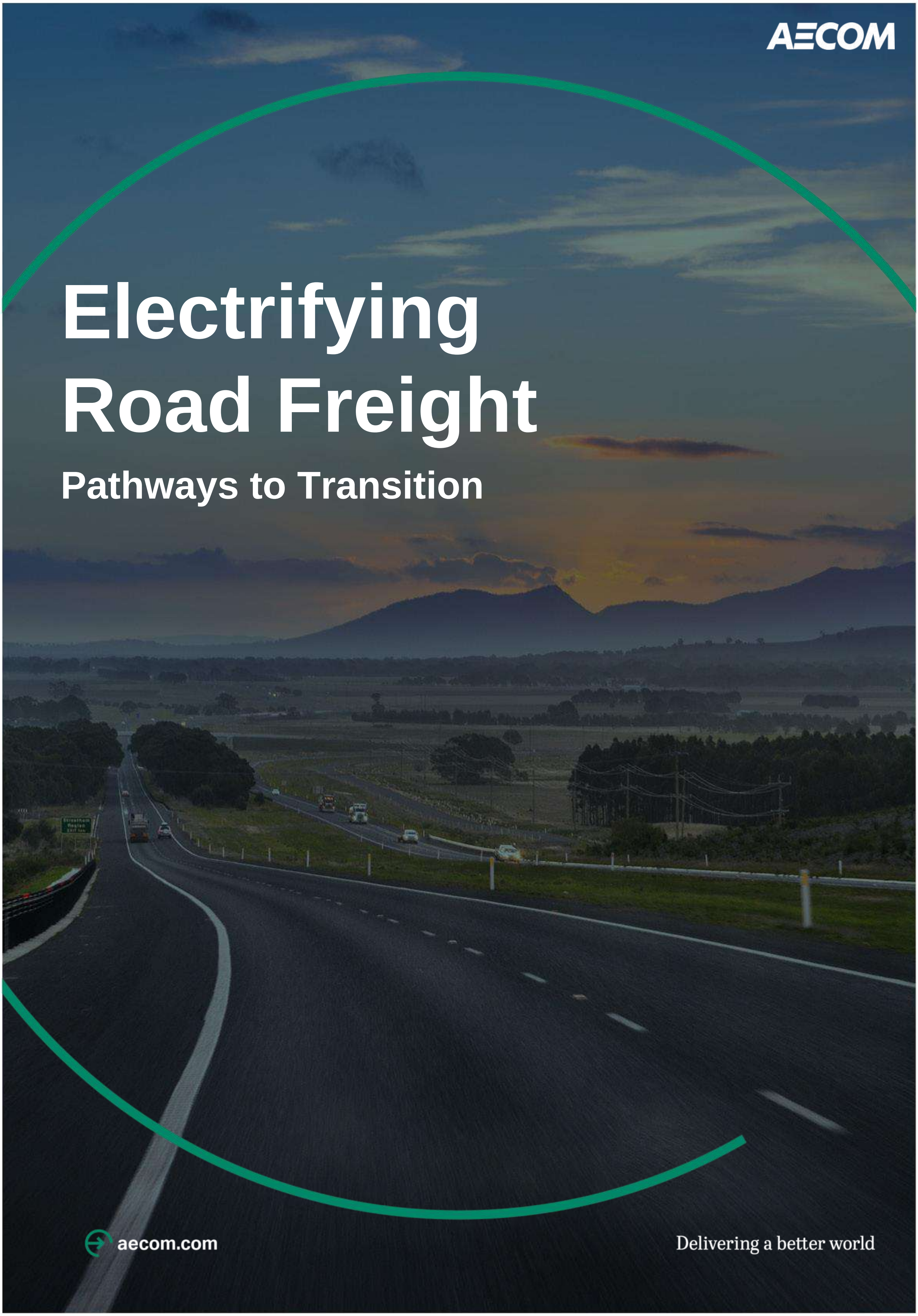

Electrifying Road Freight

Pathways to Transition

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Delivering a better world

Disclaimers

Table of Contents

Glossary

ABS	Australian Bureau of Statistics
AC	Alternating Current
ADR	Australian Design Rules
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
ARENA	Australian Renewable Energy Agency
BITRE	Bureau of Infrastructure, Transport and Regional Economics
BESS	Battery Energy Storage System
BEV	Battery Electric Vehicle
DC	Direct Current
DNSP	Distribution Network Service Provider
ESOO	Electricity Statement of Opportunities
GDP	Gross Domestic Product
GHG	Green House Gas
GVM	Gross Vehicle Mass
GWH	Gigawatt Hours
HV	High Voltage
ICE	Internal Combustion Engine
KV	Kilovolt
KWH	Kilowatt Hours
LCV	Light Commercial Vehicle
NEM	National Energy Market
NHVR	National Heavy Vehicle Regulator
NSP	Network Service Provider
NWIS	Northwest Interconnected System
OECD	Organization for Economic Cooperation and Development
SME	Small-Medium Enterprises
SWIS	Southwest Interconnected System
TNSP	Transmission Network Service Provider
WEM	Wholesale Electricity Market

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Executive Summary

Australia's road freight industry is an economic powerhouse, contributing 8.6% of our GDP[1]. The industry achieves a remarkable feat, moving the seventh largest volume of freight in the OECD, despite a relatively smaller population, GDP and absence of land borders.

Road freight not only connects communities but also underpins Australia's economic resilience and productivity.

The industry stands at a critical phase. Road freight accounts for over 80% of freight emissions and around one-third of Australia's total transport emissions - equivalent to 36 million tonnes of CO_2 annually. As freight is expected to grow by 77% by 2050[2], electrifying this sector is essential to meeting our national climate goals[3]. Electrifying this critical sector is no longer optional, but essential.

To enable this, we must ensure electrification addresses the core use cases in the Road Freight sector: **Urban Freight**, **Intrastate Freight**, and **Interstate Freight**.

By understanding the operational models, vehicles, and trips of each use case, as well as wider market trends a picture emerges of the potential of electrifying Road Freight.

Key Finding 1: Urban Freight is already on a pathway to electrification as the most feasible use case to electrify first.

Urban Freight represents the most feasible opportunity to electrify now, owing to the available vehicle types, smaller travel distances and operational patterns. There are urban freight electrified fleets successfully operating now.

Meanwhile, Intrastate Freight and Interstate Freight represent medium—to longer-term opportunities. These use cases need further assessments, planning on key routes and charging locations, and market development.

Underpinning this is the need to ensure that the energy grid can service the additional energy demands of a fully electrified road freight sector.

