest $500 million into large-scale zero-emission vehicle charging and refuelling infrastructure that is revenue generating and in the public interest." (Transport Canada, 2022, p. 9).
- The UK has established a £422 million Charging Infrastructure Investment Fund to catalyse the rollout of a "robust and diversified" public charging infrastructure. It has made investments in four charging companies (Department for Transport, 2022).

Federal funding for EV charging in Australia has largely not been forthcoming, but state governments are acting (Department of Climate Change, Energy, the Environment and Water, 2023):

- The South Australian Government is providing a grant to the Royal Automobile Association to build, own and operate a statewide charging network.
- The Western Australian Government is planning to fund and install 100 charging stations across the state.
- The New South Wales Government will provide $199 million in co-funding towards EV chargers every 5 km along commuter corridors, every 100 km on average along major highways, in residential areas with limited off-street parking and in or near commuter carparks (NSW Government, 2021). Funding for residential parking will include hundreds of ports for kerbside parking (NSW Government, 2024).

Virtually all jurisdictions surveyed expressed a desire for the private sector to take the lead on EV charging but recognised that, where markets were immature, have a pressing need and/or are uneconomic in the near/medium term, there was a role for government funding and/or investment. This is seen in the UK's bespoke funding approach for different parts of the ecosystem (Department for Transport, 2022):

- The £950 million Rapid Charging Fund (RCF) will support the rollout of at least 6,000 high-powered charge points across England's motorways and major A roads by 2035.
- The UK Government will support local authorities with over £500 million of funding, helping them find innovative ways to increase local charge point coverage (Local EV Infrastructure Fund).
- Other funding schemes include:
  - Electric Vehicle Home-charging Scheme – now pivoting to focus more on flats and rented accommodation rather than private driveways
  - Workplace Charging Scheme – now shifting focus away from staff and fleet charging and towards charging for guests and visitors in sectors like accommodation.

The UK's funding regime also reflects the government making it a priority to install charge points ahead of demand (especially on major roads) so that drivers can have confidence in switching to an EV.

The UK has also recognised that the private sector will be far less likely to invest in EV charging unless it has confidence in the uptake of EV demand growth and that other policies related to EV uptake can have a material impact:

> *Our phase out dates for new petrol and diesel cars and vans sent a clear signal of the UK's intent. This certainty has unlocked new private sector funding. In seven months, over half a billion pounds of private investment has been publicly committed to chargepoint rollout.* (Department for Transport, 2022, p. 26)

Canadian federal government co-funding for EV charging specifically aims to bootstrap private sector activity and "establish a business case for the private sector to increase its funding for Canada's electric vehicle charging network" (Transport Canada, 2022, p. 10). For every government dollar spent in Canada's Zero Emission Vehicle Infrastructure Program, the private sector has spent over double that much.

The US, like the UK, has made federal funding available for multiple parts of the EV charging ecosystem under the 2021 Bipartisan Infrastructure Law (Lyman, 2023b):

- The NEVI Formula Program provides funding (US$5 billion total over FY 2022–2026) to states to deploy EV charging infrastructure primarily along designated alternative fuel corridors like highways.
- The US$2.5 billion Charging and Fueling Infrastructure Grant Program provides competitive grants for both corridor charging and community charging. A project receiving a community grant must be "located on any public road or in other publicly accessible locations such as parking facilities at public buildings, public schools, and public parks, or in publicly accessible parking facilities". Grant funding prioritises rural areas, lower-income neighbourhoods and communities with low ratios of private parking and/or high ratios of multi-unit dwellings.

The US Inflation Reduction Act 2022 has also reinstated tax credits for EV charging stations (up to 30% of the cost or $100,000 per station), although these are closely targeted towards lower-income areas where EV accessibility tends to be more problematic. The tax credits are also contingent on meeting wage and apprenticeship conditions for the construction of charging stations (Parins & Schurle, 2022).

4.2.1 New Zealand context – funding

New Zealand's central and local governments differ from many of the jurisdictions described above.

For example, we lack relatively autonomous or well-funded states, provinces and territories like the US and Australian federal systems or Canada's provinces.

Local governments in New Zealand are not as well resourced as cities and councils in many other developed nations and generally have a narrower role (New Zealand Productivity Commission, 2019). Providing funding

for local EV charging rollouts may therefore be challenging. Local governments may wish to support EV charging through non-financial or revenue neutral/positive means such as providing flexibility in the planning environment and granting EV charger occupation permissions in a manner that recovers administration costs and/or is net revenue generating.

New Zealand also does not have a tradition of complex incentive and grant schemes like Australia and the US. However, EECA now does have a strong track record in administering funding for EV charging over several years, which policy makers could elect to build on.

4.3 Land-use and building regulations for EV charging

Governments overseas have recognised that land-use and building rules are an important enabler for the rollout of EV charging, be it through public or private investment.

The UK Government sees public charge points on local streets as a priority and is intending to set clear statutory obligations to develop local charging infrastructure strategies and oversee delivery for local governments. Work is also going to be done on how local planning instruments such as Permitted Development Rights and Traffic Regulation Orders could support charger rollout (Department for Transport, 2022). The UK has a significant number of drivers without access to off-street parking (particularly in cities) and is in the upper quartile of European nations for its ratio of on-street parking to off-street parking (European Parking Association, 2013).

Industry analysts in the US have observed that the approaches of different states and local jurisdictions toward siting EV stations vary widely:

> *Some jurisdictions have rushed to make their communities "EV-ready" by revising their building codes to make siting easier for the private companies that own charging stations. Other states, such as Florida and Missouri, have taken a quite different, protectionist approach favoring traditional gasoline stations.* (Lyman, 2023a)

Currently, US Congress appetite to pre-empt state and local rules is considered low, but it has acted in the past to create more favourable land-use regulations for cellphone tower placement under the US Telecommunications Act 1996.

In Australia, updates to the National Construction Code ensure that new buildings are designed, constructed and fitted out to enable the installation of renewable energy and EV charging. In the UK, all new homes with parking will have charge points installed at the point of construction. Similar requirements are being rolled out in Australia for non-residential properties (Department of Climate Change, Energy, the Environment and Water, 2023).

4.3.1 New Zealand context – land-use and building rules

New Zealand has national planning legislation that provides a framework for policy, planning and approvals at regional and local government levels. The framework also provides for national-level direction through national policy statements, national environmental standards, national planning standards and regulations.

Examples of national-level direction in force now include:

- national policy statements for renewable electricity generation and electricity transmission
- national policy statement on urban development
- national environmental standards for electricity transmission activities and telecommunications facilities
- regulations for forms, fees and procedures, and network utility operations.

The government has announced an intention to remove the requirement for resource consent for the installation of public EV chargers (Brown, 2024). There is not yet any publicly available detail on intended scope of this initiative or the mechanism.

4.4 EV charging network planning

Another important dimension to developing EV charging networks is spatial planning. Some jurisdictions have taken an interest in developing guidance to promote optimal charger placement:

- The Netherlands has developed placement policies for public chargers by regions and cities, which will be updated every 2 years (Netherlands Enterprise Agency, 2020).
- The Australian Government intends to develop a national mapping tool to support optimal investment in and deployment of EV charging infrastructure. The New South Wales Government has developed a masterplan map to help plan future NSW public EV fast-charging stations, supporting both industry and planners in finding ideal locations (Department of Climate Change, Energy, the Environment and Water, 2023).
- The UK Geospatial Commission is undertaking a discovery research project to explore how location data can be utilised to support planning and delivery of charge points by local authorities (Department for Transport, 2022).

4.4.1 New Zealand context – network planning

In New Zealand, there are many entities that are likely relevant to EV charging network spatial planning:

- Ministry of Transport – responsible for improving the overall performance of the transport system.
- NZTA – responsible for a land transport system that connects people, products and places, including national highways.
- EECA – supports EV uptake as part of its remit to promote energy efficiency and use of renewable energy, sets standards for EV charging equipment and provides funding towards strategically important parts of the EV charging network.
- Local government – New Zealand has 16 regional authorities and 67 territorial authorities that oversee local and regional environmental matters, public transport matters, roading and reserves, building consents and land use. Regional councils may be able to facilitate harmonised planning practices among the territorial authorities within their sphere of influence, as seen in Waikato Regional Council's guidelines for EV charging stations (Waikato Regional Council, 2023).
- Electricity distribution and transmission network owners – New Zealand has 29 EDBs and one national grid owner (Transpower), which manage the assets that transport electricity across the country from generators to end consumers.
- Land Information New Zealand (LINZ) – provides property and location information, manages Crown land and regulates overseas investment in New Zealand.
- CPOs – individual companies that operate (and in some cases develop) their own charging stations, which together make up the broader EV charging network.

Efforts to develop nationwide mapping tools to identify opportunities for the charging network will need to efficiently integrate inputs and participation from the above organisations, including complex datasets held by each organisation.

4.5 Standards for EV charging infrastructure

Standardisation in the EV charging sector is generally seen as beneficial across jurisdictions, ensuring that EV drivers receive a reliable and hassle-free user experience no matter where they travel.

In Norway, where the rate of EV uptake has been world leading, the associated rapid rollout of EV charging infrastructure has arguably suffered from a lack of basic standardisation:

> *There are a variety of public charging vendors to choose from in Norway, and therein lies part of the problem: customers find it inconvenient to maintain multiple mobile apps. And widespread system glitches—including limited options for direct payment, poorly designed parking spots, short charging cables, and malfunctioning hardware—frustrate customers and can heighten their anxiety over charger availability. In Norway's latest annual EV charging survey, half of respondents claimed that fast chargers occasionally do not work.* (Békés et al., 2023, p. 4)

The UK Government sees its role as that of setting "the right foundations for an equitable nationwide charging roll-out, removing barriers along the way" (Department for Transport, 2022, p. 3). As such, it will regulate to:

- ensure charge points are reliable and easy to use by placing requirements on open data, price transparency, standard payment methods and reliability
- make charge point design standards to improve accessibility for people of all abilities and improve signage
- make sure that the bulk of charging is smart off-peak charging where possible so that connection costs do not avoidably deter charge point deployment.

Within the EU, the alternative fuels infrastructure regulation imposes requirements such as (Boyle et al., 2024):

- CPOs having to allow EV drivers to charge on an ad hoc basis without contracts, registration and other obligations that go beyond "the mere purchase of the recharging service"
- from 2027, payment for charging along or near the Trans-European Transport Network (TEN-T) having to involve widely available methods such as card readers
- digital connectivity and smart charging capability (the latter for charge points built or renovated in 2024).

In Australia, federal, state and territory governments have agreed to work towards (Department of Climate Change, Energy, the Environment and Water, 2023):

- consistent standards and communications protocols for chargers and smart functionality
- a common mechanism for EV charger data sharing
- national service and installation rules
- streamlined network connection processes.

Federal funding under the US NEVI Formula Program sets minimum standards and requirements for projects in the areas of (Lyman, 2023b):

- installation, maintenance and operations
- interoperability of chargers with all widely available vehicle types
- traffic control and signage
- data, network connectivity, information on locations, pricing and availability
- accessibility
- reliability (24/7 accessibility, 97% uptime).

4.5.1 New Zealand context – EV charging standards

In New Zealand, NZTA provides guidance for EV charging infrastructure in relation to the national highway system[16] – signposting, parking enforcement regulations,[17] access to state highway land and so on. Local government authorities fulfil a similar role for local road networks.

EECA sets numerous technical standards for EV charging infrastructure as part of its role to regulate energy efficiency in appliances and set applicable standards alongside SNZ PAS 6010:2023 *Commercial electric vehicle (EV) charging*. WorkSafe (2020) has also outlined expectations for charging infrastructure from a health and safety point of view.

As a significant funder of public EV charging to date, EECA has set other expectations for public charging sites as a condition of co-funding such as site safety through pedestrian walkways and bollards, information provision to drivers (charging status, pricing and so on) and open payment services.

In line with its vision for nationwide coverage of fast-charging stations every 75 km across state highways, NZTA also sets minimum qualifying standards for inclusion in the network (and thus the EVRoam database of EV charging infrastructure) covering factors such as safety, reliability through real-time monitoring and 24/7 public access and interoperability for connectors and payment (NZ Transport Agency, 2024).

4.6 Promoting competition in the EV charging marketplace

A competitive EV charging marketplace is seen as highly desirable in most jurisdictions. Standardisation is complementary to this objective. For example, the Netherlands' charging strategy considers that open and competitive markets will be supported by charger interoperability, open protocols and other basic standards (Netherlands Enterprise Agency, 2020). Standardisation that promotes competition is also seen in the UK and EU requirements around price transparency and the ability to pay using commonly available methods.

The economics of EV charging facilities can be described as hyperlocal – for example, "the utilization of a charger located on the same block as a busy coffee shop or movie theater could be markedly different from that of a charger situated two blocks away from these locations" (Békés et al., 2023). This means identifying and securing the most viable sites early can confer significant competitive advantage on a CPO.[18] However, Norway's experience has shown that, due to the high level of unmet need for charging services during the country's rapid adoption of EVs, competition in the EV charging marketplace has remained relatively strong:

> *[A] clear leader has not emerged, particularly as the nascent market focused on meeting the needs of only early-adopting customers. Today, competition is intensifying as demand grows and customers' expectations become increasingly sophisticated, putting pressure on operators to deliver exceptional experiences.* (Békés et al., 2023, p. 4)

Jurisdictions have also taken care to ensure that strategic government planning and investment does not crowd out the private sector. This is seen in the UK Government's intent to scale back funding towards maturing parts of the EV charging ecosystem (private home charging and destination charging) and redeploy it towards those areas that are still facing reduced coverage, commercial barriers and/or regulatory barriers (local on-street charging infrastructure, private charging for rentals and/or high-density housing and

[16] But not exclusively the national highway system. Local RCAs are also included due to boundary issues such as when a state highway passes through an RCA township.

[17] In accordance with Land Transport Rule: Traffic Control Devices 2004, NZTA regulates parking signs, charging location signs, motorist service signs and road markings for reserved parking in relation to EVs and EV charging.

[18] This also means that CPOs that do not own land for prime sites may desire the ability to occupy them for relatively long periods as lease renewal periods pose a risk of losing occupation rights.

workplace charging in certain sectors) (Department for Transport, 2022). The UK Government is also interested in promoting greater innovation and new business models in the sector:

> *This could be through local community charging companies, longer-term on-street concessions, remote charging, cable guttering, lamppost chargers or peer-to-peer charging services.* (Department for Transport, 2022, p. 9)

4.6.1 New Zealand context – promoting competition

Like most other nations, New Zealand does not have a specific regulator assigned to the EV charging market. Larger sectors essential to societal wellbeing and the economy have specific regulators for finance (Financial Markets Authority), telecommunications (Commerce Commission under the Telecommunications Act 2001) and electricity (Electricity Authority and Commerce Commission under the Electricity Act 1992).

EV charging marketplace behaviour would fall under the general remit of the Commerce Commission to monitor and enforce fair dealings with consumers (under the Fair Trading Act 1986) and deter anti-competitive behaviour (under the Commerce Act 1986). The Commerce Commission also retains the ability to investigate the performance of any market via targeted market studies.

4.7 Information gathering, sharing and guidance on EV charging

4.7.1 Regulators, policy makers, planners and industry

Information on how EV charging networks are developing and performing is seen as important for regulators, policy makers, planners and industry participants in many jurisdictions.

In Australia, data sharing between state and territory governments is being established on vehicle and infrastructure-related information with the aim of understanding where EVs are charging and being driven, which will in turn inform what locations are most suitable for charging (Department of Climate Change, Energy, the Environment and Water, 2023).

The UK Government has shown significant interest in open data for the existing EV charging network and data that can support its efficient expansion (such as the identification of under-served areas), improved customer experiences and innovative services:

- "Standardised and consistent data is fundamental to stronger analysis and new product innovation … [such as] innovative geospatial applications and services to drive better decisions about [EV charging] rollout and ultimately improve the consumer experience" (Geospatial Commission, 2023, p. 9).
- "There is potentially untapped value in data held by the private sector to better inform chargepoint rollout" such as fleet movement data from major operators like car leasing companies and travel data held by mobile telecommunications providers (Geospatial Commission, 2023, p. 27).[19] Effective decisions about charge point rollout can be aided by richer information on how and when people are travelling as well as vehicle dwell times and locations. Suitably anonymising and aggregating such data to avoid breaches of privacy are of course considered an essential prerequisite.

[19] For example, "Aggregated and anonymised mobile network operator data is being used to help transport planners infer demand for [journey charge point hotspots in] Transport for Wales' Preferred Network modelling tool … Trips are identified by tracking the movement of individual devices based on pings between the device and cell tower and a dwell time threshold is applied to represent the gap between different trips being made by the same device" (Geospatial Commission, 2023, p. 34).

- "Knowing where current chargepoints are and their availability can help … decide where to install new chargepoints" (Geospatial Commission, 2023, p. 10). To this end, the Department for Transport laid legislation in 2023 to require CPOs to provide open access to static and dynamic data (location and availability) about their charge points using the Open Charge Point Interface (OCPI) standard. The government's intent is not to collect or hold the data centrally. Rather, CPOs must make the data they provide machine readable under OCPI, with changes to the charge point's availability updated within 30 seconds. The aim of OCPI is to accelerate the market for EV drivers through a single communication infrastructure connecting all market players, providing real-time information transparently to aid not just those planning for and monitoring the rollout of charging infrastructure but also EV drivers (or services designed to help EV drivers) in finding convenient places to charge. Earlier work in this area involved the National Chargepoint Registry,[20] which does not record real-time site usage data, unlike the 2023 UK legislation and NZTA's EVRoam database.
- In the absence of such regulation, charge point datasets would be accessible from third parties who have partnerships with operators, holding information such as location, connection type and maximum power. However, the government considers that this could be suboptimal as the data would be less findable, accessible, interoperable and reusable – not just for human consumers of the information but also electronic databases, software applications and so on.
- "The government is taking action to improve data access and sharing" concerning the availability of electricity network capacity and cost of new grid connections for EV charging infrastructure (Geospatial Commission, 2023, p. 10). In 2023, Ofgem published an Electric Vehicle Smart Charging Action Plan (Ofgem, 2023), which outlined expectations for distribution networks on making network data available.

4.7.2 Information and guidance for consumers

Information and guidance on EV charging networks is equally important (if not more so) for consumers driving an EV and/or considering purchasing an EV.

For example, the Australian Government is contemplating "tools and guidance to enable EV uptake for residents of existing multi-residential buildings" (Department of Climate Change, Energy, the Environment and Water, 2023, p. 4) – in other words, a segment of the population that wouldn't be able to charge at home very easily.

The UK has relatively comprehensive information available to the public on the EV charging network. For example, Zapmap[21] is a service that allows users to search the almost 60,000 public EV charging devices in the country. Zapmap has 1.5 million app downloads and 800,000 registered app users. The UK Government also monitors and publishes information on the EV charging network in partnership with players like Zapmap (Department for Transport, 2024).

However, consumer research undertaken in early 2024 in the UK shows that "charging remains a key barrier which needs to be addressed with both education, user experience improvements, and accelerated deployment" (Voxlin et al., 2024, p. 58) and that, although the statistics around the number of public chargers are clear, public concerns remain. The researchers advocate for fostering greater awareness around ways to address inability to charge at home as well as perceptions over lack of performance and cost of public charging. Most consumers were very unaware of the facts related to electric cars – just 7% of those surveyed knew that rapid EV charging often takes less than 30 minutes. Nearly two-thirds thought that rapid charging took well over an hour.

[20] See https://chargepoints.dft.gov.uk/login.

[21] See https://www.zap-map.com/.