This study developed a new assessment methodology, drawing on freight movement datasets, energy forecast datasets, stakeholder input, and subject matter expert input to quantify energy demand in a fully electric freight future.

Freight moving within cities and towns

Freight moving within a single state or territory's regions

Freight moving between states and territories

[1] Department of Infrastructure, Transport, Regional Development, Communications and the Arts, Freight and Supply Chains
[2] BITRE, 2022 Australian aggregate freight forecasts – 2022 update
[3] BITRE, 2023. Australian Infrastructure and Transport Statistics - Yearbook 2023

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Key Finding 2: Energy generation will not be the key determining factor in freight electrification.

This assessment found that while additional energy generation is needed, energy generation forecasts appear sufficient to meet the needs of the sector. Energy transmission and distribution networks pose a more serious challenge to the future of freight electrification – particularly to support interstate and intrastate freight rollouts.

Key Finding 3: Intrastate and Interstate freight should be staged to identify and enable charging solutions on national highways.

This report outlines a first of its kind national overview of a future electrified freight network of up to **165 future freight charging hubs**. However, this is only an initial assessment, and more work will be needed to further localise.

Finding 4: All levels of Government should work together to further refine and localise future electric freight networks.

While this report outlines important national steps to advance the transition to electric vehicles, further work is needed from state and local governments to refine localised strategies to ensure networks address local conditions.

Key Finding 5: Significant Cross-Government focus is needed to address policy and regulatory barriers to freight electrification

Though significant barriers remain. Engagement with industry and workers indicates that upfront vehicle costs, limited model availability, and operating conditions established by policy and regulatory regimes are inhibiting adoption.

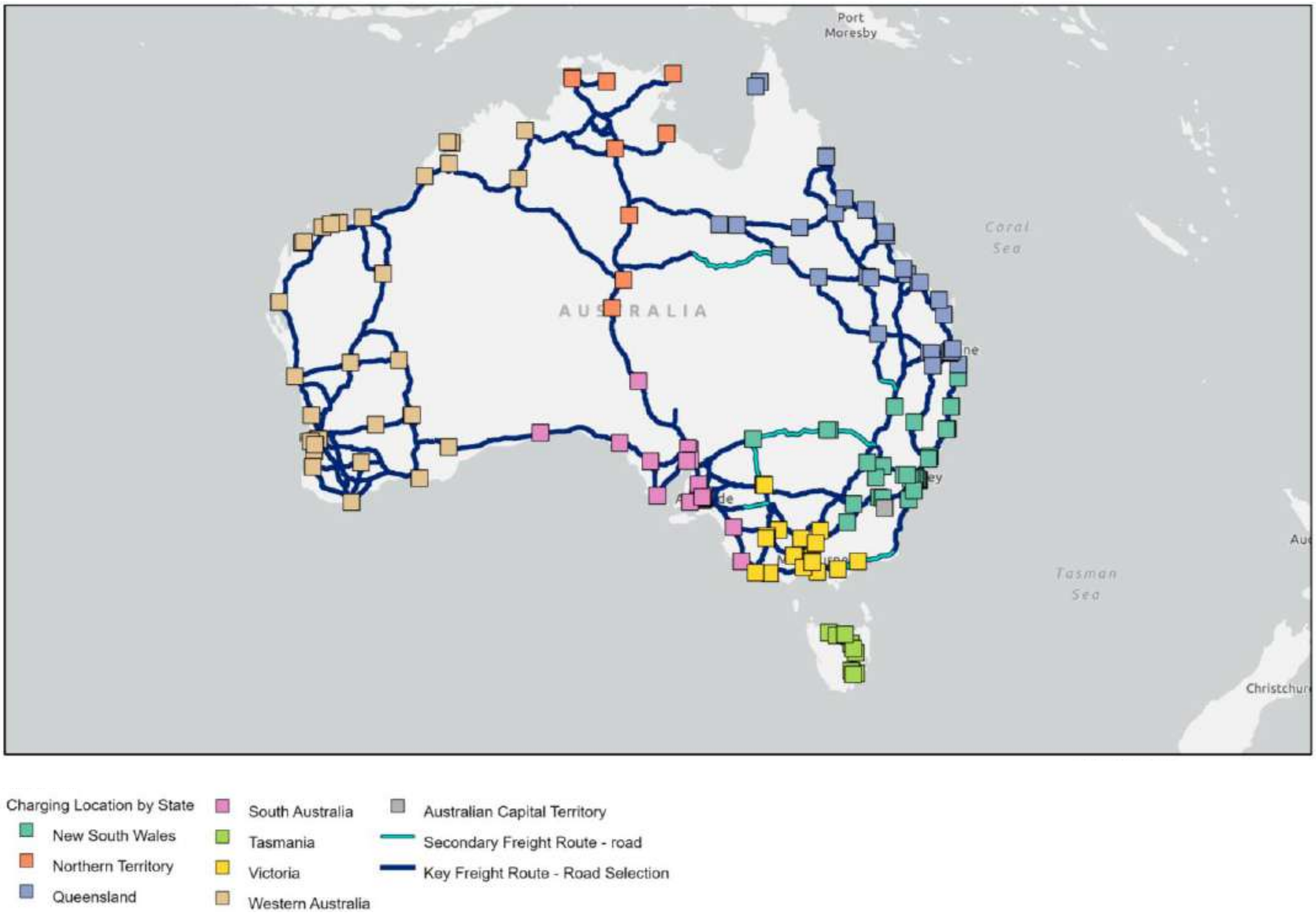
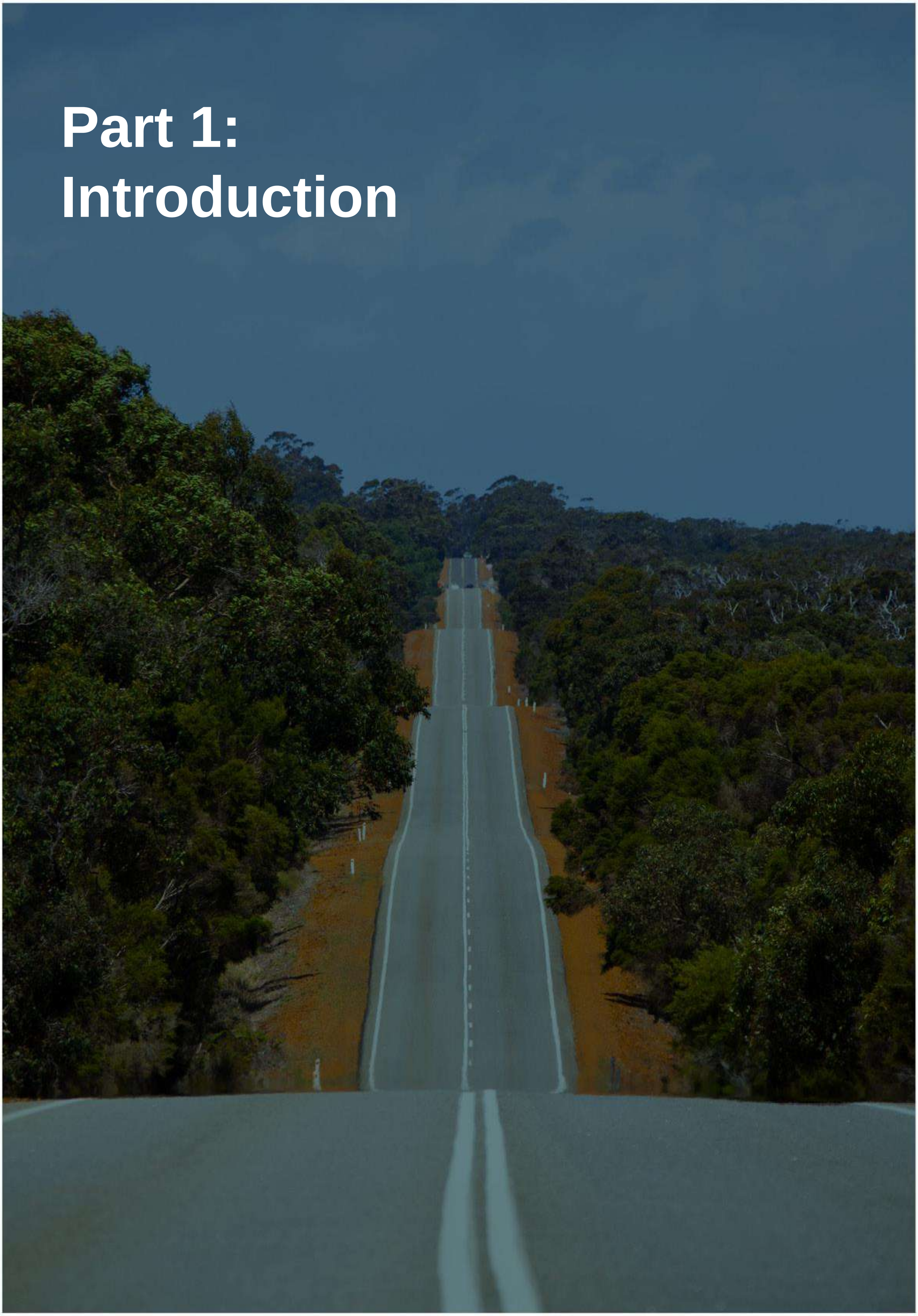


Figure 1 National Charging Network Map

To overcome these barriers, build on current successes, and work together as an industry towards decarbonisation, we have identified **21 discrete actions** across 5 key themes, as set out below.

Theme		Action
Demonstration Projects	1	**Urban Shared Charging** *Potential locations: (1) Western Sydney; (2) North Melbourne; (3) Western Brisbane* **Regional Highway Charging** *Potential Locations: (1) Pacific Powered Highway, Sydney to Newcastle; (2) Electric Coast Highway, Brisbane to Gold Coast; (3) Western Charged Highway, Melbourne to Ballarat*
Strategy and Policy	2	Develop a National Freight Electrification Strategy, including use case specific transition targets
	3	Work across all levels of Government to review the outcomes of this study and to develop localised approaches to state networks
	4	Work across all levels of Government to align regulatory pathways for Electric Vehicle use and remove potential barriers or provide regulatory incentives to adopt Electric Vehicle models (e.g. Licencing, Design Controls, Access)
	5	Develop Electric Vehicle standards and targets for Government owned freight assets and operators (e.g.: Intermodal terminals, Ports)
	6	Look to establish a Heavy Vehicle electrification tracking program, and how to best capture Electric Vehicle freight data as part of national data provision requirements
	7	Develop process standards for facilitating electrical upgrades and connections to logistics hubs, considering state/DNSP and demand
Market Support and Shaping	8	Develop a central portal for industry to access both with skills training resources and to facilitate industry access to Australian firms with electrification expertise
	9	Establish regular and routine knowledge sharing between Government and Industry to explore pilots, identify challenges, and leverage opportunities
	10	Engage directly with Owner-Operators and drivers to assist with change management
	11	Work with DNSPs to understand transition pathways, demand levels, and timelines for freight electrification and leverage learnings from development of Electric Vehicle infrastructure for fleets and bus depots
Funding Electrification	12	Fund local vehicle manufacturing to support Electric Vehicle uptake and explore opportunities to fund or support small operator access to vehicles
	13	Continue to fund specific use case pilot projects and share lessons learnt
	14	Investigate funding options to support freight customers and freight hubs to electrify assets
	15	Explore renewable energy solutions (Solar, Wind, BESS) for Electric Vehicle freight charging in remote and isolated locations
Infrastructure Delivery	16	Identify core freight routes along the suggested network staging and investigate route requirements and corridor preservation needs
	17	Identify charging locations on key routes and consider preparatory works or alignment with the delivery of other energy projects
	18	Deliver charging hubs along major freight routes, including driver facilities
	19	Support regular collaboration between DNSPs and Logistics operators with a focus on early identification of remote or large-demand locations
	20	Explore network redundancy and resiliency in terms of the number of locations and energy supply (particularly for remote locations) and prioritise interventions in line with recommendations of this study (i.e. focusing on national corridors)
	21	Deliver renewable energy solutions in remote and isolated locations

Part 1: Introduction



The Opportunity at Hand

Road Freight in Australia is crucial to the nation's economy. Trucks traverse our vast distances connecting remote communities with urban centres and then on to global markets. In doing so, they help the freight industry contribute 8.6% of our national GDP[4] – moving up to 223 billion tonnes-kilometres of freight around the country [5] each year - a number expected to grow by 77%[6] in the coming decades.

However, all this movement means freight accounts for up to 40% of the transport sector's domestic carbon emissions – with road freight alone representing 80% of these[7].

Decarbonising Australia's road freight must be a key priority to reach net zero by 2050.

8.6% of National GDP

77% Growth in Road Freight to 2050

40% of Transport emissions

While the overall adoption of electric vehicles (EVs) in Australia has seen recent success as EV passenger vehicle sales increase market share, electrifying Australia's road freight fleet remains in its early stages. By contrast, international markets are seeing a growing embrace of electric freight[8].