This UK consumer research is supported by similar work from the US (Bestvater & Shah, 2024). About 60% of Americans live within 2 miles of a public EV charger. Notwithstanding the statistics on public EV charging availability and the possibility to charge at home for many, those who live closest to a public EV charger (and probably have some first-hand familiarity with the existence of the site) were much more likely to consider purchasing an EV. The researchers state (Bestvater & Shah, 2024, p. 4): "The vast majority of EV charging occurs at home, but access to [and dare we say, *perceptions* of access to] public infrastructure is tightly linked with Americans' opinions of electric vehicles themselves."[22]

Consumer concerns over the availability and performance of public EV charging (and often fast charging in particular) are likely the result of ICE vehicle-centric mental models. Recent research from Sweden and the US summarises this:

> *Novice EV users drew from their existing mental models for petrol refueling and misapplied them to EV charging. Most experienced users had developed new mental models … adapted to diverse rates of charge, EVs' longer energy filling duration [and] co-location of EV charging with certain user activities [such as at home, at destinations or during breaks in travel].* (Sprei & Kempton, 2024, p. 1)

The above examples underscore the need for developing public awareness about EV charging in general and the role of public charging networks within that. This is particularly important in the context of numerous instances of both traditional and social media failing to convey accurate information about EVs and, in some cases, spreading outright misinformation (Voxlin et al., 2024).

4.8 Specific case studies

4.8.1 Parallels with New Zealand telecommunications networks

Telecommunications networks provide several useful points of comparison with EV charging services, including similarities and differences. There have been multiple waves of investment in fixed and mobile public telecommunications networks in New Zealand (Newman, 2008):

- Fixed copper: Traditional telephone services, later adapted to provide broadband services. This evolved from the centralised telegraph system, which began from 1863. By 1965, New Zealand was third in the world for telephone density, with 35% of the population having a phone line. It was originally deployed by the New Zealand Post Office (a government monopoly), and Telecom New Zealand was formed as a state-owned enterprise in 1987 and privatised in 1990.
- Voice-oriented mobile: Telecom launched its first mobile services in 1987, gaining 2,000 early-adopter customers in its first year. Mobile provided a complementary service to fixed telecommunications, extending its utility and growing the market for telecommunications services. In 1993, BellSouth launched the first competing mobile network. By 1995, Telecom and BellSouth mobile networks reached 95% of the population. The networks used competing technologies and handsets were not interoperable. In 1998, Vodafone bought BellSouth, which had 130,000 mobile customers compared to Telecom's 500,000 customers. By 1999, Vodafone had nearly 400,000 mobile customers and Telecom had nearly 860,000. While competition had delivered investment, it was lower than the OECD average and focused on high-density areas. During this phase, mobile networks were primarily providing voice and messaging services and were not viable substitutes for (still developing) fixed broadband.

[22] Somewhat counterintuitively, the research also showed that range anxiety is perhaps as not so large a stumbling block to EV uptake: "[O]ur data finds that attitudes toward EVs don't differ that much based on how often people take long car trips" (Bestvater & Shah, 2024, p. 11).

- Data-oriented mobile: Telecom launched its 3G network in 2004, a year after Vodafone overtook Telecom for mobile market share. In 2006, the Commerce Commission introduced number portability for fixed-line and mobile numbers. Apple launched the iPhone 3G in mid-2008. In 2009, Telecom and Vodafone ramped up their rollouts of 3G networks as smartphone sales gained pace. 2degrees also began building its mobile network, and Telecom shifted to the GSM technology used by Vodafone due to its better support by handset providers and overseas networks.
- Social good investment: In 2011, government launched the Rural Broadband Initiative, awarding $300 million to a joint bid from Telecom and Vodafone to extend fixed and mobile broadband coverage to more premises. Rural and remote broadband initiatives continue to this day, now administered by Crown Infrastructure Partners,[23] which also operates investment programmes for rural capacity (where there is mobile coverage but towers are congested), mobile blackspots (covering state highways and 168 tourism locations) and marae (extending connectivity to 649 marae).
- Fibre broadband: As demand for data increased, overbuilding the copper network with fibre-to-the-home (FTTH) broadband became an increasingly realistic proposition. In 2009, it was clear that providers were not going to roll out FTTH at scale, and government began work on its ultra-fast broadband (UFB) initiative. Government set itself up, via Crown Fibre Holdings, to establish public-private partnerships to invest in FTTH. In 2011, Telecom elected to split off its fixed networks into Chorus, a separate wholesale-only listed company. Crown Fibre Holdings partnered with Chorus and three other local fibre companies to deliver the UFB programme, with the Crown providing tailored financing support and acting as principal to contract for rollout of FTTH communal infrastructure. The UFB initiative prompted significant changes in market structure that overcame reluctance of the incumbent to overbuild their own copper network. Today, mobile operators compete vigorously with fibre, and Chorus started shutting down parts of the copper network from 2022 (Ragunathan, 2022). The Commerce Commission is currently reviewing its regulation of legacy copper services (Commerce Commission, 2024d).
- Other notable developments:
  - Since 1990, successive New Zealand governments have appointed a minister responsible for telecommunications.
  - The Telecommunications Act 2001 introduced a comprehensive regime for the regulation of telecommunications services, including establishment of a dedicated telecommunications commissioner within the Commerce Commission.
  - The Telecommunications Act includes provisions for property access by telecommunications providers, and these were extended by the Telecommunications (Property Access and Other Matters) Amendment Act 2017 to facilitate fibre broadband installations.
  - National environmental standards for telecommunications infrastructure were introduced in 2008 and extended by the Resource Management (National Environmental Standards for Telecommunication Facilities) Regulations 2016. They provide a national planning framework for network operators to install low-impact infrastructure in road reserves without the need to apply for resource consent. The 2016 extension updated the original rules to reflect changes in telecommunications technology and equipment (including fibre).
  - As mobile networks have evolved, infrastructure sharing (ranging from access tracks through to sites and towers) between suppliers has emerged as a way to reduce costs and expand investment while preserving the benefits of competition. In recent years, Spark (Kilpatrick, 2022), One NZ (Brockett, 2022) and 2degrees (Saarinen, 2022) have all followed the international trend (Bosavage, 2020) of spinning out ownership and management of site infrastructure to separate ‘towercos’. Part of the

[23] See https://www.crowninfrastructure.govt.nz/.

rationale (Simmons, 2022) for vertical separation is to support investment in 5G mobile networks, which require site densification to deliver high speeds.

  - Government has had a role in mobile network rollout through its management of radio spectrum access rights. As the market has matured, government priorities have shifted between maximising Crown revenue, supporting competition in the market and supporting social good outcomes, including the economic benefits (Faafoi, 2019) that may flow from access to 5G mobile services and providing funding for rural connectivity (Radio Spectrum Management, n.d.).
  - Since 2011, government has levied telecommunications providers to raise funds for social good investment, including a relay service for deaf and hearing-impaired, broadband for rural areas and the 111 service (Commerce Commission, 2024g).

Our observation on points of comparison to EV charging services are as follows:

- Unlike EV charging, fixed telecommunications services involve rollout of contiguous networks. They have monopoly characteristics and have a single planner per geography (per technology). For EV charging, the contiguous network portions of the infrastructure (road and electricity networks) are already in place.
- Like EV charging, mobile services can be planned and rolled out by competitors. Each investor has taken on risks around technology choice and consumer preferences. However, government has also taken an interest in planning, including to monitor market performance and to identify areas where it will fund social good investment.
- Unlike EV charging, there was a single incumbent telecommunications provider in place for whom mobile was initially a complementary (revenue-expanding) service. That party had a clear incentive (and resources) to invest in mobile telecommunications. EV charging is an adjacency for electricity retail and a threat for liquid fuelling, and neither type of supplier dominates investment.
- Like EV charging, telecommunications investment has evolved through an interplay of market structure, supply technologies, user technologies (smartphones and EVs) and consumer preferences. Passive telecommunications infrastructure such as sites, towers, power supplies and ducts have been reused as the active components have been replaced, including due to their shorter physical lives and obsolescence.
- Like EV charging, there has been a hybrid of private and public investment (plus other government interventions) in fixed and mobile telecommunications infrastructure. Government has invested in ministerial, official and regulatory oversight of the telecommunications sector and has intervened with respect to market structure and conduct.
- Government has invested in social good telecommunications services, including rural and remote services and transport blackspots. This has included investment from Crown funds and arrangements for raising and investing dedicated funds (including through levies and spectrum proceeds).

Telecommunications resilience has gained attention in the aftermath of 2023's Cyclone Gabrielle (Speidel, 2023), which had a significant impact on multiple interdependent critical infrastructures, including roading, power, fixed and mobile telecommunications and petrol stations. This has prompted sector and government reviews (Department of the Prime Minister and Cabinet, 2023; New Zealand Telecommunications Emergency Forum, 2023) and renewed consideration of how to fund levels of resilience beyond what is delivered on a purely commercial basis.

4.8.2 Harnessing data in the United Kingdom

Transport authorities in the UK appear to be at the forefront of leveraging diverse data sources to support an efficient rollout of EV charging infrastructure.

England's Transport for the North (TfN) has developed an EV charging infrastructure framework[24] that consolidates, produces and displays geospatially numerous datasets that would interest investors in EV charging in the north of England such as:

- actual chargers by area
- forecast charging demand
- forecast journey charging stops
- forecast EV uptake.

TfN states its rationale for investing in this capability:

> *A key challenge for national Government, local authorities and the private sector is planning and delivering EV charging infrastructure with confidence. This needs to be based on the latest qualitative and quantitative evidence which considers the full range of influencing factors for EV charging, and encourages the right investment which delivers comprehensive EV charging solutions across the region. With its regional perspective, partnerships, and modelling capabilities, TfN is ideally positioned to develop an enhanced evidence base that considers the users' needs and movements across the region's road network.* (Transport for the North, 2022, p. 14)

TfN is taking a systems approach to EV charging infrastructure delivery and is seeking to integrate spatial planning, travel demand, EV uptake, charging behaviour and electricity network connection and supply datasets in one place.

TfN's data inputs underpinning its work are extensive and are segmented by region across the north of England. These include:

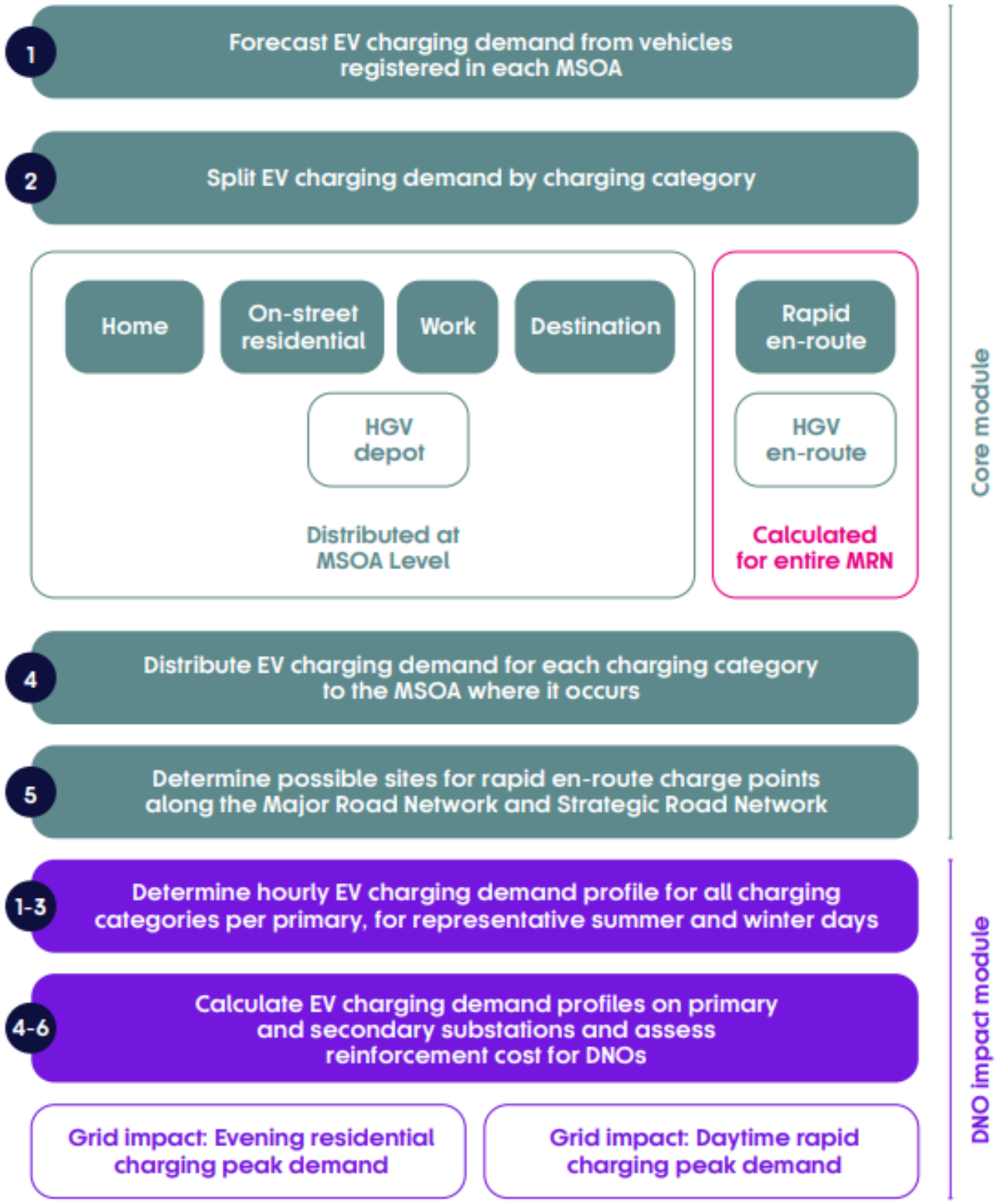
- population and households
- housing (flat, terraced, semi-detached, detached)
- employment (skill levels, employment status of residents)
- travel demand (origin-destination, mode, purpose, seasonal variation, time of day)
- vehicle flows on roads
- future travel scenarios
- EV uptake.

This data then allows TfN to make estimates about EV charging demand, where chargers may be required, impacts on distribution networks and so on (Figure 4.1). This highly data-driven process supports an efficient EV charging network in some distinctive ways:

- It promotes a whole-network view that identifies regions that may be left behind or given lower priority if left solely to market forces absent better data (as private sector investors tend to focus on the most obviously commercially attractive sites).
- The whole-of-system view also recognises the importance of and promotes a diverse charging ecosystem. In addition to fast journey charging needs, the framework can also provide guidance on the desired density of residential and destination charging in different areas.

[24] See https://evcivisualiser.z33.web.core.windows.net/.

Figure 4.1 An illustration of TfN's EV charging infrastructure framework (reprinted from Transport for the North, 2022, p. 63)



4.8.3 Network resilience

As EV uptake grows and more drivers become reliant purely on EVs for their regular travel habits, the resilience of the EV charging ecosystem will become increasingly important in the face of natural disasters, weather events and other emergencies or disruptions.

Public policies worldwide regarding emergencies consider the fuel supply chain for fossil fuel vehicles but are largely silent on EV charging (Hussain & Musilek, 2022). New Zealand is no exception – the National Civil Defence Emergency Management Plan Order 2015 requires lifeline utilities to (among other things):

- ensure they are able to function to the fullest possible extent, even though this may be at a reduced level, during and after an emergency
- make available their plans for functioning during and after an emergency
- participate in the development of the national civil defence emergency management strategy and civil defence emergency management plans.

However, the definition of a lifeline utility does not expressly contemplate EV charging. Examples of lifeline utilities in the National Civil Defence Emergency Management Plan Order are water supply; wastewater and stormwater collection; electricity, gas and petroleum distribution; and telecommunications, broadcasting and transportation networks, including roads, railways, airports and ports.

The literature, albeit largely theoretical and high level, discusses ways in which the functionality of EV charging infrastructure in emergencies can be improved and optimised at various stages from pre-event to post-event (Hussain & Musilek, 2022):

- Pre-event planning: Consideration should be given to on-site battery energy storage and renewable generation (such as solar PV) at EV charging stations since this can reduce their reliance on the electricity network. Further consideration could be given to right sizing generation and storage to improve uptime through credible emergency scenarios. However, we note that the addition of local generation and storage at an EV charging site could add considerably to the cost structure of a CPO, which may warrant discussion between local electricity networks,[25] local government, central government and CPOs. Emergency plans should also consider how EV users would be expected to charge their vehicles ahead of an impending event, either ahead of an evacuation or fuelling up to shelter in place. The implied wait times and/or power system demand may identify supply-demand gaps to address.
- During events: While it is generally accepted that infrastructure may perform increasingly poorly during an emergency, planning around EV charging infrastructure should consider how priority is given to certain EVs (those associated with essential services or those lowest on charge) and/or how energy is rationed among customers if need be. Electricity networks should also be aware of major EV charging sites and evaluate their priority to remain energised over other loads and locations.
- Following events: EV charging stations should be suitably prioritised for reconnection during electricity restoration exercises. Electricity networks should also consider the ways in which EV charging sites can support post-event recovery operations through on-site generation, on-site battery storage and vehicle-to-grid technology.[26]

[25] Electricity networks may be able to procure flexibility services from such distributed energy resources to optimise network investment and operations. This would create added incentives for CPOs to invest in such technologies beyond improving the resilience of their sites to emergency events.

[26] We note again that, if such power system services are appropriately valued and compensated, they could create incentives for CPOs to invest in the necessary technologies. This would bolster not just the resilience of individual EV charging sites but also that of the wider power system. Procuring services to support post-event recovery is not unprecedented in the electricity sector. For example, Transpower in its role as national power system operator formally procures black start ancillary services to liven the power system following major blackouts.

It is interesting to note that what constitutes an event that challenges the resilience of the EV charging network may be somewhat counterintuitive. For example, EV charging networks have sometimes come under pressure during periods of extremely cold weather, even when electricity supply and CPO operations have been maintained. This is because EV batteries tend to deliver less range and charge more slowly at low temperatures. Many EVs low on range have thus descended on charging stations in the cold, with lengthy charge times causing cascading delays for other drivers needing to charge. This issue was recently observed during the aftermath of a major snowstorm in the US Midwest (Toussaint, 2024). Conversely, Norway's EV drivers and EV charging networks have routinely weathered patches of extreme cold reasonably well. This is attributed to EV drivers being more knowledgeable about the need to maintain their batteries at suitable temperatures and above minimal charge levels in cold weather. Many Norwegian EV drivers keep their cars parked under cover during cold weather or even warm up their vehicles while connected to a private charger before setting off on a long journey.

The dependence of EV charging networks on the electricity system's resilience is self-evident. However, like many other services, EV charging stations are often dependent on another lifeline utility – telecommunications networks. This is because most EV charging stations rely on wireless or wired broadband connectivity to collect payment either via mobile app or card reader, among other functionalities. When Telstra experienced a major outage affecting both fixed and mobile broadband nationwide, this affected the reliable operation of CPOs on their network (Lawler-Cass, 2024).

Despite the evident reliance of EV charging networks on electricity and telecommunications, it is not clear that EV charging would necessarily be materially less resilient than comparable infrastructure that we are all familiar with today. For example, post-Cyclone Gabrielle, many petrol stations struggled to function without fibre communications and inaccessible roads prevented them from being resupplied in a timely fashion (Webb-Liddall, 2023). Other petrol stations lacked backup generation and could not operate until power was restored to them (Pennington, 2023).

The fossil fuel industry value chain is (understandably and justifiably) also structured in a way that motorists are reliant on relatively centralised public fuelling sites. If, following a regional emergency, many of these key sites are incapacitated or not able to be supplied with fuel, this may require motorists to travel long distances (roading network permitting) to fuel up. However, if an EV charging network evolves according to the model described in section 3.2, charging choices – especially due to private and destination charging – become much more distributed and diverse than fuelling for ICE vehicles. For example, a study looking at the flood risk to London's EV charging infrastructure acknowledged that the (widely dispersed) private chargers in the city faced very different flooding risks to public chargers (Raman et al., 2022).

4.8.4 Kerbside charging in the US

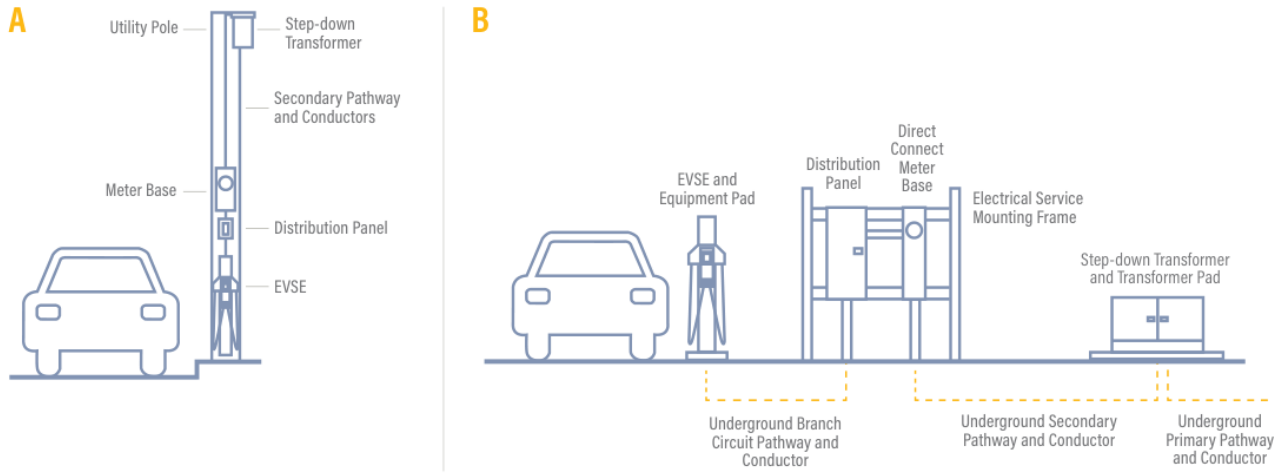
As discussed in section 3.2, private and destination charging are essential parts of the EV charging ecosystem. If these market segments are sufficiently developed, they will alleviate demand on the fast journey charging network, which tends to be the most expensive per port and most prone to congestion.

However, not all those contemplating an EV will have access to private charging at home or at work. On-street, kerbside EV charging is an emerging category that could help bridge this gap and drive EV adoption from early adopters towards the early majority of car drivers. For this to occur, kerbside charging needs to be low cost and relatively straightforward to roll out. Many players will also need to come together in unison – local authorities, electricity utilities, CPOs and so on.

Kerbside charging is a growing area of focus in the US given less than 40% of households are equipped with EV-compatible charging capability such as a 240 V power connection in a garage (Simović et al., 2022). Pole-mounted chargers (PMCs), which involve tapping into an existing electric service like a streetlight or power pole, are showing promise as a way to provide on-street charging (Figure 4.2). Such poles are

relatively common in areas where people reside or work. PMCs can also be 55–70% cheaper to deploy than a greenfield installation (Werthmann & Kothari, 2021) and do not require invasive construction work or significant additional space.

Figure 4.2 PMC infrastructure (A) versus typical EV charging infrastructure (B) (reprinted from Werthmann & Kothari, 2021, p. 8)



A downside of PMCs connected to streetlights is that such connections may only support slow rates of charge. US streetlights are usually powered by a 120 V connection, which would only support ~1–2 kW of (level 1) charging output. However, in Europe, Australia and New Zealand, 220 V power supply makes this issue much less pronounced. Future streetlight conversions to LED lighting are expected to create additional spare capacity for PMC loads. The conversion programmes themselves will also offer opportunities to deploy PMCs efficiently at the same time (Simović et al., 2022).

Some cities such as Los Angeles and Kansas City have also succeeded in upgrading streetlight PMC capacity relatively inexpensively (Werthmann & Kothari, 2021). In Los Angeles, the streetlight cabling conduits were able to support a 240 V supply and so a second live wire was added to support PMC deployment. In Kansas City, some PMCs were able to be fed with a 240 V supply line from a nearby control box or transformer.

In contrast to streetlights, many US electric utility poles could support as much as 3–19 kW of (level 2) power output for EV charging without upgrades (Simović et al., 2022).

PMC deployments are planned or under way in seven US cities, albeit at (initially) relatively small scales ranging from handfuls to hundreds (Simović et al., 2022). Vertical integration of electricity distribution and retail in many US jurisdictions makes it easier for PMC rollout to occur in some ways. Electric utilities can easily coordinate site assessment, installation and maintenance for EV charging infrastructure in tandem with their existing investment and maintenance programmes for power poles and, where applicable, electric utility-owned street lighting. Charging for power sold through a PMC by the owner of the pole would also be permitted where vertical integration exists and the distributor is also a (sole or incumbent) retailer.

Conversely, mounting charging stations on a pole sometimes requires an encroachment permit or right of way from a local authority, which can be costly and time-consuming relative to the low capital cost, low installation cost and rapid deployment timeframes of PMCs (Werthmann & Kothari, 2021).

4.8.4.1 PMCs outside the US

Kerbside charging has also gained interest outside of the US.

The New South Wales Government has recently announced a first round of EV kerbside charging grants for over 600 charging ports (NSW Government, 2024). Grant recipients are a relatively diverse group representing both local councils and CPOs with different business models – for example, JOLT is a CPO that offers free and/or reduced cost charging to drivers supported by advertising.

The UK has also made significant strides with PMCs. London alone had over 3,500 streetlight chargers in 2021 according to one source (Werthmann & Kothari, 2021). Today, the number is likely to be over 8,000, according to Ubitricity (2024), one of the largest CPOs in the UK.

London Councils (the collective of local government in London comprising 32 boroughs and the City of London) together with Transport for London have developed guidance for boroughs seeking to provide EV charging facilities for residents (Transport for London, 2024). The resources include advice on:

- securing public funding such as through the Local EV Infrastructure Fund discussed in section 4.2
- obtaining private funding through loans, bonds, property developers and other public-private partnerships
- streetscape and accessibility considerations for on-street charging infrastructure
- procurement of EV charging infrastructure.

The above factors have created a supportive environment for boroughs to work with private EV charging firms like Ubitricity to roll out PMCs.

5 Literature survey – information

This section discusses three types of literature relevant to the following information sections of this report:

- EV charging infrastructure – relating to EV charging infrastructure and either addressing information needs directly or serving as examples of the use of information relevant to EV charging.
- New Zealand information – key sources discussing New Zealand information topics.
- General information – papers dealing with general information topics.

5.1 EV charging infrastructure

Several international papers discuss approaches to dealing with information or information availability and usage in other countries. Bernard and Hall (2021) look at local government planning implementation of civic charging infrastructure with insights from Amsterdam, London, Oslo, Paris and Stockholm. The paper:

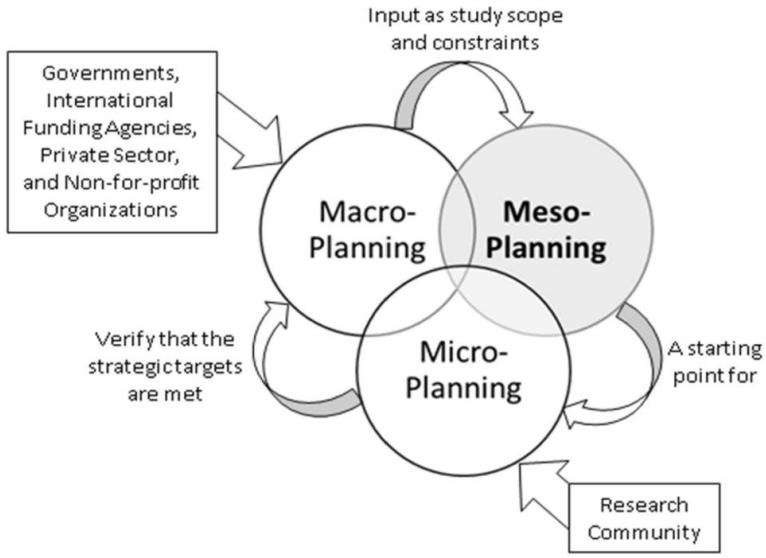
- highlights the impact of soft costs on charger delivery, including due to the time taken up by communication between stakeholders
- discusses obstacles relating to information held by stakeholders but not made available
- contrasts demand-driven, planning-oriented and business-oriented approaches where demand-driven refers to an approach where public funding is triggered by user requests
- provides best-practice recommendations for cities working with stakeholders (Figure 5.1).

Figure 5.1 Best practice recommendations to deploy EV charging (reprinted from Bernard & Hall, 2021, p. 12)

Stakeholder	Primary contribution(s)	Best practices for city engagement
Grid operator	• Provide a heatmap to identify energy grid constraints and locations with suitable charging capacity and easy grid connection. This map should be dynamic, searchable, and regularly updated. This map can also show where upgrading will be done due to other projects in the area.[a] • Provide a guide on how to fill out a request for grid connection.	• Contact grid operator(s) early in the process to ask for the heatmap mentioned on the left. • Identify one point of contact or an "EV-expert" team to deal with stakeholders' questions and requests for grid upgrade and connection.
City agencies (city planning, transportation, engineering, public works)	• Provide a map of pre-selected areas where charging station deployment would be immediately approved. These include locations with no or limited accessibility issues, other projects underway, conflicts with underground utilities, or conflicts with city goals such as historic district preservation.[b]	• Engage with all public agencies that own land on which publicly accessible charging stations could be implemented (e.g., housing, parks, schools, transit, healthcare).
Private landowners and businesses (retail stores, publicly accessible car parks, fueling stations)	• Request to display their land on the map showing suitable charging station locations if they are interested in installing either AC regular or DC fast publicly-accessible chargers on their property.	• Match private landowners with operators if the planning-oriented approach is chosen. • Establish a list of information required for a private landowner to be matched with a charging station operator. This list would include the number, type, and exact location of chargers, and business model desired.
Charging station operators	• Provide information on charging stations type, location, and utilization data. • Ensure interoperability of their charging stations and ability to pay with any means of payment.	• Require that charging station operators provide access to data in order to inform their decision-making process. This could be done in exchange for the right to operate, especially if the station is located on public land. • Require interoperability of the charging stations and the ability to pay with any means of payment.
Taxi, ride-hailing, and car sharing companies	• Provide information on fleet electrification rate, pick up and drop offs locations, drivers' residence location and home charging accessibility. • Potentially provide funding to ensure drivers' access to charging infrastructure.	• Engage with companies to discuss charging stations locations and fleet electrification goals.
Public	• Join EV driver associations to voice your opinion, needs, and concerns. • Engage with city regarding proposed charging station installations. • Suggest a charging station location.	• Engage with the community to hear their concerns and answer their questions. • Adopt a demand-driven approach or allow electric vehicle drivers to suggest a charging station location to know where to install charging stations. • Clearly communicate on EV-related programs and raise public awareness.
Other levels of government (national, regional, metropolitan)	• Coordinate to ensure a cohesive regional network. • Provide funding.	• Engage with them to discuss policies and financial incentives, and ensure interoperability of the network.

Torkey and Abdelgawad (2022) discuss the distinction between micro-level, meso-level and macro-level planning (Figure 5.2) and present a framework for meso-level planning based on lessons learned from 25 cities with very high EV penetration and as a practical starting point for cities.

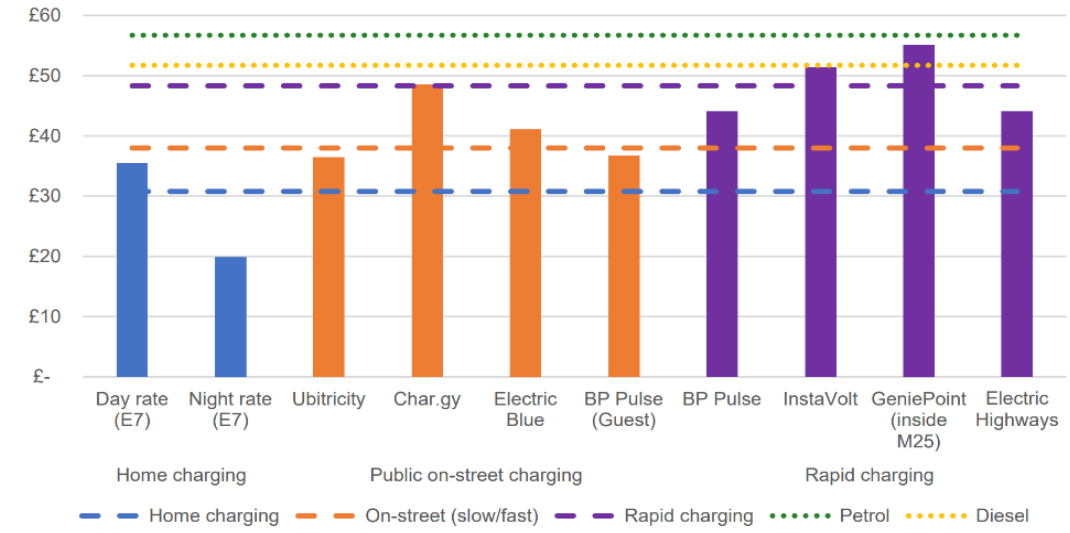
Figure 5.2 EV charging services deployment planning (reprinted from Torkey & Abdelgawad, 2022, p. 194).



Wood et al. (2023) provide an example of a modelling exercise at a national level that has drawn on a good base of US information to produce projection of EV charger demand and related insights. The paper reports on modelling using a suite of tools that are publicly available.

Competition and Markets Authority (2021) provides an example of analysis focused on performance of the UK market for charging services rather than on planning. Appendix E of its report details information used for analysis (public and private datasets, confidential business plans and costing information from suppliers and information gathered through public consultation. It also provides examples of analysis outputs (Figure 5.3).

Figure 5.3 Analysis of total monthly cost of in-home, public on-street, rapid charging and petrol/diesel (reprinted from Competition and Markets Authority, 2021, p. E5)



Note: Dotted lines indicate weighted averages for public on-street and rapid charging, standard electricity average price for home charging, and average diesel/petrol prices.
Source: CMA analysis of Zap-Map data, 26 February 2021. Chart is based on Table 1 and includes only PAYG options and excludes ultra-rapid charging.

5.2 New Zealand information

New Zealand literature reviewed includes transport sector information, EV and CPO market information, energy sector information and discussion of data and information more generally.

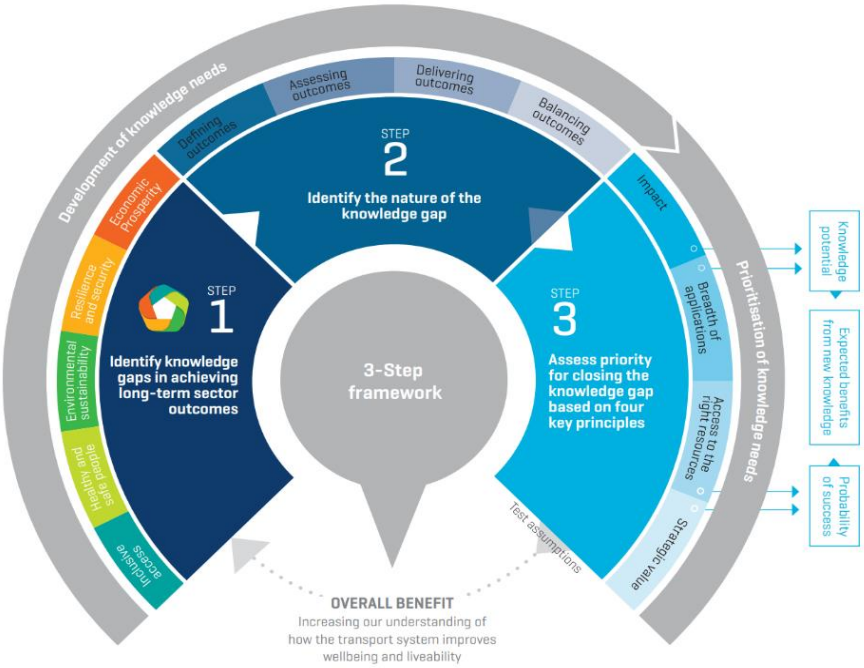
5.2.1 Transport sector information

The Ministry of Transport provides New Zealand's main sources of transport data (Figure 5.4) and has published strategic documents on transport data, including a a Transport Evidence Base Strategy (Ministry of Transport, 2019) that provides a knowledge development and prioritisation framework (Figure 5.5).

Figure 5.4 Transport data and sources (reprinted from Williams et al., 2023, p. 3863)

Description	Source (s)
VKT by vehicle and fuel type	Annual vehicle fleet statistics report (Ministry of Transport, 2019a)
Vehicle occupancy	Transport indicators (Ministry of Transport, 2019b)
Aircraft pkm	Air travel statistics and modelling (Cross and Wang, 2014)
Rail passenger activity	Transport indicators (Ministry of Transport, 2019b)
Freight activity and modal shares	National freight demand study (Deloitte and et al., 2014)
Energy intensities	Tiwari and Gulati (2013) and Technical Research Centre of Finland Ltd (2017)

Figure 5.5 Ministry of Transport prioritisation framework (reprinted from Ministry of Transport, 2019, p. 19)



Definitions:

- **Inclusive access** — Enabling all people to participate in society through access to social and economic opportunities such as work, education, and healthcare
- **Healthy and safe people** — Protecting people from transport-related injuries and harmful pollution and making active travel an attractive option
- **Environmental sustainability** — Transitioning to net zero carbon emissions and maintaining or improving biodiversity, water quality, and air quality
- **Resilience and security** — Minimising and managing the risks from natural and human-made hazards, anticipating and adapting to emerging threats and recovering effectively from disruptive events
- **Economic prosperity** — Supporting economic activity via local, regional, and international connections, with efficient movements of people and products

- **Defining outcomes** — Identifies and defines the outcome to pursue
- **Assessing outcomes** — Identifies how the outcomes might be best assessed
- **Delivering outcomes** — Identifies the best intervention(s) to secure improvements or to close any gaps to the desired state
- **Balancing outcomes** — Identifies the appropriate balance and trade-off between outcomes and efforts

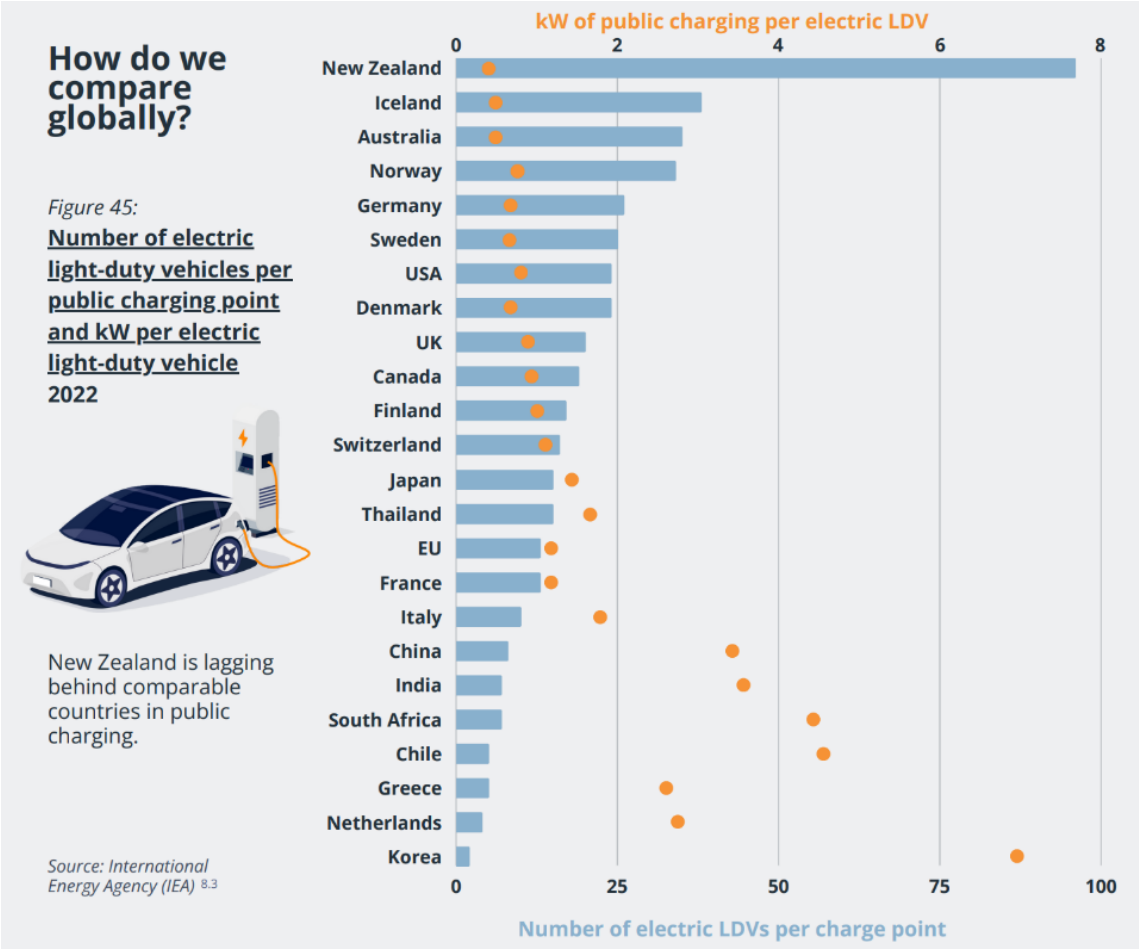
- **Impact** — Assessing the extent to which current knowledge can be advanced
- **Breadth of applications** — Assessing the extent to which the new knowledge can be spread and absorbed across the wider sector and applications to help build sector capability
- **Access to the right resources** — Assessing whether there is access to the right capacity, capability, tools, data, systems and financial resources (eg through better sector integration) to close the knowledge gap
- **Strategic value** — Assessing whether the new knowledge can be used to help address the strategic issues faced by the sector

- **Knowledge potential** → Size and breadth of benefits
- **Probability of success** → Extent to which the new knowledge can be translated into tangible outcomes

5.2.2 EV and CPO market information

Drive Electric (2023b) provides accessible reporting from EECA information and other sources (Figure 5.6).