The challenge, therefore, is to translate the success seen by early adopters both here and abroad into the unique operating environment of Australian road freight at scale.

To do so, government must be aware of some critical challenges within the freight industry. Chief amongst these is that the average operating margin of a freight operator is only 2%[9]. Further, the industry is made up of a high proportion of small-medium enterprises that own a small number of vehicles, of which the average age is over 14 years.

2% Average Profit Margin

98% of operators are SME's

14 Average Freight Vehicle Age

As such, the industry has very real concerns about the adoption of electric vehicles, from the high initial investment required, to range limitations, fears of battery replacement costs and a need for nationally consistent charging infrastructure.

While increasing market maturity and battery technology improvements will likely ease some of these concerns, charging infrastructure will likely remain a barrier to adoption without focused collaboration, planning and support between government and industry.

[4] Department of Infrastructure, Transport, Regional Development, Communications and the Arts, Freight and Supply Chains
[5] BITRE, 2022 Australian aggregate freight forecasts – 2022 update
[6] BITRE, 2022 Australian aggregate freight forecasts – 2022 update
[7] Climate Change Authority, 2021
[8] ICCT 2023. Europe's Electric Truck Market Surges
[9] ATA, 2023

The Project Purpose

Road freight serves a diverse range of purposes, with each trip presenting its own unique requirements and challenges. Freight vehicles span from large articulated trucks and road trains down to smaller trucks and vans depending on specific logistical needs. Similarly, the distances covered can vary widely – from short urban last-mile deliveries to the vast journeys of interstate freight crisscrossing the country.

While the current road freight industry is dominated by traditional internal combustion engine vehicles (contributing to 36,442,000 tonnes of GHG emissions in 2023[10]), it is clear that to achieve our national climate goals, and to increasingly respond to growing customer demand, as well as recent climate reporting requirements, that the industry must change to adopt new and cleaner vehicle options.

This report seeks to explore the challenges and impacts of transitioning road freight to a battery-electric future. Identifying the current market dynamics and conditions operators face, trends in current and future vehicle or technology markets, exploring the sector's central use cases as well as the potential energy demand of each, and, critically, what impact on energy supply may be expected in an electrified future.

There are three key items to consider when reading this report.

1. **The report considers Road Freight exclusively, rail, sea and air freight are excluded.**
2. **The report considers a transition to battery electric vehicles (BEVs) only. While other alternative fuel solutions may prove effective for some use cases, for the purposes of this report only BEVs have been considered (due to their current and expected availability in the market).**
3. **The report seeks to understand the overall impact of a widespread adoption of BEVs in the road-based freight sector by 2040. As such ambitious EV uptake targets have been used to understand what factors and impacts need to be considered should a high freight EV uptake target be adopted.**

[10] BITRE, 2023. Australian Infrastructure and Transport Statistics - Yearbook 2023

Study limitations

The project is underpinned by data collation sourced from publicly available freight and energy data. In conducting the study AECOM has reviewed the current and upcoming market conditions for freight vehicles and vehicle charging, estimated energy demand, outlined grid impacts and provided recommendations for next steps. This report has been prepared at a high level with most of the data and discussion reflecting either national or state level.

As the data used to inform the use cases as outlined above has been sourced from publicly available sources which are subject to the following limitations:

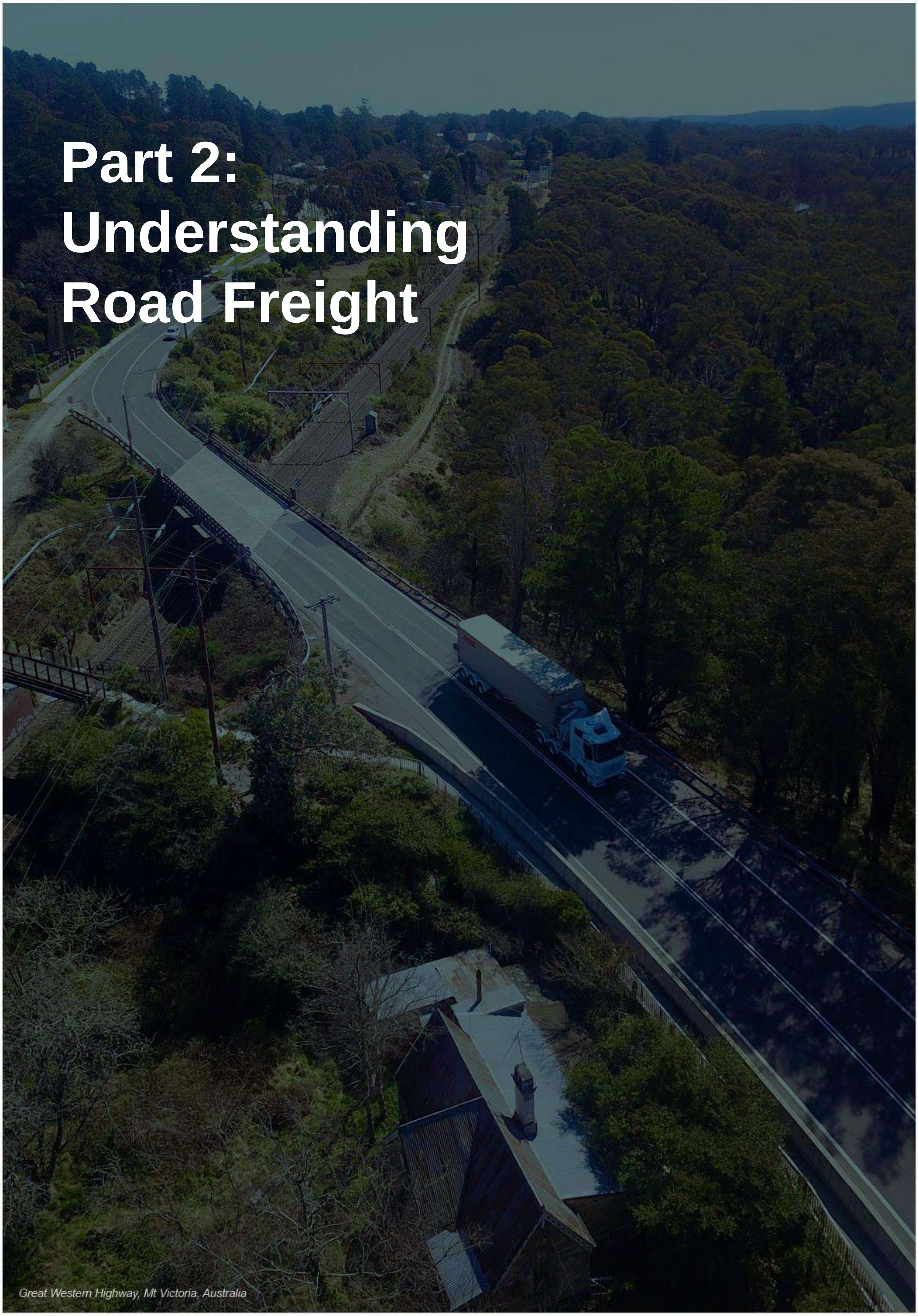
1. The primary data source used to determine the three use cases is the ABS Survey of Motor Vehicle Use 2020. This formerly recurring publication was discontinued in 2020. Whilst this publication is four years old, it is deemed to be a suitable proxy for the high-level nature of this project.
2. The light commercial vehicle category has been considered in its entirety in the data analysis phase of this project. It is understood however that as the category considers vehicles including Utes and vans it is likely a proportion of these vehicles are conducting personal trips with no relation to freight movements – however due to these vehicles capacity for freight, the challenge with determining an effective segmentation, and to allow for our energy assessment to act as a greater ‘stress’ test on the grid they have been included as a singular vehicle class.
3. As noted by the National Heavy Vehicle Regulator (2017)[11] the ABS Survey of Motor Vehicle Use did not consider vehicles which are not currently in use. As agreed with ARENA, this reporting has not made adjustments to the ABS’s data due to the high-level nature of this project.
4. Energy forecasts have been taken from publicly available forecasts produced by AEMO. These forecasts outline a forecast energy supply and demand to 2035.
5. The data sourced for this study included only transmission infrastructure across Australia, the majority of which are at voltages of 110kV and above. The data does not include Distribution Substations or other HV lines.
6. A future reference year of 2040 has been used to calculate future fleet and energy demands. This has been selected to reduce greater uncertainty in data extrapolation, and more closely align with energy supply forecasts.
7. Vehicle movement data from vehicle counters and visualisation of truck GPS data has been utilised at a high level to understand key routes and some central locations. Exact vehicle numbers at selected locations have not been identified or forecasted out to 2040. Future work will be required to further refine and determine localised demand.