Figure 5.6 Drive Electric published a public-facing report in 2023 on EVs that included information on EV charging (Drive Electric, 2023b, p. 42)



EECA maintains dashboards, publishes information on its funding rounds and provides a range of analysis, standards and reporting. EECA provides a wealth of information, including quantitative and qualitative – for example, consumer research exploring EV purchase decisions and charging behaviours (Figure 5.7).

Figure 5.7 Example of EECA research on consumer perceptions (reprinted from EECA, 2023b, p. 20)

Public Charging Barriers

Barrier	%
Having to queue/ wait for a charger	55%
Cost to charge	36%
They aren't located in convenient places where I'm passing / going	29%
It takes too long to charge	17%
There aren't any near enough to me	16%
Concerned about degrading battery through a fast charging network	13%
No room at public chargers when towing	10%
They're not all compatible with my ev	9%
I don't always know where to find them	9%
Concern about safety	4%

5.2.3 Energy sector information

Energy sector information includes material from government, regulators and suppliers. Transpower provides useful planning and analysis in its dual roles as grid planning and system operator. An example is its annual planning report, which discusses industry trends and provides planning information for New Zealand's grid backbone and 13 grid regions (Transpower, 2023).

For regulators, the Electricity Authority and Commerce Commission both provide information repositories to the public:

- The Electricity Authority's Electricity Market Information (EMI) website[27] provides access to granular sector data, reports and modelling tools. The EMI website includes data and information sources from service providers (such as clearing manager data), subscription data services (such as hydro data and ASX futures), market participants (such as disclosure requirements) and the Electricity Authority itself (the Registry).
- The Commerce Commission provides website access and downloadable databases of information disclosed by EDBs (Commerce Commission, 2024e). It also recently reviewed disclosure requirements on EDBs (under Part 4 of the Commerce Act) to ensure sufficient information was available to assess EDB performance in a changing environment. It decided to expand reporting requirements on EDBs relating to network constraints, geospatial data and pricing information (Commerce Commission, 2024f).

5.2.4 Government data and information

Other government agencies provide a range of relevant information or perspectives on information topics.

The Government Data Strategy and Roadmap (data.govt.nz, 2021) outlines principles for government to use to monitor and report on the health of the government data system.

The Public Service Commission has also set out expectations for government gathering information associated with regulatory compliance, law enforcement and security functions (Public Service Commission, n.d.). Its model standards for information gathering by government are developed within the context of the legislative framework of each agency's own legislation and responsibilities under the Privacy Act 1993.

Audit New Zealand published its 2023 report on insights from its reviews of local government long-term planning, which includes a section focusing on quality of asset information. It noted that limited good-quality asset information can lead to underfunding, poor renewals forecasts, unplanned costs, increased risk of asset failures and reduced levels of service (Audit New Zealand, 2023).

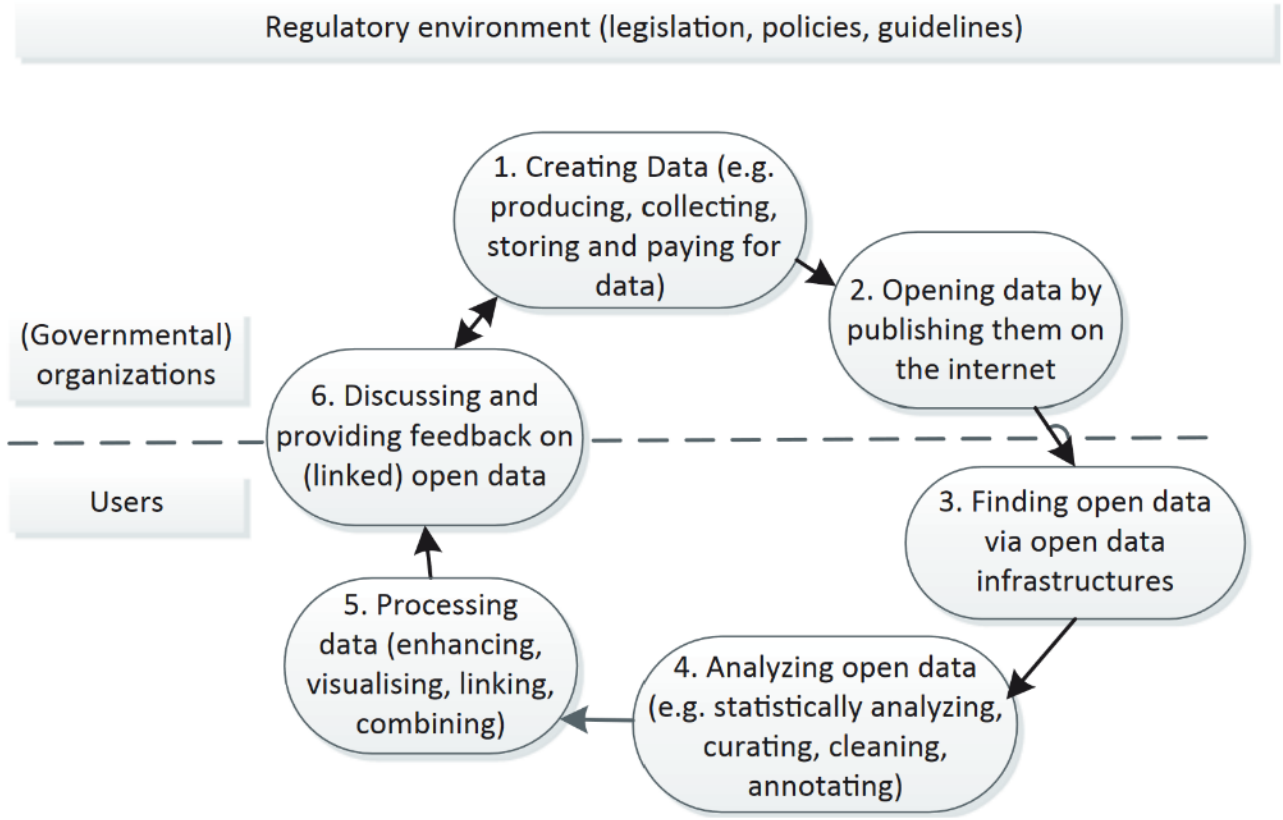
5.3 General information

Finally, there is a body of literature dealing with information generally, including material focused on open data.

Zuiderwijk and Janssen (2014) considered barriers and development directions for open data and discussed a process view of open data, highlighting the respective roles of government, data creators and data users (Figure 5.8), which was then used to identify technical and social barriers at each process step. Another example is Chen et al. (2022), who report on empirical confirmation of a relationship in financial markets between the cost of information collection and the quantity and quality of data collected (by financial analysts) about firms. The paper highlights the importance of soft (subjective and contextual) information in improving the quality of analysis.

[27] See https://www.emi.ea.govt.nz/.

Figure 5.8 Process view of open data development (reprinted from Zuiderwijk & Janssen, 2014, p. 119)



6 Information gaps

This section examines information needs associated with charging services and identifies information gaps. From this base, we then recommend a prioritised set of information improvements that could assist with ensuring effective and efficient EV charging infrastructure.

6.1 Information needs

To assist with identifying information needs, we have used our functions framework to identify key questions. We then consider the information needed to answer those questions.

6.1.1 Key questions

As set out in Table 6.1, we have identified key questions that drive information needs for each function in the market for charging services. We have considered information needs against functions that align with our framework with the following modifications. We have:

- added policy and monitoring roles – our functional framework focuses on the supply chain, but government agencies also have roles (regardless of their involvement in delivery) to monitor markets and determine policy settings
- consolidated funding and building – although they can be carried out by different actors, these functions have similar information needs.

Table 6.1 Key questions drive information needs for each function in the charging services market

Function	Who?	Why?	Key questions
Policy and monitoring	Government, including regulators	To promote New Zealand's economic and social wellbeing (The Treasury, 2019)	• How is the market performing? • Is intervention warranted?
Planning	Suppliers and government	To determine the best available option for meeting demand	• What will demand be? • What is the best option to meet demand?
Funding and building	Suppliers, lenders and investors	To expand supply	• What will the facility cost? • What will the facility earn?
Operating	Suppliers	To sustainably deliver valued services	• Are services meeting consumer needs? • Are services profitable?
Demand	Consumers	To travel	• How will I charge my vehicle?

Below we discuss each function in more detail and identify information needs associated with key questions.

6.1.1.1 Policy and monitoring information needs

At a high level, these are the key questions for government (in its policy role) to understand:

- How is the market performing?
- Is intervention warranted?

Government has direct and indirect interests in how the market is performing:

- Direct interest: Charging services represent a growing area of economic activity serving a growing number of consumers. Government has also contributed funding to charging services and set various goals for the supply of charging services.

- Indirect interests: Charging services impact the transport system and contribute to emissions reduction goals (by supporting EV uptake). They are also an important contributor to electrification of the economy so have an impact on energy systems.

Where government identifies issues with market performance, it may wish to evaluate intervention options and assess whether these could improve performance and may wish to evaluate the effectiveness of implemented interventions. Information needs for this purpose may vary, but we have considered common information requirements.

Many aspects of market performance may be of interest, often to different government agencies:

- NZTA's interests (NZ Transport Agency, 2021) include:
  - advancing its primary objective to contribute to an effective, efficient and safe land transport system in the public interest
  - managing the state highway network
  - prioritising use of the National Land Transport Fund in a way that is consistent with the government policy statement on land transport.
- The Commerce Commission's interests (Commerce Commission, 2023b) include ensuring that:
  - New Zealanders receive the benefits of competition: greater value, innovation, productivity and choice
  - consumers, including businesses, are informed, empowered and their interests are protected
  - consumers of essential services (including electricity network services) are not disadvantaged by a lack of competition.
- The Electricity Authority's interests (Electricity Authority, 2023b) include:
  - to promote competition in, reliable supply by, and efficient operation of, the electricity industry for the long-term benefit of consumers.
- The Climate Change Commission's interests (Climate Change Commission, 2023b) include:
  - providing independent, expert advice to the government on mitigating climate change, including through reducing emissions of greenhouse gases
  - monitoring and reviewing government's progress towards its emissions reduction and adaptation goals.

There are two common needs for monitoring and policy:

- A reference view of what good looks like, for example, in terms of charger coverage and capacity, congestion levels or pricing: This can be high level (number of journey chargers per EV) or more detailed (a full reference plan for the number, type and location of public chargers). A reference view provides a point of comparison for actual outcomes, which can help with diagnosing market performance.
- Quantifying costs and benefits (cost-benefit analysis): This is an analytical task, which in turn can benefit from a range of information. At a high level, the analytical task involves:
  - establishing the logic that links the proposed intervention to the expected benefits – for example, financial support will mean more charge points, which will both increase transport system resilience and reduce EV purchase hesitancy, which will lead to greater EV uptake, which will in turn reduce transport costs, emissions costs and health costs
  - quantifying the strength of the above relationships – for example, how much resilience will improve and how much charger supply and EV uptake will increase
  - quantifying the value of the benefits.

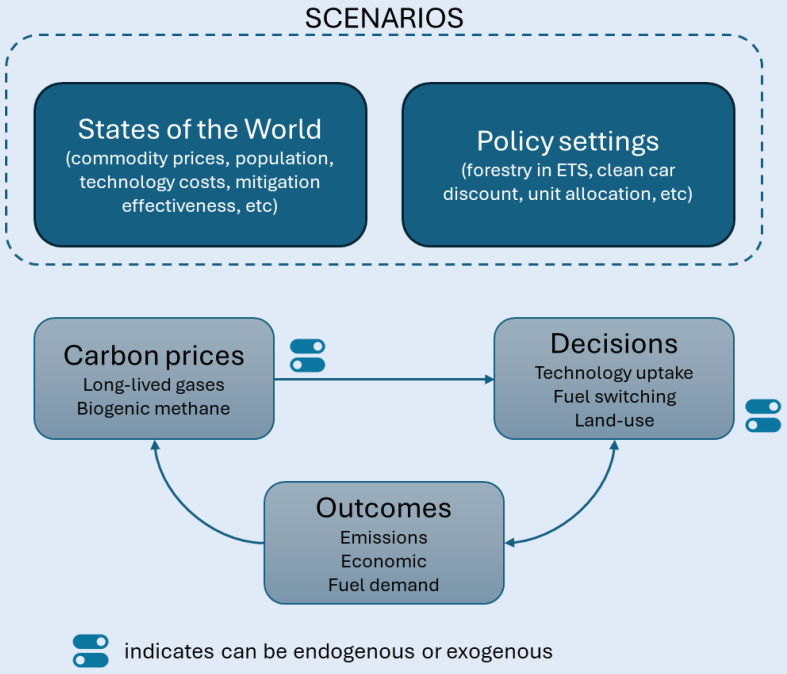
The first two cost-benefit analysis steps above rely on market knowledge and depend on the nature of the planned intervention. Broadly, interventions can include:

- funding – such as grants or financing (loan or equity)
- other financial incentives – such as tax credits or accelerated tax depreciation
- obligations – such as information sharing, co-location, equipment standards or interoperability requirements
- barrier removal – such as changes to resource planning or network connection requirements
- supply – such as making public land available or providing site infrastructure.

Benefits quantification can rely on a mix of qualitative assessments and quantitative modelling. Many of the relevant benefits are captured in the ENZ model developed for the Climate Change Commission and Ministry for the Environment (Concept Consulting, 2021). ENZ is a whole-economy model that projects the economic and emissions outcomes for the sectors in the economy that produce emissions and allows users to model the likely impact of various policy interventions. Figure 6.1 provides a general description of ENZ's operation.

Figure 6.1 ENZ model generates insights on impact of various drivers on economic and emissions outcomes

ENZ projects economic and emissions outcomes of emissions-intensive sectors of the New Zealand economy and provides insights into how outcomes may be impacted by different states-of-the-world drivers and policy settings.



ENZ projects decisions that will drive economic and emissions outcomes such as whether households buy an EV or ICE vehicle or landowners switch from farming to forestry. In many areas, these decisions can be modelled endogenously driven by price signals decision makers face for the given scenario parameters (such as relative EV versus ICE purchase prices). In other areas, decisions are exogenously specified given current lack of information on key drivers (such as the cost of zero-emissions aircraft). Areas that allow for endogenous decisions can also be exogenously specified.

Modelled outcomes span items such as electricity demand, landfill gas emissions and milk production. Crucially, outcomes from various sectors are interlinked to capture material feedback loops that can occur across the economy. For example, fuel switching from fossil to electric options increases electricity demand, driving the need for electricity generation and network investment, which increases electricity prices and in turn slows the rate of fuel switching. ENZ solves for these effects each year and feeds outcomes into the following year – it is a dynamic recursive model.

Carbon prices are a key feature of the model and can be specified exogenously or determined endogenously by solving for the price that will deliver a given emissions objective. ENZ also has scenario functionality that allows users to test and compare how outcome vary across different states-of-the-world assumptions or policy settings.

ENZ has a transport module that, among other things, models uptake of EVs for the different categories of the light and heavy road fleet. This functionality allows exploration of the potential impact of different policies that may affect the incentives on consumers to purchase an EV or an ICE vehicle. As well as functionality to explore the effect of policies such as the Clean Car Standard, Clean Car Discount and RUC options, functionality has been developed to explore the potential effect of different extents of public charger provision on vehicle purchase choices. However, this relies on high-level assumptions as to the relationship between charger availability and EV uptake rates. There is limited empirical data on the strength of such relationships let alone how they may vary with other factors (such as relative purchase cost of EVs and ICEs). ENZ's scenario functionality allows for testing the sensitivity of outcomes to the strength of this relationship.

The integrated, whole-economy nature of ENZ allows for flow-on effects of different levels of EV uptake to be properly modelled, including the extent of generation operation (renewable and fossil) and network build and the consequent effects on electricity prices, which affect EV uptake rates in an internally consistent fashion.

In addition to the standard economic costs of vehicle decisions (capital costs, non-fuel operating costs, petroleum costs, electricity costs), ENZ projects emissions impacts, including carbon emissions, and the human health consequences from ICE tailpipe emissions.

Within this context, Table 6.2 identifies potential information requirements for policy and monitoring, noting actual needs depend on the role government plays and interventions it chooses to evaluate or implement.

Table 6.2 Information needs for policy and monitoring

What?	Why?	Comment
How is the market performing?		
Public charging asset information, including: • location • capability • commissioning date.	To understand the physical network of charging sites and appliances as it stands today and how it has evolved to date.	Basic information to understand the assets that underpin charging services delivery.
Public charging investment pipeline information, including: • planned additions • barriers.	Pipeline information helps understand whether supply is set to expand to meet growing demand.	Expansion is a key priority given anticipated demand growth.
Public charging market structure, conduct and performance information, including: • site and appliance ownership • consumer pricing and terms • congestion and reliability • customer experience.	Market performance is commonly assessed using a structure-conduct-performance approach (Perloff et al., 2007).	A well-performing market delivers benefits for consumers and reduces the size of the gap where public investment may be needed.
Market knowledge (for EV charging services market).	To understand the dynamics influencing market performance.	Market knowledge is built up over time through monitoring and engagement.
Is intervention warranted?		
Quantitative and qualitative information on impacts of charging services on EV uptake, including: • EV purchase sentiment • consumer perceptions of charging • unmet charging demand.	To assess the extent to which intervention is likely to improve EV uptake.	Specific intervention options may have other information needs covered under other functions (such as planning and funding). Information may be at a macro level (general relationship between congestion and uptake) or segmental (impact of specific deficiencies).

6.1.1.2 Network planning information needs

At a high level, these are the key questions for network planning whether carried out by government or suppliers:

- What will demand be?
- What is the best option for meeting demand?

In generic terms, network planning involves:

- projecting demand
- projecting capability to meet projected demand
- from the above, identifying shortfalls (with reference to target outcomes such as resilience)
- identifying the best options to address identified shortfalls.

These steps can be applied at different levels of granularity such as projecting:

- aggregate New Zealand-wide demand for public journey chargers
- the optimum mix of public destination and journey chargers for a given neighbourhood
- the number and distribution of chargers needed to support charging along a particular route
- the optimal location and capacity for public journey charging hubs.

Demand projections have multiple sources of uncertainty, including consumer charging behaviour and factors influencing EV uptake.

Any information that helps reduce or better understand uncertainty is valuable for network planning as are policy settings or interventions that improve predictability.

The definition of a best option can vary but typically involves maximising utility by:

- maximising net consumer benefit (benefit less cost) or profitability
- meeting necessary planning standards (such as safety and resilience).

Table 6.3 compares how the context for network planning for EV charging services compares to other familiar networks in New Zealand.

Table 6.3 EV services have similarities and differences to other familiar infrastructure types

Comparator	Similarities	Differences
Electricity transmission and distribution	• Essential service underpinning economic activity and community wellbeing. • Expectation of near-universal coverage across the country.	• Electricity network services have strong natural monopoly characteristics so have a single supplier and central planning (for each geographic area). • Electricity networks are fully mature services with high uptake and modest growth. • Electricity networks have regulatory oversight of resilience and reliability.
Electricity generation	• Multiple suppliers compete to meet demand. • High degree of decentralised planning. • Interdependency with centrally planned network.	• Generation must integrate closely with power system to meet common quality and system operation requirements in real time. • Generation market is fully mature.

Comparator	Similarities	Differences
Fixed telecommunications networks	• Essential service underpinning economic activity and community wellbeing. • Expectation of near-universal coverage across the country. • New technology over-building legacy technology (fibre/copper and electric/liquid). • Competition between technologies influences market conduct and performance.	• Fixed telecommunications networks have natural monopoly characteristics. • Fibre coverage is more expensive than fibre capacity and coverage is built out contiguously. • Transition from copper to fibre has been very rapid because it is easy and clearly beneficial for consumers to change. • Transition to EVs is rate-limited by capital intensity and long life of vehicles.
Mobile telecommunications networks	• Essential service underpinning economic activity and community wellbeing. • Multiple overlapping and competing networks. • Some competition with other technologies (mobile versus satellite and fixed broadband, journey versus destination and private charging). • Expectation of very high geographic coverage. • Public interest in social good outcomes (including remote area coverage, resilience, rural performance, competition and interoperability).	• Initial rollout of mobile networks was by vertically integrated monopoly provider (Telecom). • Mobile initially extended the utility (to consumers) of mature telecommunications networks without displacing legacy technology (it grew an existing market). • Mobile networks today are mature businesses using mature technologies. • To compete in mobile, a new provider needs relatively high nationwide coverage. • Development of the market for mobile telecommunications has benefited from multiple government interventions such as co-location rules, environmental planning reform and public funding.
Liquid fuelling network	• Essential service underpinning economic activity and community wellbeing. • Multiple suppliers compete to meet demand. • High degree of decentralised planning.	• Petrol stations have large share of the market for refuelling light vehicles. • Charging facilities likely to be much more dispersed than petrol stations with many more sites. • Fuel has a high degree of vertical integration spanning sites, domestic distribution and import. • Fuelling infrastructure has evolved over time rather than as a rapid overbuild and displacement. • EV charging has a broader range of competing service models.
Public roading network	• Essential service underpinning economic activity and community wellbeing. • Expectation of very high geographic coverage. • Public interest in social good outcomes (including safety, resilience and coverage).	• Most public roading is funded through public funding pools not from direct users. • Private investment in public roads is always via a public-sector gatekeeper. • Public roading is an interconnected network (not a collection of point assets).

From this comparison, these are key insights regarding planning for EV charging infrastructure:

- Unlike roading, electricity and fixed telecommunications networks, EV charging does not involve monopoly-owned contiguous networks with an inherent need for centralised planning.
- Like electricity generation, parties can compete to add EV charging capacity based on their own decentralised planning and views of the best option to meet demand.

- Like all the networks covered in Table 6.3, there is public interest in EV charging outcomes. This can justify intervention in the form of monitoring, standards and funding. Centralised planning can support these activities (such as providing a baseline view against which to compare market outcomes).
- Like mobile telecommunications, a market with competing providers can be effective at mobilising private capital, while government intervention can help to remove barriers, improve market function and deliver some social good outcomes for segments of the market (such as resilience and rural coverage).
- EV charging interfaces with public roading, which involves interacting with public-sector gatekeepers (roading authorities that control roading corridors and access).
- Like electricity generation and electricity networks, there is some coordination needed between a central planner (the network) and independent investors, but this does not have to extend to a need for fully centralised planning.
- EV charging has many significant points of difference from liquid fuelling.

Within this context, Table 6.4 identifies potential information requirements for EV charging services planning.

Table 6.4 Information needs for network planning

What?	Why?	Comment
What will demand be?		
Journey information, including: • journey distances by vehicle type (light passenger car, motorcycle, light commercial van).	Journeys are the ultimate driver of demand for transport energy.	Journey distances also influence the portion of travel demand that can be met from private, at-base charging. As such, understanding journey distance distributions is more valuable for EV charging than ICE fuelling.
Traffic flow information.	To support spatial dimension to EV services planning.	Particularly relevant to journey charging.
Vehicle fleet information, including vehicle: • type • fuel type • location • for BEVs, range and charging characteristics (such as power and compatibility).	To inform estimates of the portion of journeys and flows relating to EVs. BEV range influences the portion of travel demand that can be met from private, at-base charging, and charging characteristics inform option design (and obsolescence of existing chargers).	Tracking the existing fleet composition provides a base from which to project future composition.
Private charging information, including: • households without off-street parking • consumer preferences.	To inform estimates of the portion of EV charging demand met through at-base charging.	In an immature market, preferences may evolve quickly.
EV market maturity information such as: • prevalence of EV-only households • EV uptake by marketing persona.[28]	Help link EV uptake to journey demand.	EV uptake is likely to migrate through various personas as the market matures – for example, as two-car households move from having one EV (with the ICE used for longer trips) to two EVs.

[28] Marketing personas are used in consumer research and marketing to segment a market into consumers with common needs or preferences. For EVs, this could include personas such as urban commuter, family taxi or fleet buyer.

What?	Why?	Comment
Information on demand drivers, including: • fuel and carbon price projections • vehicle price and availability projections (EVs and ICE vehicles) • travel mode shift projections • consumer outlook • policy outlook.	To inform projections of how EV journey volumes will grow.	
Information on charging services, including (in addition to asset and pipeline information from Table 6.2): • utilisation rates • congestion levels.	Provides a base for understanding and projecting unmet demand.	Congestion provides an alternative to (or cross-check on) more bottom-up methods of assessing demand. This means better access to congestion information can reduce the need for journey and flow information.
What is the best option for meeting demand?		
Consumer preferences (market research).	To understand the type of charging service that will best meet consumer needs.	In an immature market, preferences may evolve quickly.
Site availability and suitability.	To understand where charging could be located, including in relation to roading and complementary services (such as retail or hospitality).	Sites can be greenfield (undeveloped), brownfield (including existing carparks) or serviced (an existing charging hub).
Electricity network connection cost.	Network connection costs vary significantly and are material to overall cost. Charges vary depending on physical costs and differences between EDBs in how they allocate costs to access seekers.	Costs can include: • connection – establishing physical link from site to network • reinforcement – contribution to upgrade or reconfiguration of the network to accommodate higher demand.
Balance of capital costs.	To understand overall upfront cost of competing options.	May include site-specific costs such as property and installation costs and more generic costs such as the charging appliance.
Balance of operating costs.	To understand overall ongoing cost of competing options.	
Complementary revenue.	Complementary revenue sources (such as advertising) can lower the net cost of supply.	
Network information such as: • transport system risk analysis • social equity analysis.	To test whether options deliver social good outcomes such as rural access or transport system resilience.	Unlikely to be considered by private investors but may be of key interest for public sector monitoring and investment.

6.1.1.3 Funding and building information needs

At a high level, these are the key questions for funding and building:

- What will the facility cost?
- What will the facility earn?

These questions are directly relevant to suppliers and their investors and lenders and can be of interest to government if it is supplying grants, incentives or financing.

The funding and building functions convert a plan into physical assets ready for operation and delivery of charging services.

Funding includes:

- determining the size and timing of revenue and costs
- securing financing to bridge the difference in timing between cash outlays and revenue accumulation.

These steps can be applied at a project, programme or business-wide level. Where there is public funding, government typically tries to assess the extent to which funding is necessary (whether investment would be viable without public funding). This helps government to assess additionality (the extent to which its intervention will produce an increase in supply rather than a bare wealth transfer). Where government provides financing, it also needs to assess and monitor credit risk (for debt) or investment risk (for equity).

Building involves detailed design and equipment procurement plus scheduling and construction of physical works. This typically involves coordination across multiple suppliers and may involve gaining approvals from parties such as the roading authority, local authority (for resource consent) and electricity network.

The design process involves optimising the planned build with considerations such as:

- site configuration, including road access and queuing space
- electricity network connection, including routing and sizing
- appliance selection, including capabilities (such as power, telemetry), compatibility (including connector types and communications protocols) and reliability (including after-sales support)
- customer experience (including amenities, lighting and security)
- stormwater management and, if applicable, wastewater and drinking water connections.

Design can be easier (sometimes at the expense of flexibility) with clear guidelines, standards or policies.

The construction process can include ordering equipment and contracting for network access (electricity and water, if applicable), siteworks and commissioning.

Table 6.5 sets out potential information needs for funding and construction.

Table 6.5 Information needs for funding and construction

What?	Why?	Comment
What will the facility cost?		
Land information, including: • site availability • ownership, value, lease/sharing terms • restrictions or limitations.	Land costs can vary from zero through to a significant portion of total facility cost.	
Electricity network information, including: • network location and capacity • technical requirements (such as metering) • connection charge and fees • ongoing charges.	Network connection is typically a significant upfront cost component. The level and structure of ongoing charges may influence design choices.	Connection charges may be payable to a network operator (for a new facility with a new or upgraded connection) or to the site host (for a facility on an existing site or hub).
Appliance information, including: • purchase cost • reliability • installation cost • expected useful life.	Third major cost component.	

What?	Why?	Comment
Services cost information, including for: • monitoring and reporting systems • billing systems • wayfinding systems.	To complete the cost picture.	May include combination of upfront costs (such as equipment) and ongoing costs (transaction fees or service subscriptions).
What will the facility earn?		
Revenue information, including: • projected utilisation • intended pricing • complementary revenue • grants.	Drivers of earnings.	Utilisation projections may draw on information from nearby or similar facilities and information on volume drivers (such as roading or urban development plans).
Operator's cost of capital.	To convert future cashflows into present values to enable like-for-like comparison.	A supplier may add a hurdle rate. A public funder may use a generic discount rate.
Financial information, including: • business plan • assets and liabilities • risk assessment.	Relevant for financing whether by private or public sector. Also relevant for grant funding where viability of provider is of concern.	For financing, information needs may be more detailed and enduring (such as to monitor credit risk).

6.1.1.4 Operating information needs

At a high level, these are the key questions for operating charging services:

- Are services meeting consumer needs?
- Are services profitable?

Once a facility has been built, suppliers (and their funders or finance providers) need information to deliver services and monitor and manage performance (Table 6.6). This is particularly important in an immature market where consumer preferences, business models and service performance are evolving rapidly (and hence innovation is important). Government also has an interest in service performance, including due to its funding role and its direct and indirect interests in overall market performance.

Table 6.6 Information needs for operations

What?	Why?	Comment
Are services meeting consumer needs?		
Uptake information, including: • utilisation • revenue.	Reveals whether service is meeting a need.	Most useful in comparison to nearby services or comparable facilities.
Customer satisfaction.	Informs where and how service could be improved to better meet consumer preferences.	Consumer research is particularly valuable in early-stage markets.
Are services profitable?		
Operating costs.	Combines with revenue to produce operating margin.	Including the information on ongoing costs set out in Table 6.5.
Asset information such as: • actual useful life • mid-life capital costs.	Informs complete picture of profitability.	

6.1.1.5 Consumer information needs

At a high level, the key question for consumers is how they will charge their vehicles.

This question is of interest:

- prior to purchasing an EV – charging is a new and unfamiliar part of owning an EV so gaining comfort that charging will be available and will meet a consumer's needs contributes to overcoming hesitancy
- for EV owners and drivers – EV drivers need information to establish their routine charging behaviours and when planning a long journey or other travel that will necessitate some change to their routine (such as staying away from home overnight).

Pre-purchase information can range from general to specific (Table 6.7):

- General pre-purchase information informs whether a consumer will consider purchasing an EV in the first place, including general sentiment towards EVs. This can also be influenced by misinformation and by misapplied mental models.
- Specific pre-purchase information helps someone actively considering an EV purchase to make their decision.

Table 6.7 Information needs for consumers

What?	Why?	Comment
How will I charge my vehicle?		
Information about charging and EV ownership, including education and marketing information.	To combat misinformation and misapplied mental models.	Multiple parties have an interest in educating potential EV consumers, including EV sellers, charging services providers, electricity businesses and government.
Pre-purchase information, including: • likely charging needs, including information about EV ranges and charging speeds • public charging information, including: – pricing – availability and reliability – coverage – capability – customer experience • home charging information, including: – upfront costs – ongoing costs – capability.	To help a potential purchaser realistically assess charging as part of their overall purchase decision.	Can include education to help consumers adapt from liquid fuelling to EV charging mental models.
Vehicle owner information on public charging, including: • wayfinding • pricing • congestion information • reliability information • capability and capacity • customer experience.	To help vehicle owners to select and use a charging service.	Includes a mix of static information (such as charger locations) and dynamic information (such as charger availability).

6.1.2 Consolidated list of information needs

Through exploring key questions related to each function, we have compiled the list of potential information needs in Table 6.8.

Table 6.8 Consolidated list of information needs for EV services market

What	Who and why
• Public charging asset information, including: – location – capability – commissioning date.	• Government, to inform monitoring, policy work and cost-benefit analyses. • Government, to inform baseline planning. • Suppliers, to inform expansion planning. • Consumers, to inform EV purchase and usage decisions.
• Public charging investment pipeline information, including: – planned additions – barriers. • Public charging market structure, conduct and performance information, including: – site and appliance ownership – consumer pricing and terms – congestion and reliability – customer experience. • Market knowledge (for EV charging services market).	• Government, to inform monitoring and policy work.
• Information on impacts of charging services on EV uptake, including: – EV purchase sentiment – consumer perceptions of charging – unmet charging demand.	• Government, to inform policy and cost-benefit analysis.
• Journey information, including: – journey distances by vehicle type (light passenger car, motorcycle, light commercial van). • Traffic flow information. • Vehicle fleet information, including vehicle: – type – fuel type – location – range (for BEVs). • Private charging information, including: – households without off-street parking – consumer preferences. • Information on demand drivers, including: – fuel and carbon price projections – vehicle price and availability projections (EVs and ICE vehicles) – travel mode shift projections – consumer outlook – policy outlook.	• Government, to inform baseline planning. • Suppliers, to inform expansion planning.

What	Who and why
Information on actual demand for charging services, including: • utilisation rates • congestion levels.	• Government, to inform baseline planning. • Suppliers, to inform expansion planning. Note: Usage indicators can complement (or provide substitute for) planning information listed in row above.
• Consumer preferences (market research). • Site availability (high-level). • Electricity network connection cost. • Balance of capital costs. • Balance of operating costs. • Complementary revenue.	• Government, to inform baseline planning. • Suppliers, to inform expansion planning.
• Charging network information such as: – transport system risk analysis – social equity analysis.	• Government, to inform baseline planning, policy work and cost-benefit analysis.
• Land information, including: – site availability (detail) – value or lease terms – restrictions or limitations. • Electricity network information, including: – network location and capacity – technical requirements (such as metering) – connection charge and fees – ongoing charges. • Charging appliance information, including: – purchase cost – reliability – installation cost. • Services cost information, including for: – monitoring and reporting systems – billing systems – wayfinding systems. • Revenue information, including: – projected utilisation – intended pricing – complementary revenue – grants. • Operator's cost of capital. • Financial information, including: – business plan – assets and liability – risk assessment.	• Suppliers, for financing and building facilities. Note: This information is also of interest to government if providing grants or financing.

What	Who and why
• Uptake information, including: – utilisation – revenue. • Customer satisfaction. • Operating costs. • Asset information such as: – actual useful life – mid-life capital costs.	• Suppliers, for managing performance.
• Information about charging and EV ownership, including education and marketing. • Pre-purchase information, including: – likely charging needs, including information about EV ranges and charging speeds – public charging information, including: ▪ pricing ▪ availability and reliability ▪ coverage ▪ capability ▪ customer experience – home charging information, including: ▪ upfront costs ▪ ongoing costs ▪ capability.	• Consumers, prior to EV purchase.
• Vehicle owner information on public charging, including: – wayfinding – pricing – congestion information – reliability information – capability and capacity – customer experience.	• Consumers, post-EV purchase

6.2 Information availability

Table 6.9 summarises our assessment of information availability by function. We have used a qualitative three-tier categorisation.

Table 6.9 We have categorised information availability for each function

Function	Information availability			Comments
	Very limited	Somewhat limited	Available	
Policy and monitoring	• Charger pipeline. • Charging market structure, conduct and performance.	• Basic public charging asset information. • Impacts of charger services on EV uptake.		Existing charger information readily accessible but incomplete (especially for destination chargers). Limited transparency on pipeline except for co-funded chargers. Limited information on charger market structure, conduct and performance.

Function	Information availability			Comments
	Very limited	Somewhat limited	Available	
		• EV charging services market knowledge.		Some publicly available market research but relatively high level (and ages quickly).
Planning	• Electricity network capacity and costs. • EV charging network information (transport system risk, social equity analysis).	• Journey information. • Traffic flow information. • Demand drivers. • Charging services usage. • Consumer preferences (market research). • Site availability. • Facility costs (capital and operating).	• Vehicle fleet information.	Electricity network and charging network information not readily available. Traffic and site information somewhat available through local government open datasets on spatial information (traffic count, zoning). Capital and operating costs somewhat available through international benchmarks.
Funding and construction	• Service cost information. • Revenue information. • Financial information (business plan, assets, liabilities, supplier cost of capital).	• Land information. • Electricity network information.	• Appliance information.	Limited transparency on land (public land lease terms and cost) and electricity network information (connection terms and costs). Appliance information available through EECA's approved list of chargers but doesn't include costs. Revenue and financial information commercially sensitive. EECA has some limited service cost information gained through its funding activities.
Operating	• Uptake (utilisation, revenue). • Customer satisfaction. • Operating costs.	• Asset information (actual useful life, mid-life capital costs).		Limited publicly available research on New Zealand perceptions and preferences. Limited public information on operations (noting no major listed businesses dedicated to charging).
Consumers		• Pre-purchase information (pricing, coverage).	• Vehicle owner information.	CPOs provide customer-facing information on pricing, locations and so on. Vehicle manufacturers provide information on EVs, with less emphasis on at-home and public charging. Range of specialist and general media information and analysis. EECA and rightcar.co.nz provide a range of consumer-facing information.