Due to the challenges with publicly available data throughout this project, additional recommendations for digital infrastructure improvements have been included.

Any future projects stemming from this project should consider the above limitations.

[11] NHVR, 2017. Age of heavy vehicle fleet and non-conformity

Part 2: Understanding Road Freight



Great Western Highway, Mt Victoria, Australia

Road Freight in Australia Today

What is a freight vehicle?

Freight vehicles vary widely, ranging from small vehicles through to large road trains. Underlying this variety is a set of core approved vehicle designs established by the **Australian Design Rules**[12] (ADR). These offer specific standards for aspects ranging from vehicle dimensions and weight to the number of axles and trailers permitted. Building on these standards, the Austroads Vehicle Classification System in turn provides another framework for categorising vehicles by size, configuration, and usage. This system includes 13 distinct vehicle classes, ranging from Class 1 (short vehicle) to Class 13 (triple road trains)[13].

In the face of this variety of vehicles, this report has adopted a simpler approach to classifying freight vehicles, based on the Australian Bureau of Statistics (ABS) classification approach used in the Survey of Motor Vehicle Use 2021. This defines a set of broad classifications to all motor vehicles in Australia with freight vehicles encompassed within just three basic categories (Figure 2).

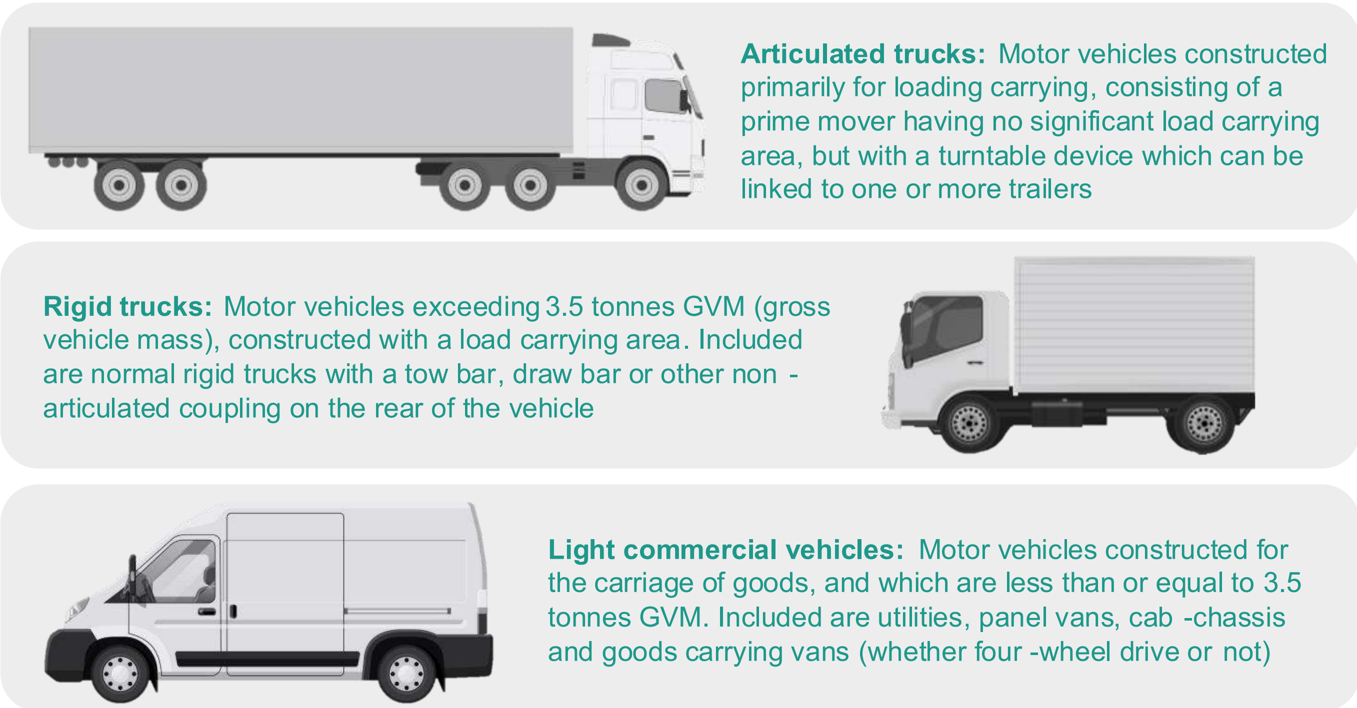


Figure 2 ABS Freight Vehicle Classifications

By adopting these simpler classifications, the complexity of vehicle typologies can be captured and assessed using existing ABS data, while also allowing for a broader accessibility of this report's findings – without requiring detailed technical knowledge of vehicle design specifications.

It should be noted that the ABS classification of Light Commercial Vehicles (LCV's) does encompass a broad swath of vehicles, including standard Utility Vehicles, which are a highly popular model of vehicle with the general public.

While it is understood that many these LCV's may not be utilised to transport freight or large loads frequently, in order to leverage available datasets, as well as to reflect their underlying design potential, they have been incorporated into this assessment as a consolidated batch of vehicles.

[12] Australian Design Rules
[13] Austroads: Vehicle classification

The Road Freight Industry at a Glance

Australia's road freight industry is a crucial part of the national freight network - with around 30% of the freight task in 2020 being undertaken by road freight[14]. The industry is a complex supply chain of interconnected operators of varying size fulfilling an ever-growing freight task.

Operating within a complex regulatory environment, spanning across all levels of government, and influenced by local operating conditions, and commercial demands. Together, the industry keeps Australia running, and punches above its weight globally in terms of sheer output compared to other countries (Table 1).

Table 1 Comparison of National Road Freight Tonne-Kilometres

OECD State	Annual Tonne-Kilometre (2022)	National Population (2022)	Annual Tonne-Kilometre per person
1. **United States**	3 trillion	333 million	9,009
2. **Poland**	406 billion	37 million	10,973
3. **Turkey**	323 billion	84 million	3,845
4. **Germany**	303 billion	83 million	3,651
5. **Spain**	266 billion	47 million	5,660
6. **Mexico**	256 billion	128 million	2,000
7. Australia	234 billion	26 million	9,000

The Australian Road Freight industry achieves a herculean task, moving the seventh largest volume of freight of any country in the OECD – despite having a smaller population, a smaller GDP, and the absence of land connection to other markets.

Electrification has the potential to make every kilometre cheaper and more efficient.

To further understand the Australian road freight industry, several key factors should be considered that underscore some of the operational realities that are likely to impact on electrification.

Regulations

The National Heavy Vehicle Regulator (NHVR) serves as the primary federal authority administering the Heavy Vehicle National Law. The NHVR provides a consistent approach to heavy vehicle regulation nationally, enhancing safety and productivity. States in turn retain authority over some aspects including licencing and access.

Additionally, access to the road network for heavy vehicles is governed by local, state and federal laws and regulations that dictate permissible routes, vehicle sizes, and operating times. These are designed to protect infrastructure and ensure public safety or amenity but can pose operational challenges. For instance, restrictions on certain routes may require longer travel distances, increasing operational costs and time. Additionally, curfews in urban areas to limit noise impacts can limit delivery times, affecting service efficiency. Overall, this provides effective regulatory oversight, but at times can result in a complex system to navigate.

Impact on Electrification: Regulatory controls can affect electric truck availability and operations, as well as potential carrots to electrification in terms of extended hours of operations, regulatory easing.

[14] BITRE 2022. Australian aggregate freight forecasts

Small operators

Whilst largescale logistics enterprises play an important role in Australia's freight industry, 98% of operators are small-to-medium enterprises (SMEs) with 70% having only one truck[15]. This can lead to challenges in achieving economies of scale, accessing capital for investment in newer technologies, and navigating regulatory requirements.

Impact on Electrification: The industry may have limited or varying capacity for rapid scale change.

Low Margins

The industry has a median profit margin of only 2%[16]. This creates financial constraints that can hinder investment in fleet upgrades and technology adoption. Low margins increase vulnerability to external shocks, price fluctuations and economic downturns. This financial pressure necessitates a focus on operational efficiency and cost management.

Impact on Electrification: Limits the capacity to bear the upfront capital costs associated with acquiring BEV vehicles and infrastructure - despite the operational cost efficiencies BEVs can offer.

Age of Operators

The industry's workforce is aging, with 57% of truck drivers aged 45 or older[17], a significant proportion of drivers and operators are approaching retirement age. This demographic trend raises concerns about the future availability of skilled labour and the potential loss of industry knowledge to support a transition – as many drivers function as owner-operators. Conversely, over the timeline of a 10-15 year fleet transition this aging workforce may see a consolidation of the industry into larger enterprises.

Impact on Electrification: Timelines for fleet transition should consider changing market dynamics that may make electrification more viable as older owner-operators retire.

Design Controls

Australia utilises a national framework to regulate vehicle design through the ADR. These regulations specify the allowable dimensions and weights of specific vehicle classes. These classes in turn inform associated controls and regulations of vehicle use and access. However, controls on vehicle weight limitations – adopted to maintain road safety and infrastructure integrity – do not currently allow for any special consideration for the additional weight of onboard batteries (without an extraordinary exemption).

Non-compliance can result in penalties and increased scrutiny from relevant local, state or federal bodies. Operators must ensure their vehicles are loaded within prescribed limits, considering factors including axle load distribution and total vehicle mass align with both federal and state regulations.

Impact on Electrification: Operators may find it challenging to import or purchase electric variants that meet design requirements.

Licensing

Heavy vehicle licenses vary by state but are typically categorised based on the Gross Vehicle Mass (GVM) and configuration of the vehicle, with greater weights requiring more advanced licences to be held by drivers. Progression to higher license classes typically requires holding a lower-class license for 1–2 years and completing additional training and assessments depending on the jurisdiction[18].

However, as BEV variants often have a greater GVM, this can create operational hurdles for operators by requiring more advanced licences be held by drivers operating BEVs compared to the same model ICE variants.

Impact on Electrification: Current licencing challenges can discourage operators adopting BEVs.

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[15] EVC & ATA, 2022.
[16] ATA, 2023.
[17] ABS, Jobs and Skills – Truck Drivers
[18] Transport for NSW, Getting a heavy vehicle licence

Industry perspectives on electrification

Given this operating environment, stakeholders interested in freight's future cut across Government, Industry, and Unions.

Despite this broad range of stakeholders, a common consensus exists. Namely that while there is growing interest in freight electrification, a number of barriers remain. With some stakeholders suggesting that without greater government support and investment that the industry will not be able to meet 2050 emissions targets.

These barriers (Figure 3) primarily relate to the cost and availability of vehicles and infrastructure. Particularly the potential impact on operators with smaller margins, for whom the capital costs of BEV's may be challenging.

Notably, while operational challenges initially ranked low in initial discussions, further conversations routinely raised the need for operational alignment of BEV's and charging with commercial operations as a key concern.