Across the areas covered above, we note the following:

- EV charging services touch on multiple government agencies and regulators, with no clear home for government monitoring, policy or information stewardship. EV charging services are important for transport, energy, climate change, and consumer and economic outcomes.

- Key information gathered today is either voluntary or ad hoc:
  - NZTA's EVRoam database provides the best information on charger locations and capabilities and is used by EECA for its public-facing dashboards. However, it is a voluntary service, which limits options to ensuring data quality and completeness or for extending information to areas that incumbent suppliers may consider commercially sensitive (such as utilisation or revenue).
  - EECA has gathered rich information on costs and aspects of market knowledge through its funding activities. However, this information is not structured, cannot be made more widely available and is tied to the longevity and scope of government funding programmes.
- There is no natural home for consolidating information from different agencies or regulatory regimes, for example:
  - roading, traffic and charging network data and analysis held by NZTA, Ministry of Transport and local roading authorities
  - electricity network connection cost information disclosed by EDBs and Transpower under Commerce Commission regulations
  - technical information produced by EECA on topics such as standards and approved appliances.
- For some information, there is a tension between the value that could be gained through public availability and the commercial value to parties who hold the information. This means such information is unlikely to become widely available without some form of compulsion. Information availability is a potential barrier to entry for new participants in the market for EV charging services, especially for journey charging (with its challenging commercial proposition). Existing suppliers have generally benefited from government funding to gain entry, so there is a risk that discontinuing government support without addressing information access could have an unintended lock-in effect on market structure.
- Consumer research and education have key roles to play in addressing EV purchase hesitancy. Without ongoing, detailed consumer research, it is unclear how government should optimise between education and funding or where government should target its funding. There is unlikely to be a generalised relationship between charging services availability and EV uptake. Rather, there are a collection of charging services market segments that each have an evolving impact on EV hesitancy.

Other information gaps can be resolved by parties through undertaking some effort:

- Land information and site accessibility information is not readily available but can be inferred (by developers, policy makers, funders/investors) by analysing the spatial datasets available through local councils (spatial zoning data, traffic counts). This enables the different roles to develop their own independent views of unmet demand and existing utilisation levels at different charger locations.
- Appliance information is currently available from EECA (approved charger list) alongside technical specifications for public chargers developed with industry (publicly available specifications). Although the resources are not regulated, it provides a useful aid to the industry to help guide development projects.
- Charger asset and cost information (useful life, mid-life capital cost, operating costs) is not readily available publicly or aggregated but can be sourced by requesting the information directly from manufacturers and suppliers or from international sources such as NREL's EVI-X modelling suite.

6.3 Prioritised information gaps

We have prioritised information gaps into high priority and secondary. While we used a range of considerations to inform our suggested prioritisation, we found the following criteria useful (Audit New Zealand, 2023):

- Relevance: Every data item must have a direct influence on the output (or outcome) that is required (a decision on when to renew the asset or specific data input into a predictive condition model). For example, the information gap should be relevant to a function or achieving an outcome rather than just being nice to have.
- Appropriateness: The volume of data and the frequency of updating should align with the stage in the asset's life and the criticality of the service being provided. For example, data should be right sized and fit for its purpose.
- Reliability: The data should be sufficiently accurate, have sufficient spatial coverage and be appropriately complete and current. For example, the information should be complete enough to be relied on by individual actors to make judgements about policy and planning and to inform investment decisions.
- Affordability: The data should be economic to collect and maintain. For example, the burden (financial or otherwise) in collecting and maintaining the information should not outweigh the benefits (unnecessary compliance costs, harm to innovation/competition).

We have prioritised gaps from the standpoint of government and consumer interest in a well-functioning market for EV charging services. Table 6.10 summarises our prioritised information gaps, with the high-priority gaps ranked in priority order.

Table 6.10 We have identified high-priority and secondary information gaps

Category	Information gaps
High priority	• Basic network information. • Dynamic network information. • Consumer research on vehicle purchasers and EV drivers. • Consumer information for vehicle purchasers. • Improved information on electricity network costs.
Secondary	• Charger cost information. • Charger network analysis focused on public good investment cases.

Below we provide more information on each priority gap, including our rationale and thoughts on options for addressing each gap.

6.3.1 Basic network information

Basic network information provides an essential foundation and could include:

- site information, including location, electrical capacity and any limitations on access
- charger information, including capacity and capabilities, age and ownership.

Much of this information is collected in EVRoam but only on a voluntary basis. As such, the information is not complete and there is no mechanism for ensuring CPOs keep information up to date – including as information requirements are refined (for example, to align with the OCPI protocol) or as sites and chargers are upgraded or retired.

Basic network information provides a foundational layer of information for all functions, including:

- monitoring market performance
- planning
- consumer decision making.

Establishing a robust information base requires funding for development and operation, including enforcement, plus a regulatory regime for identifying and imposing obligations on CPOs. One option for this could be use of the Electricity Industry Act 2010, which provides:

- a mechanism for defining classes of industry participant who must register with the Electricity Authority (noting an Order in Council is required to introduce new participant types)
- a rulebook (the Electricity Industry Participation Code) that can be used to impose obligations on industry participants
- a dedicated regulatory agency (the Electricity Authority) with capabilities that include information management
- funding via an industry levy.

While this provides a ready-made regulatory regime, it may not be suitable in practice because the purpose of the Electricity Industry Act focuses squarely on the electricity industry, so the Electricity Authority would not be able to take non-electricity sector benefits into account when developing any arrangements for CPOs.

The Land Transport Act 1998 could provide an alternative home but does not contain ready-made provisions and does not cover similar types of intervention with a similar span of policy objectives. Likewise, the Commerce Act provides frameworks that partially align but its policy focus is also relatively narrow (focused only on in-market benefits).

Given the above, it is not clear that there is existing primary legislation with a suitable scope to accommodate policy objectives associated with EV charging.

However a regime was implemented, it would be necessary to consider how broadly obligations to provide basic network information should extend. Given that the cost of complying with basic network information obligations is unlikely to be too onerous and that the charging services market involves an interplay between journey and destination charging, we would recommend a relatively low capacity-based threshold (such as 7 kW) for publicly available chargers.

As with EVRoam, the information gathered should be made readily available, including through public-facing dashboards and industry-facing application programming interfaces (APIs).

6.3.2 Dynamic network information

From the base described above of comprehensive basic network information and accompanying regulatory infrastructure, we consider it would be valuable to add dynamic information on charger uptime and utilisation.

Dynamic information could be gathered in one of two ways:

- Real-time information: Appliances communicate their status, for example, offline, available or in use. This could supply information useful for wayfinding as well as for calculating uptime and utilisation (percentage of time spent in-use).
- Ex-post information: CPOs report at the end of each month on appliance usage. Reports could include granular information (such as session start times, end times and energy transferred) and/or aggregate information (such as monthly uptime, utilisation and energy transfer).

Ex-post information may be less onerous for CPOs and the regulator and would likely provide sufficient information for most purposes.

Why dynamic information is valuable:

- Planning: Utilisation information is the gold standard for capacity expansion planning since it encapsulates information relevant to consumer preferences and service profitability. Currently, this information is only available to incumbent CPOs, which have largely achieved their market position with

the aid of government funding. Making this information available would level the playing field for small or new-entrant CPOs

- Monitoring: Uptime and measures of utilisation (time spent charging and energy transferred) would provide rich information for market monitoring. This could assist with identifying where regulatory intervention may be beneficial and with directing government funding and ensuring value for public money.

Real-time information could additionally be used as a base for consumer information such as wayfinding and congestion information. However, CPOs have incentives to ensure drivers find and use their services anyway, so it is not clear that there is a case for intervention with respect to wayfinding.

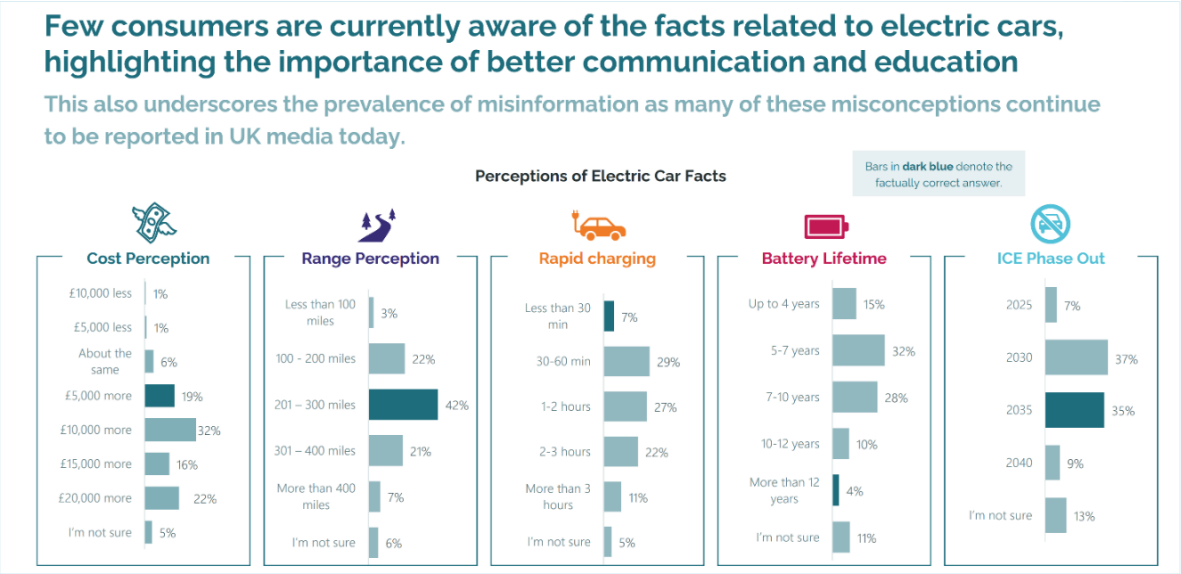
6.3.3 Consumer research on vehicle purchasers and EV drivers

The markets for EVs and for EV charging services are both at early stages of development. To deliver on the potential benefits to New Zealand of EV technology, New Zealand consumers will need to gain familiarity and comfort with EVs and EV charging. We expect the following through this transition:

- The consumers purchasing EVs will need to shift from enthusiastic early adopters, through early and late mainstream consumers and into late adopters. Each of these cohorts will differ in their awareness, attitudes and needs as will various segments of the light vehicle market (such as remote, rural, suburban, metro, families, tradespeople and people without at-home charging).
- The charging services market will evolve with new CPOs entering the market and with the services offered changing over time in dimensions such as pricing, amenities, bundling, performance, convenience, coverage, density and reliability. Charger appliances will also evolve with the potential for on-site batteries and generation to reduce the network and energy components of CPO costs over time.
- Mental models of consumers will adapt, evolving from thinking of EV charging as being like liquid refuelling to understanding the range of ways in which charging can best be built into journeys and downtime to manage cost, convenience and utility.
- Vehicle capabilities will evolve. EVs are likely to become increasingly attractive as battery costs continue to fall, battery performance continues to improve and EV options (including in the second-hand market) expand. While the upper range of EV charging speed and range is likely to continue to increase, the market may also mature its current tendency to oversize batteries as consumers grow more comfortable with smaller batteries and the attendant weight and cost savings.
- Home and work charging will evolve. Availability of charging at workplaces and homes is likely to expand, and kerbside charging may become more widely available. If electricity network and retail pricing continue their trend towards greater cost-reflectivity, the cost of at-base EV charging should also continue to fall.
- Consumer journeys are continuing to evolve as urban form and public transport systems evolve, availability of remote working and online services evolve, e-bikes expand the utility and reach of cycling to more people, demographics change and attitudes to mobility change.
- ICE and liquid refuelling markets will evolve with declining demand and the potential for escalating costs (as the fixed costs of liquid fuel distribution are spread across smaller volumes) and falling availability.

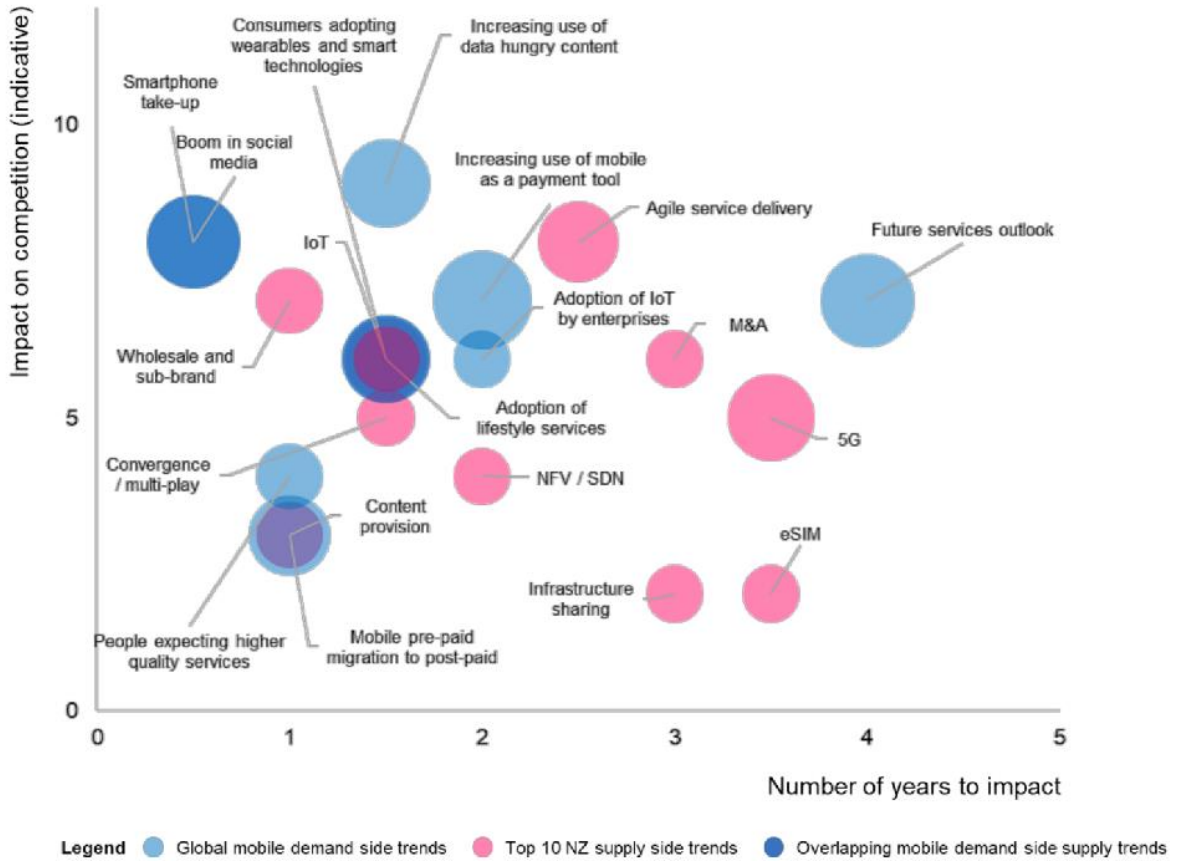
All these dynamics combine to make consumer preferences a major source of uncertainty. As such, there is significant value in consumer research aimed at shedding greater light on how New Zealand consumers are thinking about their vehicle purchase decisions and how EV users are thinking about their charging needs. Figure 6.2 provides an example of how consumer research can illuminate factors influencing consumer preferences.

Figure 6.2 UK consumer research provides information on evolving consumer perceptions and misconceptions (reprinted from Voxlin et al., 2024. p. 30)



Consumer research is also commonly used by regulators in New Zealand to help understand market performance, to shape communications and to prioritise work programmes. For example, the Commerce Commission regularly measures and reports on broadband speeds and publishes market and consumer analysis of telecommunications markets (such as that shown in Figure 6.3).

Figure 6.3 The Commerce Commission has used consumer research to inform its monitoring of telecommunications markets (reprinted from Dehiri & Williams, 2019, p. 7)



Consumer research is not only of value to vehicle manufacturers and CPOs but has wider public value. For example, publicly available consumer research could assist with:

- market monitoring, particularly of market performance
- prioritisation and cost-benefit analysis of government funding and could help inform the balance of effort between consumer education and investment in charging as well as informing which types of investment to make in the charging services market – for example, government investment in charging services could focus on:
  - transport system resilience
  - rural access
  - remote locations, including tourism areas
  - major journey hub infrastructure
  - route densification
  - accelerating near-commercial journey or destination charging
  - metro or residential kerbside
  - taxis, ride hailing vehicles, couriers or delivery vehicles
  - reliability or customer experience enhancements
  - deepening competition
  - underwriting demand risk
- material to guide and inform public education and CPO and EV manufacturer marketing.

6.3.4 Consumer information for vehicle purchasers

Following from the above, we consider there would be value in enhancing the information available to vehicle purchasers. EV uptake delivers various public benefits so there is public value in addressing consumer hesitancy:

- EV uptake is influenced by perceptions of EV charging as well as the actual state and performance of the EV charging services market. It is likely to be more cost-effective to balance investment between information and infrastructure than to focus on infrastructure alone. This is because misconceptions significantly influence EV purchase intentions (Voxlin et al., 2024).
- EV and EV charging markets in New Zealand do not have large dominant providers with incentive, ability and credibility to fulfil the function of providing category-level marketing. The contrasts, for example, with the market for fibre broadband services where Chorus invests $3 million per year on category-level marketing (Chorus, 2023).
- It is not unusual for government to play a role in promoting technology adoption, particularly where the technology can drive significant productivity gains, for example, by providing media packs with information on 5G mobile (Ministry of Business, Innovation and Employment, 2020).

Government investment in consumer information can take a range of forms from simply making consumer research publicly available to working with media, industry and consumer organisations to design and share research and resources.

6.3.5 Improved information on electricity network costs

Key issues with electricity network costs are that they:

- can be a material cost component for charging services, especially for journey charging sites or large charging services hubs

- vary significantly by installation, including due to physical characteristics of each site, differences in EDB charging methodologies and (depending on how costs are allocated) whether network capacity upgrades are needed to accommodate the installation
- can be unpredictable, making planning difficult and delaying delivery.

Network costs are an area of industry, government and regulatory focus, so the need for improvement in this area has been identified previously. As such, we mention network costs here for completeness rather than for the purpose of making further recommendations. Key work relevant to network costs includes the following:

- Cabinet has agreed to form a cross-agency taskforce involving MBIE, Ministry of Transport, EECA and Crown Infrastructure Partners to coordinate an EV infrastructure workstream (Brown, 2024). This includes working with the Electricity Authority on the matters below.
- The Electricity Authority is progressing development of a potential amendment to the Electricity Industry Participation Code to regulate connection pricing methodologies (Electricity Authority, 2024). This work could potentially improve consistency across EDBs, improving predictability and reducing charges for some EDBs. The Electricity Authority also has a programme of work reviewing regulatory settings for distribution networks that includes addressing non-price barriers to network connections (Electricity Authority, 2023c). This work could improve how EDBs engage with CPOs, including how they share information to facilitate connections.
- The Commerce Commission has reviewed and extended information disclosure obligations for EDBs (Commerce Commission, 2024e). This includes expanded reporting requirements relating to network constraints, geospatial data and pricing information.

6.3.6 Secondary priorities

In addition to the priorities above, we have identified two further areas where expanded information may be beneficial:

- Charger cost information on actual costs incurred in the delivery of charging services with a focus on capital expenditure on network connections and appliances. This information is useful for monitoring and planning. EECA has a collection of forecast cost information from funded projects. However, this is not a systematic or structured source of information.
- Charging network analysis information to assist with the planning of charging services with a focus on areas where a particular public good rationale such as transport resilience or social equity may apply.

6.3.6.1 Charger cost information

Cost information is useful in multiple ways, including for monitoring, planning and financing decisions:

- Information on typical costs (together with utilisation) could inform a schedule of standardised grants aimed at accelerating deployment of near-commercial charging facilities (for example, $x per installation of a specified type).
- Information on typical costs by capacity could help inform government's view of the optimal mix between journey and destination charging.
- Information on cost and utilisation distributions could help inform sizing and prioritisation of funding allocated to segments of the charging market such as kerbside, remote or transport system resilience.
- Any cost information can assist potential entrants or investors to build their understanding of the New Zealand market opportunity.

Sharing of cost information may help to promote competition where there is limited information available. This is because policies that require businesses to publish information about prices, outputs or sales may increase the amount of information available to businesses about their competitors and their strategies, making it easier to accommodate each other's behaviour and facilitate conduct such as leader-follower pricing (Commerce Commission, 2023a). This can promote competition as it places downward pressure on costs and pricing.

As an example in the US, EVI-LOCATE[29] provides an independent source for cost information to build and locate chargers by comparing estimated demand for regions/locations and the costs to build public chargers in that region, including connection costs.

Cost information is also used by regulators to monitor and measure market conduct and competition within the sector (such as telecommunications and electricity distribution).

6.3.6.2 Charging network analysis

Network analysis can assist suppliers to identify opportunities and government to inform policy and prioritise funding allocations. For example, Transpower publishes the following network analysis:

- Strategic context: Transpower voluntarily published documents such as *Whakamana i te mauri hiko* (Transpower, 2020) to provide context on its view of sector trends and long-term planning priorities. The document is widely used, including by regulators, generators, major users, potential investors, media and government agencies.
- Network planning: Transpower is required to publish analysis regularly highlighting where investment will be needed to address grid reliability and where investment may deliver economic benefits (such as by enabling lower-cost generation). This reporting highlights where there are investment opportunities, including for parties who could invest to remove the need for Transpower to invest (for example, in utility-scale batteries).
- Security assessments: As system operator, Transpower publishes analysis of near-term system capacity margins. This helps inform parties of tight supply and supply risks.
- Pipeline: Transpower publishes a new connection enquiries dashboard, which presents a high-level overview of new connections on its transmission network (Transpower, 2024). This provides visibility to industry into the scale of new load and generation assets seeking connection into the grid.

For charging services, there is no network operator equivalent to Transpower, but government agencies could provide useful analysis of:

- charger densities, including areas where densities are low relative to EV registrations or traffic flows
- transport system resilience analysis, highlighting where backup routes are under-served by EV charging infrastructure
- remote area blackspots, highlighting where charging capacity is unavailable or low relative to seasonal demand
- favourable development areas, highlighting where demand potential is high relative to existing capacity and assessing key development hurdles (such as network constraints or highway access).

Existing examples of charging network analysis already available:

- For round 10 of EECA's Low Emission Transport Fund, proposals were sought for 14 specific holiday journey routes and 25 other specific locations (EECA, 2023a).

[29] See https://evi-locate.nrel.gov/.

- EECA maintains a planning tool for what it calls community charging. This includes regional information on projected EV numbers and existing chargers.
- EECA maintains a dashboard for its co-funding pipeline, showing planned co-funded projects by region, CPO and power.
- The Climate Change Commission publishes a demonstration path, with includes projections of EV numbers consistent with New Zealand meeting its emissions reduction obligations (Climate Change Commission, 2023b).

7 Conclusion

This project set out to provide information that could aid in the establishment of a comprehensive public EV charging network in New Zealand.

We developed a four-part framework to assist with context as well as identifying key themes from international case studies, drawing comparison to New Zealand and examining some specific case study topics.

From this base, we completed a systematic, top-down assessment of potential information needs. We then assessed information gaps and developed a prioritised list with supporting rationale.

Finally, we contacted a range of organisation who helped us to compile a comprehensive inventory of New Zealand work relevant to EV charging infrastructure (see Appendix A).

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Appendix A: Inventory

This is a snapshot of work under way across government agencies, universities and other organisations relevant to policy settings and practice for EV charging services. It responds to the research objective to undertake an inventory of work with a New Zealand focus (government led, academic) to aid in informing the approach to an efficient and effective publicly available charging network. We collated the inventory by:

- carrying out a desktop review to identify publicly available or discussed work across organisations we were aware of that are working on EV matters
- identifying contact people at each organisation, including with the help of our project steering group
- emailing contacts during the last week of May and first week of June 2024, providing our draft inventory and requesting assistance to identify additional work and improve our descriptions of work we had already identified.

In total, we contacted 18 organisations (Table A.1).

Table A.1 Organisations contributing to inventory

Organisation	Comment
Ara Ake	Supports FlexForum.
Auckland University of Technology	
Climate Change Commission	Provides impartial advice to governments, including recommendations on Emissions Trading Scheme settings, emissions budgets and emissions reduction plans
Commerce Commission	Regulator responsible for competition, fair trade and consumer issues plus economic regulation of electricity networks
Drive Electric	Focus on electricity network connection
Electricity Authority	Regulator responsible for electricity network access arrangements, including pricing methodologies
Electricity Engineers' Association	Leading FlexTalk in association with the Energy Efficiency and Conservation Authority
Electricity Networks Aotearoa	Industry organisation for EDBs
Energy Efficiency and Conservation Authority	Information, standards promotion and funding roles and co-funded early EV charger rollout
FlexForum	Cross-industry group formed to identify a set of actions to integrate distributed energy resources into the electricity system
Ministry for the Environment	
Ministry of Business, Innovation and Employment	
Ministry of Transport	
NZ Transport Agency (NZTA)	State highway asset owner and co-funds most public roading
Transpower	National grid operator
University of Auckland	Includes the Transportation Research Centre
University of Canterbury	Includes the Electric Power Engineering Centre (EPECentre)
University of Waikato	

The inventory for each organisation is set out below. Note we did not contact and receive responses from all parts of each organisation and there may be other organisations that we did not identify.

A.1.1 Auckland University of Technology (AUT)

AUT is a university in Auckland with five faculties and 14 schools, including the School of Engineering, Computer and Mathematical Studies. It also has a Centre for Future Power and Energy Research, whose research areas include EVs. Its website is www.aut.ac.nz.

Item	Link	Description
Review of electric vehicle technologies, charging methods, standards, and optimization techniques (Arif et al., 2021)	https://openrepository.aut.ac.nz/items/30069d96-3ec8-406c-a64e-855ef4768fa0	A research paper reviewing EV technology, charging methods, standards and optimisation techniques.
Modelling of large-scale EV charging demand: A New Zealand case study (Su et al., 2019)	https://openrepository.aut.ac.nz/server/api/core/bitstreams/cbf4b140-8c59-409f-92ad-da60e1d0d974/content	A modelling paper using a multivariate probabilistic model to estimate aggregated EV charging loads to assist in the planning of electricity distribution networks.

A.1.2 Climate Change Commission

The Climate Change Commission is an independent government agency focused on climate action. It provides independent advice to the government on how New Zealand can meet its climate goals and monitors the government's climate progress. It produces a range of advice to government, including advice on the direction of emissions reduction plans and emissions budgets and reviewing New Zealand's climate targets. Its website is www.climatecommission.govt.nz.

Item	Link	Description
Energy and Emissions in New Zealand (ENZ) model (Climate Change Commission, n.d.)	https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/inaia-tonu-nei-a-low-emissions-future-for-aotearoa/modelling/	The ENZ model can be used to estimate carbon emissions and other costs. It includes the main emitting sectors, including energy and transport. The modelling includes assumptions on vehicle charging proportions (home versus public) and costs. The versions of the model used to develop advice are publicly available.
Ināia tonu nei: a low emissions future for New Zealand (Climate Change Commission, 2021)	https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/inaia-tonu-nei-a-low-emissions-future-for-aotearoa/	Contains advice to the government on EV uptake and supportive charging infrastructure.
Advice on the direction of policy for the government's second emissions reduction plan (Climate Change Commission, 2023a)	https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/advice-for-preparation-of-emissions-reduction-plans/2023-advice-to-inform-the-strategic-direction-of-the-governments-second-emissions-reduction-plan-april-2023/	This advice made recommendations to government for the development of this second emissions reduction plan for the period 2026–30. The advice included a recommendation for the government to rapidly upscale vehicle charging infrastructure.
Advice on the fourth emissions budget (2036–2040) (Climate Change Commission, 2024)	https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/preparing-advice-on-emissions-budgets/advice-on-the-fourth-emissions-budget/	Preparation of advice for next emissions budget period, including advice on how emissions budget and 2050 target may realistically be met such as by pricing and policy methods. This includes analysis of EV uptake.

Item	Link	Description
Emissions monitoring and reporting (Climate Change Commission, 2024c)	https://www.climatecommission.govt.nz/our-work/our-upcoming-work/#monitoring-and-reporting	First annual review on progress towards meeting emissions reductions due in mid-2024. It will include an assessment of the government's emissions reduction plan and progress in its implementation, including new opportunities to reduce emissions.
Accelerated electrification (Interim Climate Change Committee, 2019)[30]	https://www.climatecommission.govt.nz/public/Advice-to-govt-docs/ICCC-accelerated-electrification-report.pdf	A report on electrification, including a brief discussion of transport policy options and recommendations by the Productivity Commission in its low-emissions economy inquiry on interventions to encourage EV uptake.

A.1.3 Commerce Commission

The Commerce Commission is an independent Crown entity and is New Zealand's primary competition, fair trading, consumer credit and economic regulatory agency. It is responsible for enforcing five Acts, including the Commerce Act 1986. Under Part 4 of the Commerce Act, it has a role regulating markets where there is little or no competition (and little prospect of future competition), including EDBs and Transpower. It sets price and quality controls for 17 non-exempt EDBs (not community-owned) and Transpower. In addition, all EDBs and Transpower are subject to information disclosure requirements. Its website is comcom.govt.nz.

Item	Link	Description
2025 reset of the electricity default price-quality path reset (DPP) (Commerce Commission, 2024b)	https://comcom.govt.nz/regulated-industries/electricity-lines/electricity-lines-price-quality-paths/electricity-lines-default-price-quality-path/2025-reset-of-the-electricity-default-price-quality-path	The Commerce Commission is setting revenue path and quality standards for non-exempt EDBs for up to 5 years from April 2025. Includes consideration of issues related to accommodating network demand growth from electrification, including EVs. In the draft decision, it proposed provision of additional expenditure allowances for EDBs to purchase low voltage network data, which will help EDBs make efficient investment decisions.
Electricity lines customised price-quality path (CPP) (Commerce Commission, n.d.)	https://comcom.govt.nz/regulated-industries/electricity-lines/electricity-lines-price-quality-paths/electricity-lines-customised-price-quality-path	An EDB currently on a DPP can apply for a CPP if it would better suit their specific needs and those of their consumers. A CPP is a more tailored option than a DPP.
2025 Transpower individual price-quality path (RCP4) (Commerce Commission, 2024c)	https://comcom.govt.nz/regulated-industries/electricity-lines/electricity-transmission/transpowers-price-quality-path/2025-transpower-individual-price-quality-path	RCP4 sets revenue limits and quality standards for Transpower for 5 years from April 2025. This is currently ongoing, with the most recent publication being a draft decision.
Information disclosure requirements for electricity distributors (Commerce Commission, 2024e)	https://comcom.govt.nz/regulated-industries/electricity-lines/information-disclosure-requirements-for-electricity-distributors	Information disclosure requirements apply to all EDBs. These include disclosure of expenditure, asset management, pricing and other financial information. Requirements were recently expanded: • relating to communicating network constraints and geospatial information • requiring EDBs to report their new connection practices, including what they are doing to minimise the cost for consumers (Commerce Commission, 2024f).

[30] This report was prepared by the Climate Change Commission's predecessor.

Item	Link	Description
2023 input methodologies review (Commerce Commission, 2024a)	https://comcom.govt.nz/regulated-industries/input-methodologies/input-methodologies-for-electricity-gas-and-airports/input-methodologies-projects/2023-input-methodologies-review	Input methodologies (IMs) are rules and processes the Commerce Commission sets upfront to use in its regulation of electricity distribution and transmission services. IMs were last reviewed in 2023, and the Commerce Commission made several changes to the IMs to better support new connection investment (including for public EV chargers) required for New Zealand's transition to a low-emissions economy.

A.1.4 Drive Electric

Drive Electric is a not-for-profit industry organisation representing parties with interests in e-mobility, including vehicle manufacturers and importers, energy retailers and EDBs, fleet companies, private charging businesses and CPOs. We contacted Drive Electric's CPO sub-group, which has commissioned several research reports. Not all reports are published, but interested parties can contact Drive Electric to request reports. Its website is www.driveelectric.org.nz.

Item	Link	Description
State of the nation report: E-mobility in New Zealand 2023 (Drive Electric, 2023b)	https://driveelectric.org.nz/wp-content/uploads/2023/09/Drive-Electric-State-of-the-Nation-Report-2023.pdf	Detailed report on e-mobility in New Zealand, including material on EV charging.
Distribution network access for public EV chargers (Concept Consulting, 2023c)		Report providing an overview of the regulatory context for network access and options for improving access.
Demand-side analysis of the Clean Car Discount (Concept Consulting, 2023b)		Report analysing the impact of the Clean Car Discount (and its removal) on EV uptake.
CPO principles for access to network connections (Sapere, 2024)		Report developing principles that would improve the efficiency of electricity distribution network access arrangements.
Proposed framework for allocating public funds (DETA, 2024)		Report proposing a principles-based framework for allocating public funds to EV charging infrastructure.

A.1.5 Electricity Authority

The Electricity Authority is an independent Crown entity established by the Electricity Industry Act 2010 that is responsible for governance and regulation of New Zealand's electricity industry. The Electricity Industry Act authorises the Electricity Authority to make and amend the Electricity Industry Participation Code 2010 (Code). The Electricity Authority's role includes overseeing EDBs' interactions with other industry parties and ensuring they comply with the requirements of the Code. The Electricity Authority currently has a focus on improving distribution pricing to help deliver better outcomes for consumers. We contacted the Electricity Authority's retail and networks policy team. Its website is www.ea.govt.nz.

Item	Link	Description
Distribution pricing (Electricity Authority, 2024)	https://www.ea.govt.nz/projects/all/distribution-pricing/	Policy work on a draft Code amendment to regulate connection pricing based on concern regarding inefficiently high upfront charges.

Item	Link	Description
Delivering key distribution sector reform: Work programme (Electricity Authority, 2023a)	https://www.ea.govt.nz/documents/3929/Work_programme_Oct_231406907.13.pdf	Ongoing work programme to update regulatory settings for distribution networks. Includes addressing non-price barriers to efficient connection of load.
Future security and resilience (Electricity Authority, n.d.a)	https://www.ea.govt.nz/projects/all/future-security-and-resilience/	Multi-year programme focused on adaptation of power system operation to address new technologies, including EV charging.
Generation investment survey (Concept Consulting, 2023a)	https://www.ea.govt.nz/documents/4414/Generation_Investment_Survey_-_2023_update.pdf	Survey of multiple generation developers to ascertain likely future generation investment and key barriers preventing investment. Previous version also prepared in 2022.
Network Connections Technical Group (NCTG) (Electricity Authority, n.d.b)	https://www.ea.govt.nz/about-us/our-people/our-advisory-and-technical-groups/network-connections-technical-group/	The NCTG provides independent advice to the Electricity Authority on non-price enablers and barriers to large-capacity network connections. It also investigates ways to make the connection process more efficient.

A.1.6 Electricity Engineers' Association

The Electricity Engineers' Association provides the New Zealand electrical supply industry with advice and information on technical, engineering and safety issues affecting the electricity industry. It represents over 76 corporate members and more than 550 individual professional members. It provides a range of publications, including technical and safety guides and standards, safety and asset management resources and industry reports. Its website is www.eea.co.nz.

Item	Link	Description
Demand flexibility common communication protocols project (FlexTalk) (Electricity Engineers' Association, n.d.)	https://www.eea.co.nz/Site/asset-management/adr-project/about-adr-project.aspx	Investigation into New Zealand implementation of protocols for communication between distribution networks and distributed resources, including private and public EV chargers.

A.1.7 Electricity Networks Aotearoa (ENA)

ENA represents and advocates on behalf of all 27 EDBs in New Zealand. Its strategic focus is climate, customers and collaboration. ENA is aiming to help deliver a low-carbon future for New Zealanders based on reliable, safe and affordable electricity networks. Its website is www.ena.org.nz.

Item	Link	Description
Future Networks Forum (Electricity Networks Aotearoa, n.d.c)	https://www.ena.org.nz/fnf/	This project involves mapping the connections journey of two important EDB customer segments – public EV charging providers (CPOs) and large distributed generation developments (such as solar farms). The project will produce a prioritised set of recommended improvements to EDB connection processes to address pain points in the above connection journeys.
EDB connection factsheets and contribution policies (Electricity Networks Aotearoa, n.d.a)	https://www.ena.org.nz/resources/connection-map/	Factsheet for each EDB that provides connection information, including how connection charges are calculated. Also provides one web location to access the full connection policies of all 29 EDBs.

Item	Link	Description
EDBs investment driver heatmap (Electricity Networks Aotearoa, n.d.b)	https://www.ena.org.nz/resources/edbs-investment-driver-heatmap/	Heatmaps showing contribution to increased electricity demand of five drivers of: • population growth • new commercial/industrial point loads • EVs • industrial process heat conversion • residential and commercial gas conversion. Heatmaps are based on data gathered from EDBs using a simple survey and are shown for three periods (2023–2030, 2031–2040 and 2041–2050).

A.1.8 Energy Efficiency and Conservation Authority (EECA)

EECA is a Crown entity established by the Energy Efficiency and Conservation Act 2000 to encourage, promote and support energy efficiency, energy conservation and the use of renewable sources of energy, including through advice, promoting public awareness, promoting practices and technologies, arranging research, assessment, demonstrations and studies, and monitoring. Its website is www.eeca.govt.nz.