> **"Even if the cost of vehicles and infrastructure can be reduced, if vehicles and infrastructure do not align with the operational realities of the industry, adoption may remain limited."**
>
> - *Industry Feedback*

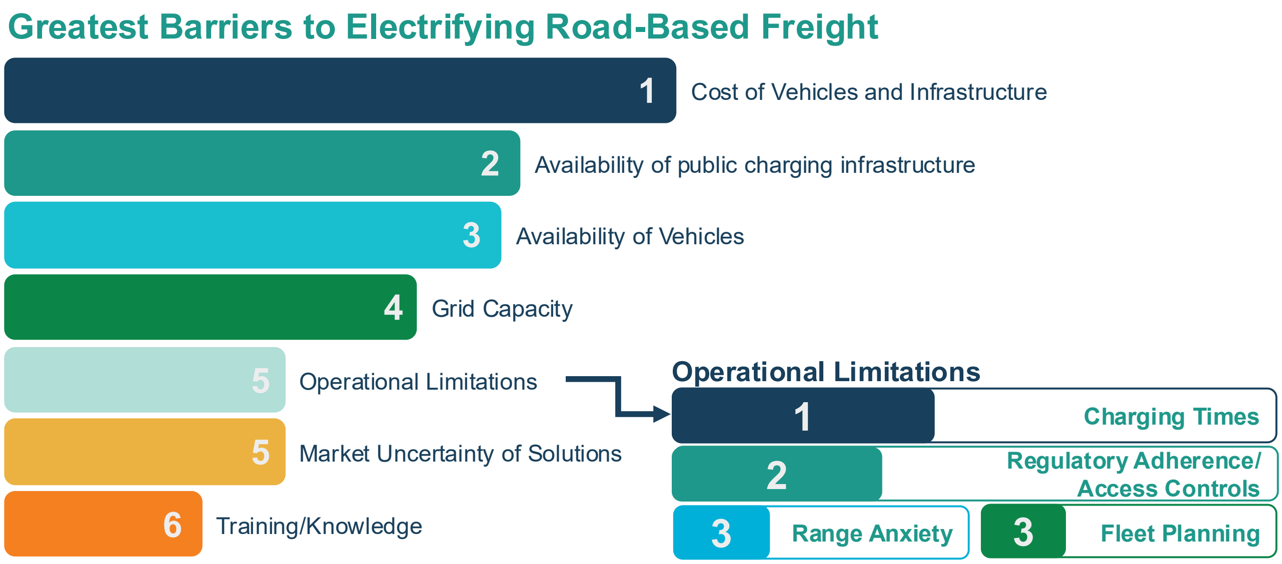

Figure 3 Stakeholder identification on key barriers to freight electrification

Stakeholder Identified Opportunities to Support Electrification

Utilise freight customers to support electrification

To avoid a top-down push from Government, attention should be placed on freight clients for a market led push for decarbonised supply chains.

Leverage regulatory easing to incentivise electrification

Ease regulatory barriers in a targeted manner (where safe to do so) to create operational 'carrots' for electrification.

Further improve access to knowledge and data

Leverage existing industry interest by advancing more trials - and shouting about them, while providing access to knowledge and skills.

Understanding the Freight Fleet and Ecosystem

The average freight vehicle in Australia is over 14 years old, while this is not vastly dissimilar to the average passenger vehicle age - 11.8 years[19] – it represents a much longer fleet hold time than non-freight related commercial fleets, which typically operate on a replacement cycle of roughly 3-5 years[20].

However, there is a high degree of variability within freight vehicle ages based on the type of vehicle (Figure 4). Smaller vehicles typically lean more towards the national passenger fleet average (10 years), while larger vehicles, particularly larger rigid trucks, are utilised the longest. Suggesting smaller vehicle cycles are more suited to earlier EV fleet adoption.

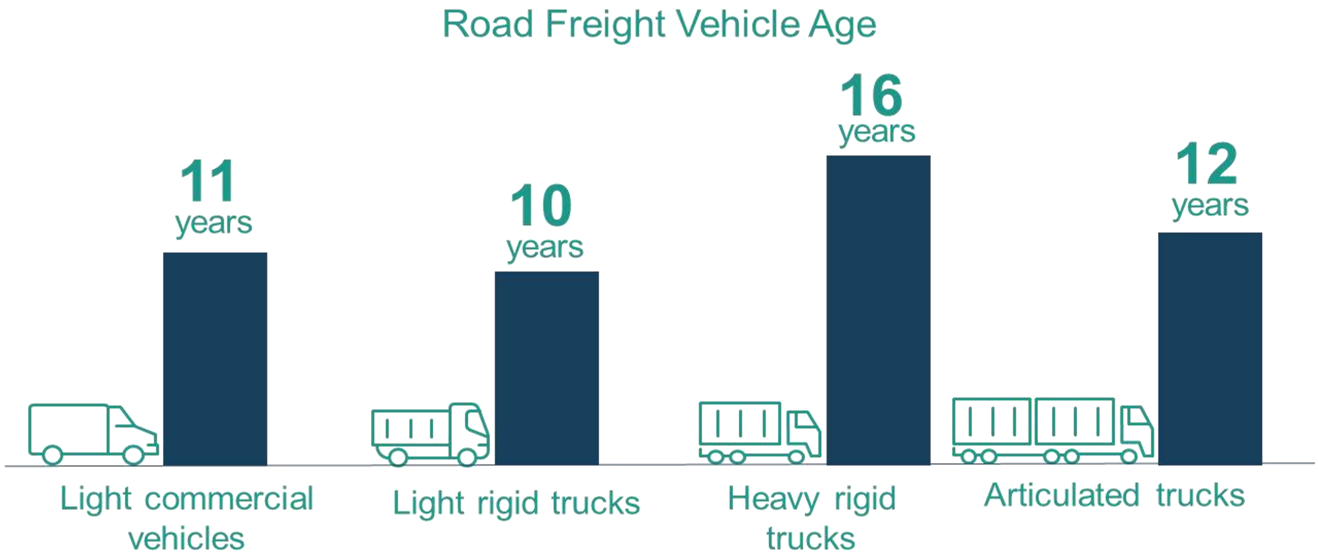

Figure 4 Average freight vehicle age (Source: BITRE, Road Vehicles, 2023)

Feedback from industry suggests that these replacement cycles can further vary based on an individual operators' commercial strategies, by market conditions at a given time, or even by state/region. As such it can be difficult to quantify a typical replacement rate.

It is understood that larger operator's trend towards quicker fleet cycle rates (roughly every five years) to keep up with new technology and to benefit from enhancements to fuel efficiency or safety technology. While also leveraging their greater buying power and relationships with manufacturers to reduce acquisition costs where possible[21].