Item	Link	Description
Public EV Charger Dashboard (EECA, 2024c)	https://www.eeca.govt.nz/insights/data-tools/public-ev-charger-dashboard/	The EV Charger Dashboard combines data drawn from EVRoam with internal data, including the pipeline of EECA co-funded projects (approved but not yet installed). Ongoing work includes use of spatial tools to identify where other EV chargers are sited that are not registered with EVRoam. The dashboard is updated quarterly. In time, it should become a live resource using real-time data feeds. The dashboard includes data on: • where public EV chargers are located, who owns them, their power ratings and how long they've been operational • BEVs per charge point and kW charging per BEV (including an average for the country and rates for each region) • the co-funding pipeline, including how many charging units are live and how many are in progress, the power rating of co-funded charging units, where charging units will be located, who the applicants were and when go live is.
Community EV Charger Planner (EECA, 2024a)	https://www.eeca.govt.nz/insights/data-tools/community-ev-charger-planner/	A planning tool for government agencies and CPOs to identify where EV charging infrastructure is projected to be required to meet the future uptake of EVs. The focus is community charging. It includes projections of how many additional chargers are needed, when (out to 2033) and where.
Low Emission Transport (LET) Fund (EECA, n.d.a)	https://www.eeca.govt.nz/co-funding-and-support/co-funded-transport-projects/ https://www.eeca.govt.nz/co-funding-and-support/products/public-ev-charging-urban-infill/ https://www.eeca.govt.nz/assets/EECA-Resources/Co-	The fund focuses on activities in the transport sector that move people and/or goods on roads, off road and in the marine and aviation sectors to: • demonstrate innovative solutions that will enable future adoption and deployment • reduce energy-related emissions in the transport sector

Item	Link	Description
	funding/LETF-files/LEVCF-and-LETF-project-list-rounds-one-to-twelve-Feb-2024.xlsx (summary of approved projects).	• address market and organisational barriers through co-investment and diffusion of new knowledge and learnings • share knowledge and learnings to stimulate wider replication of successful projects and solutions in the transport sector. The LET Fund: Public EV Charging fund was recently open for applications (closed 31 May 2024). from organisations capable of delivering EV charger projects. Investment is available for network connection costs of the project up to 35% of the total project cost. $15 million available this round.
New Zealand public EV charging (EECA, 2021)	https://www.eeca.govt.nz/about/news-and-corporate/consultations/new-zealand-public-ev-charging/	This consultation paper sought views on proposed approaches for identifying locations for public fast EV charging infrastructure and how to prioritise those locations. The consultation was to help EECA develop a roadmap of the future rollout of the public EV charging network and included a short overview of EECA's view on the role of public charging.
Insights on efficient and low emissions transport (EECA, n.d.b)	https://www.eeca.govt.nz/insights/eeca-insights/	Filter by focus area 'efficient and low emissions transport' to view various pieces of research.
Plugging into the future: How New Zealand is electrifying its roads (EECA, 2024b)	https://www.eeca.govt.nz/insights/eeca-insights/plugging-into-the-future-how-new-zealand-is-electrifying-its-roads/	A summary of insights from the data in the Public EV Charger Dashboard (see above) and data from its EV charging survey (see below). It includes discussion of public charging behaviour, EV charging infrastructure challenges and expectations for larger charging hubs.
Electric vehicle charging research: Insights into EV owners' charging habits, and use of public EV charging (EECA, 2023b)	https://www.eeca.govt.nz/assets/EECA-Resources/Research-papers-guides/EECA-Public-Charging-Research-March-2023.pdf	Reports insights from an EV charging survey that EECA did in February 2023 (following an earlier survey in late 2021). Includes insights on how much public charger use there is (and how this changed between the two surveys), people's views on whether there are enough public chargers and the extent to which smart charging is used at home.
SNZ PAS 6010:2023 *Commercial electric vehicle (EV) charging*	https://www.standards.govt.nz/shop/snz-pas-60102023/	The publicly available specification (PAS) sponsored by EECA explains how to optimise EV charging systems to ensure EVs are safely and efficiently charged at commercial premises, including: • an overview of EV technology to guide public-facing businesses and supplies of EV supply equipment (EVSE) and associated equipment and services that want to use good practice for public and commercial EV charging • prescriptive technical requirements to comply with this PAS, including installation considerations for property owners and EVSE installers • an EVSE pre-purchase assessment tool (checklist) for business owners or senior managers responsible for managing vehicle fleets • references to WorkSafe safety requirements and NZTA guidance.

Item	Link	Description
Improving the performance of electric vehicle chargers (EECA, 2022b)	https://www.eeca.govt.nz/about/news-and-corporate/consultations/improving-the-performance-of-electric-vehicle-chargers/	This sought views on ways to improve the energy performance of private EV chargers. It focused on how private EV chargers can help improve energy outcomes in New Zealand. The paper included consideration of whether EV chargers should have to transmit information on their location and use and, if so, what information should be transmitted. The focus on in-home EV chargers in this paper means it's not directly relevant.
Electric vehicle charging technology: New Zealand residential charging perspective (KPMG, 2019)	https://www.eeca.govt.nz/assets/EECA-Resources/Research-papers-guides/EV-Charging-NZ.pdf	Early report focused on private at-home charging.
Interactive EV charger tool	Unpublished	This tool accumulates EV charger status updates streamed from EVRoam and converts them into a timeseries of inferred charger plugin events at each EV charger. It uses a simple statistical method for estimating at each EV charger site the number of EVs queuing for a charge and the number of missed charges due to the charger being occupied or unavailable. It then uses a traffic light system to highlight sites experiencing significant congestion. The tool presents data that could be commercially sensitive so is not publicly available.

A.1.9 FlexForum

FlexForum brings together individuals and organisations across the electricity ecosystem to work together to speed the delivery of distributed flexibility and maximise the benefits for households, businesses and communities. Its website is www.flexforum.nz.

Item	Link	Description
Flexible charging is an easy and obvious choice for EV owners, but… (Oliver, 2024)	https://flexforum.nz/flexible-charging-is-an-easy-and-obvious-choice-for-ev-owners-but/	A project in partnership with EECA with a focus on private charging that started with a workshop for industry participants to share their experience and perspective on the EV charging choices of households and businesses.
Flexibility Plan 1.0 (FlexForum, 2022)	https://flexforum.nz/flexibility-plan/	A plan that sets out initial steps for unlocking the value of distributed energy resources and flexibility in the electricity system. It identifies 39 steps across five areas – coordination and collaboration, data and information, technical requirements, processes, and regulatory settings. Delivering the steps will require input from a range of parties, including EDBs, Transpower, electricity retailers, regulators and policy makers.

A.1.10 Ministry for the Environment

The Ministry for the Environment is the government's primary adviser on environmental matters. It is also responsible for several regulatory systems, including climate change. Its role includes monitoring, reviewing and reporting on the climate change regulatory system to ensure it is having its desired effect. Its website is www.environment.govt.nz.

Item	Link	Description
Reducing barriers to electric vehicle uptake – Behavioural insights: Analysis and review (Ministry for the Environment, 2018)	https://environment.govt.nz/publications/reducing-barriers-to-electric-vehicle-uptake-behavioural-insights-analysis-and-review/	The purpose of the report was to identify barriers to EV uptake in New Zealand, discuss the attitudes and behaviour behind the barriers and propose ways to overcome them. The report finds that there were significant perceptual and behavioural barriers to increasing light EV uptake, including: • driving range concerns • New Zealanders expecting charging stations to be as prevalent as petrol stations and that charging time should be less than 5 minutes • the higher purchase price of EVs relative to ICE vehicles. The report concludes that changing the approach to education, awareness and marketing through behavioural insights might speed up EV uptake.

A.1.11 Ministry of Business, Innovation and Employment (MBIE)

MBIE has a range of responsibilities and functions, including in the areas of building and energy, business and employment, immigration and tourism, and science and technology. In the area of energy, MBIE is involved in work to improve energy efficiency, including lowering gas emissions and fostering growth in renewable energy. We contacted MBIE's Electricity Markets Policy Team. Its website is www.mbie.govt.nz.

Item	Link	Description
Challenges and regulatory policy solutions for integrating public EV charging stations: International case studies (Baringa, 2023)	https://www.mbie.govt.nz/assets/baringa-ev-international-case-studies-report.pdf	This report was commissioned by MBIE to support advice to the government on measures to support public EV charging and is focused on electricity network connection issues. The report presents international case studies describing how the UK and Australia are managing the transition towards EVs and supporting public EV charging infrastructure with a focus on regulatory policy solutions. The report considers four key elements of the regulatory framework and industry practice that impact the connection cost and connection timeliness for public EV charging: network visibility, connection process, connection charges and distribution use-of-system tariffs.
Measures for transition to an expanded and highly renewable electricity system (Ministry of Business, Innovation and Employment, 2023)	https://www.mbie.govt.nz/dmsdocument/26909-measures-for-transition-to-an-expanded-and-highly-renewable-electricity-system-pdf	This discussion paper was one of five MBIE released in August 2023. It discusses measures that might be needed to support a successful electricity system transition and touches on issues related to EV charging. It notes there are a range of challenges to connecting public EV chargers to distribution networks and says that these challenges will need to be addressed to achieve the necessary investment in public EV charging infrastructure ahead of demand.
Projections of electric vehicle fleet size (Ministry of Business, Innovation and Employment, 2015)	https://www.mbie.govt.nz/dmsdocument/4257-projections-of-electric-vehicle-fleet-size	This document provides a description of the method used to project the number of EVs and associated electricity demand used for the draft Electricity Demand and Generation Scenarios 2015.

A.1.12 Ministry of Transport

The Ministry of Transport is the government's primary adviser on transport. It provides advice about how the transport system needs to change to support the New Zealand economy and the transport needs of New Zealanders. It works closely with transport Crown entities (including NZTA) and is responsible for monitoring these Crown entities' performance. Its website is www.transport.govt.nz.

Item	Link	Description
Government to boost public EV charging network (Brown, 2024)	https://www.beehive.govt.nz/release/government-boost-public-ev-charging-network	Cabinet has agreed the work programme to include: • development of a cost-benefit framework for government co-investment in public EV chargers (led by Ministry of Transport working with EECA, MBIE, and Crown Infrastructure Partners) • reducing red tape and regulation, including removing the requirement for a resource consent for the installation of public EV chargers (led by MBIE and Ministry for the Environment) • enabling standards to improve consumers' capability to shift home EV charging demand away from network peaks (led by MBIE).
Charger siting optimisation	Unpublished	Proof of concept extension of MONTY transport modelling that selects sites for public charging to optimise travel and uses a representation of the New Zealand roading network. Journey mix is a key input. Optimisation objective can include minimising travel distance or minimising deflection from optimal routes.
Charging our future: Government EV charging work programme (2023–2026) (Ministry of Transport & Ministry of Business, Innovation and Employment, 2023a)	https://www.transport.govt.nz/assets/Uploads/EV-Charging-Work-Programme.pdf	A national EV charging strategy and government work programme (out to 2026) to support the strategy. The objective of the strategy is to improve EV charging infrastructure across New Zealand to ensure that New Zealanders can charge when and where they need to.
Charging our future: National electric vehicle charging strategy for Aotearoa New Zealand 2023–2035 (Ministry of Transport & Ministry of Business, Innovation and Employment, 2023b)	https://www.transport.govt.nz/assets/Uploads/EV-Charging-Strategy.pdf	
Monthly motor vehicle fleet statistics (Ministry of Transport, n.d.b)	https://www.transport.govt.nz/statistics-and-insights/fleet-statistics/sheet/monthly-mv-fleet	Data on fleet size by month. Includes breakdown by motor technology (eg, battery electric, hybrid diesel, hybrid petrol, etc), region and owner area type (eg, large/major urban, small/medium urban, and rural).

A.1.13 NZ Transport Agency (NZTA)

The Land Transport Management Act 2003 establishes NZTA and sets out its responsibility to contribute to an efficient, effective and safe land transport system in the public interest. NZTA has regulatory, infrastructure, planning and investment management functions in the land transport system. Its roles include managing and overseeing regulatory requirements for land transport, investigating and reviewing accidents involving transport on land, managing the state highway system, overseeing the planning and delivery of public transport and delivering (or managing the delivery of) research and training in relation to the land transport system. Its website is www.nzta.govt.nz.

Item	Link	Description
EVRoam (NZ Transport Agency, n.d.c)	https://www.nzta.govt.nz/planning-and-investment/planning/transport-planning/planning-for-electric-vehicles/evroam/	EVRoam is a cloud-based database based on real-time information form EV public charging infrastructure in New Zealand. It was developed to help NZTA monitor the development of the public charging infrastructure network.
Electric vehicle charging stations maps (NZ Transport Agency, 2024)	https://www.nzta.govt.nz/planning-and-investment/planning/transport-planning/planning-for-electric-vehicles/national-guidance-for-public-electric-vehicle-charging-infrastructure/enabling-a-nationwide-network-of-public-charging-infrastructure/	Maps of EV charging stations, including a live map that feeds off EVRoam and maps that are updated monthly.
Advice for road controlling authorities (NZ Transport Agency, n.d.b)	https://www.nzta.govt.nz/planning-and-investment/planning/transport-planning/planning-for-electric-vehicles/national-guidance-for-public-electric-vehicle-charging-infrastructure/enabling-the-development-of-public-charging-infrastructure/advice-for-road-controlling-authorities/	Advice to RCAs and consenting authorities, including: • recommending that RCAs restrict certain sites for EV charging and enforce this restriction • recommending that consenting authorities engage with charging operators early and noting that RCA approval is required for associated facilities.
Advice for consenting authorities (NZ Transport Agency, n.d.a)	https://www.nzta.govt.nz/planning-and-investment/planning/transport-planning/planning-for-electric-vehicles/national-guidance-for-public-electric-vehicle-charging-infrastructure/enabling-the-development-of-public-charging-infrastructure/advice-for-consenting-authorities/	
National guidance for public EV charging infrastructure (NZ Transport Agency, n.d.d)	https://www.nzta.govt.nz/planning-and-investment/planning/transport-planning/planning-for-electric-vehicles/national-guidance-for-public-electric-vehicle-charging-infrastructure/	Provides links to NZTA's guidance on public EV charging infrastructure and includes: • information for users of public EV charging infrastructure (including information on the different charging systems, safety precautions and emergency procedures) • implementation recommendations for setting up a public charging facility.

A.1.14 Transpower

Transpower is New Zealand's national grid owner and system operator. As the grid owner, Transpower manages the flow of electricity across New Zealand's high voltage national electricity transmission grid. As system operator, Transpower is responsible for operating the wholesale electricity market through which generators sell electricity to retailers. Transpower's strategy is focused on future proofing the national grid for increased electricity demand from transport and process heat electrification and increased reliance on renewable generation. Its website is www.transpower.co.nz.

Item	Link	Description
Net Zero Grid Pathways (Transpower, n.d.)	https://www.transpower.co.nz/nzgp	Multi-year programme to investigate a series of enhancements to the existing grid (now to 2035) and future grid investments to enable electrification on the interconnected grid backbone (beyond 2035).
Transmission planning report (Transpower, 2023)	https://www.transpower.co.nz/our-work/industry/transmission-planning	An annual report on demand growth and grid investment pressures. It provides a plan for the grid backbone and 13 grid planning regions. It identifies areas where the grid is likely to become constrained and Transpower's plans for addressing constraints.
A roadmap for electrification (Transpower, 2021)	https://static.transpower.co.nz/public/uncontrolled_docs/Transpower_Electrification%20Roadmap_SCREEN3_LR.pdf?VersionId=zWH7t3oyvYzkLjWnYDJRrEvKXePWom6n	Transpower's thinking on electrification of process heat and transportation.
Distributed energy resources – understanding the potential (Reeve et al., 2020)	https://static.transpower.co.nz/public/publications/resources/Distributed%20Energy%20Resources%20-%20Understanding%20the%20potential%20-%20main%20report%20-%20final.pdf?VersionId=wY4wfpqjiE4gVgsLpCLX83h1n.4FS9Ub	A report on the role of distributed energy resources and the potential flexibility for the New Zealand energy system.
Whakamana i te mauri hiko – Empowering our energy future (Transpower, 2020)	https://www.transpower.co.nz/about-us/our-strategy/whakamana-i-te-mauri-hiko-empowering-our-energy-future	A report discussing Transpower's thinking on the potential energy futures for Aotearoa New Zealand.

A.1.15 University of Auckland

The University of Auckland has several research centres. We contacted the Energy Centre (based in the Economics Department with strong links to the School of Engineering and Faculty of Science) and the Transportation Research Centre, which conducts research related to transportation engineering. Its website is www.auckland.ac.nz.

Item	Link	Description
Analysing EV users' intention to use dynamic wireless charging facilities: A study from New Zealand (Majhi et al., 2024)	https://researchspace.auckland.ac.nz/handle/2292/67922	Presents a study using an online staged preference survey and structural equation modelling approach that investigates EV users' intention and acceptance of dynamic wireless charging technology.
Investigating facility allocation and public acceptance of dynamic wireless power transfer system for electric vehicle charging (Majhi, 2023)	https://researchspace.auckland.ac.nz/handle/2292/68451	This PhD thesis discusses design issues of dynamic wireless power transfer (DWPT) charging systems. evaluates research on effective placement of DWPT facilities. compares the performance and economic feasibility of DWPT to plug-in charging on the Auckland motorway network using a traffic simulation-based framework and reports results of an online survey to investigate the acceptance and intention of DWPT technology among EV users in New Zealand.

Item	Link	Description
Optimal allocation of dynamic wireless charging facility for electric vehicles (Majhi et al., 2022b)	https://doi.org/10.1016/j.trd.2022.103461	Investigates the dynamic wireless charging (DWC) allocation problem from the decision maker's perspective to minimise individual users' costs and the investment cost. The paper proposes a mixed-integer optimisation model to achieve a cost-effective solution for the optimal placement of DWC facilities on the large road network while maintaining an acceptable state-of-charge level.
Assessment of dynamic wireless charging based electric road system: A case study of Auckland motorway (Majhi et al., 2022a)	https://doi.org/10.1016/j.scs.2022.104039	This paper examines the impact of dynamic wireless charging-based electric road systems on EV flow and energy consumption using a traffic simulation-based methodological framework. The paper includes a case study for the Auckland motorway network and consideration of the financial feasibility of dynamic wireless charging against a plug-in system.
A spatio-temporal approach to electric vehicle uptake: Evidence from New Zealand (Sheng et al., 2022)	https://doi.org/10.1016/j.trd.2022.103256	Uses spatial negative binomial regression models to estimate spatio-temporal factors that influence consumers' EV purchase decisions. The paper tests two hypotheses of whether: • charging infrastructure has a neighbourhood effect on EV uptake • EV adoption by technology enthusiasts during the early-adopter phase affects subsequent adoption once the technology becomes widely spread. Results show that charging infrastructure in neighbouring areas and early adoption positively affect subsequent technology adoption. It concludes that policy initiatives aiming to increase electrification of transport should consider the likelihood of early adoption and the spatial proximity of charging infrastructure.
A systematic review of charging infrastructure location problem for electric vehicles (Majhi et al., 2021)	https://doi.org/10.1080/01441647.2020.1854365	The first part of the paper ranks wireless power transfer technologies for EV charging based on technological and system readiness. The second part assesses different modelling approaches used to analyse the transportation network and to locate both static and wireless EV charging facilities.
Economic analysis of dynamic inductive power transfer roadway charging system under public-private partnership – Evidence from New Zealand (Sheng et al., 2020)	https://doi.org/10.1016/j.techfore.2020.119958	Assesses the economic viability of a dynamic inductive power transfer system for EVs through public-private partnership (PPP) using a net-present value framework. The research found: "for a 15-year concession period under PPP where the private investor is expecting a 12.5% return, the government can contribute 9.46% towards the initial investment and charging roadway users a toll of 37 cents/kWh".

A.1.16 University of Canterbury (including EPECentre)

The University of Canterbury has many research centres, including the Electric Power Engineering Centre (EPECentre), a research centre for electric power and clean energy applications. EPECentre brings together industry, researchers, academia and students to foster innovation. We contacted the EPECentre. Its website is www.canterbury.ac.nz.

Item	Link	Description
Generic EVSE efficiency test procedure and generic EVSE OCPP test procedure (EPECentre, 2023)	https://www.eeca.govt.nz/assets/EECA-Resources/Generic-EVSE-Efficiency-Test-Procedure.pdf (appendices)	This project evaluated the efficiency of some level 3 DC fast chargers and level 2 AC home chargers. The project included: • compliance testing of EVSE manufacturers' implementation of the Open Charge Point Protocol (OCPP) • insights into EV internal charging efficiencies • investigation of battery management system responses (active thermal management strategies) of some of the most common EVs in New Zealand.
Modelling the hosting capacity of Orion's low voltage network for EV charging (McNab et al., 2021)	https://ir.canterbury.ac.nz/server/api/core/bitstreams/bb9bf406-7b99-4a6a-a753-f3c62147b9c6/content	This paper was the second stage of Orion's assessment of low voltage network performance in the face of increasing levels of EV charging. The paper models 236 distribution transformers and their downstream LV networks on Orion's distribution network using a probabilistic methodology developed by the EPECentre. The model captures a wide range of scenarios and encompassed data from New Zealand-centric inputs, including national travel surveys, household smart meter demand profiles and the EV fleet composition. Modelling focuses on at-home EV charging.

A.1.17 University of Waikato

The University of Waikato has 12 schools and faculties, including a faculty of law. Its website is www.waikato.ac.nz.

Item	Link	Description
Electric vehicle policy: New Zealand in a comparative context (Barton & Schütte, 2015)	https://www.researchgate.net/publication/286449668_Electric_Vehicle_Policy_New_Zealand_in_a_Comparative_Context	An analysis of the laws and policies that can be put in place to encourage the uptake of EVs in the light vehicle fleet.