Smaller operators typically replace fleets over a longer period as the capital investment required for a new truck is proportionately higher and so are more likely to purchase used vehicles – resulting in a typically older overall fleet[22].

This ecosystem of fleet cycling underscores the need for a strategic and phased approach to electrification. Aligning the transition to EVs with fleet replacement dynamics, to minimise operational disruption, reduce upfront costs, and ensure that charging infrastructure and grid upgrades are delivered in time to support demand.

A poorly coordinated transition could lead to infrastructure bottlenecks, underutilisation of new technologies, and increased costs for operators required to replace vehicles prematurely.

The industry is made up of a natural interconnected network - as older vehicles 'flow' through the market from larger to smaller operators – preserving this ecosystem is critical to market competition.

- *Industry Feedback*

[19] BITRE, 2024. Road Vehicles Australia – January 2024
[20] NRMA – How long should you keep a fleet vehicle?
[21] ARENA, 2024. Stakeholder Consultation
[22] ARENA, 2024. Stakeholder Consultation

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Australia: From Capital Cities to Cattle Stations

From dense urban cities, through to the desert outback, our freight network must remain robust enough to serve the whole country. Both to ensure economic productivity, but also to provide resources for the communities that most need them. In particular, our remote and indigenous communities who rely on trucks traveling sometimes thousands of kilometres to bring critical supplies and connection.

To connect the nation, dedicated national freight routes have been designated as shown in Figure 5. These provide pre-approved routes for freight vehicles with supporting infrastructure along the way such as rest stops and NHVR operated weigh stations. While this provides a baseline level of national connectivity – connecting key ports, distribution centres, and resource hubs – each state in turn provides a finer grained network of approved local roads for heavy vehicles, allowing for greater connectivity.

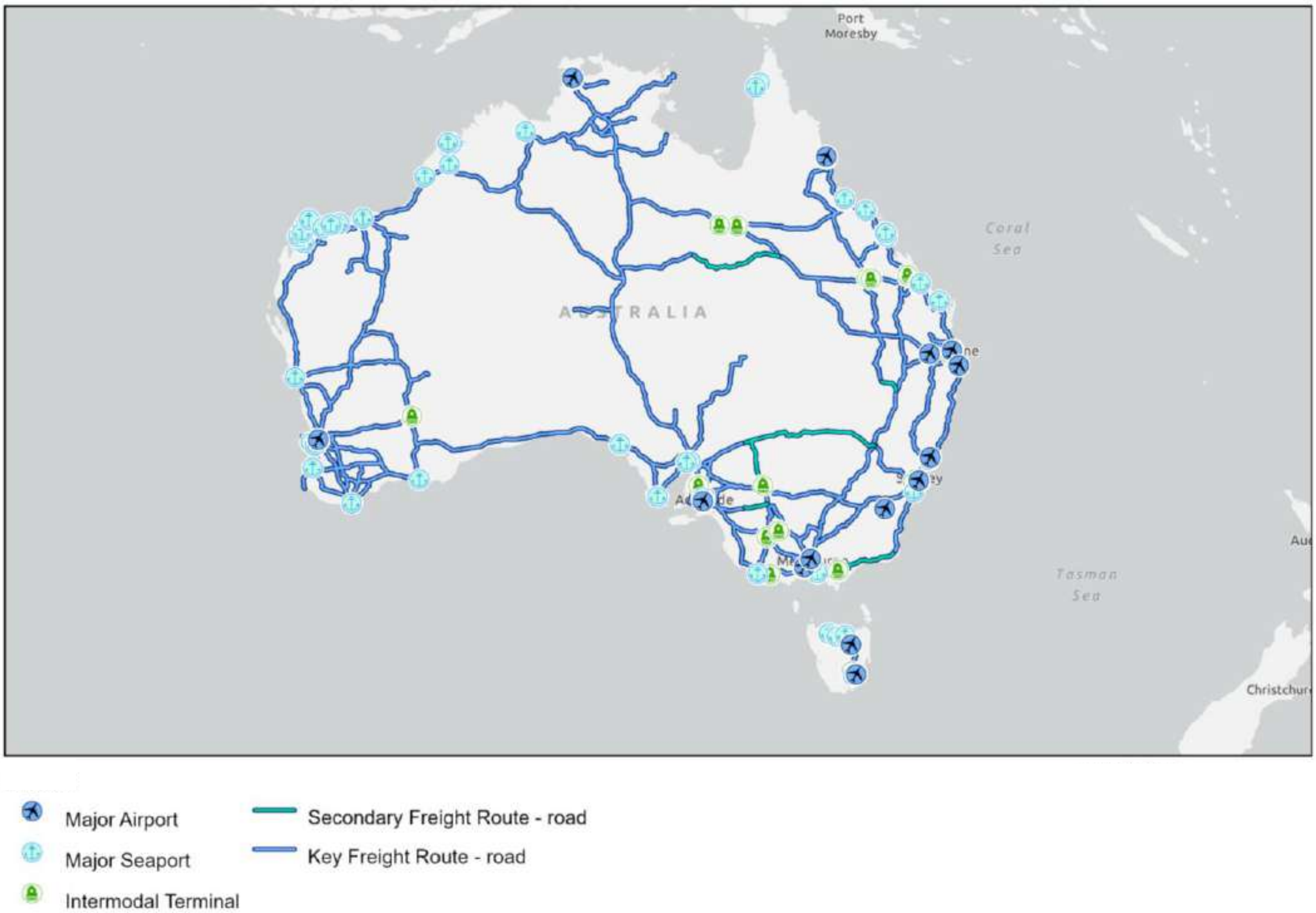

Figure 5 Map of Australia's key road-based freight routes (source: National Map)

Across this network, the movement of goods and vehicles sees significant regional variation. With states along the eastern seaboard seeing the largest share of the national road freight task in terms of both goods moved, as well as vehicle kilometres travelled.

Figure 6 presents a state-by-state overview of key statistics outlining how this national freight task varies.

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VIC

26.2% of national load

17bn kilometres travelled

64% of travel is within urban or regional areas

	No. of Vehicles	Avg annual km
LCV	760,000	11,000
Rigid	120,000	19,000
Artic	3,000	45,000

NSW

26% of national load

21bn kilometres travelled

62% of travel is within urban or regional areas

	No. of Vehicles	Avg annual km
LCV	940,000	12,000
Rigid	160,000	16,000
Artic	20,000	49,000

QLD

21.5% of national load

17bn kilometres travelled

64% of travel is within urban or regional areas

	No. of Vehicles	Avg annual km
LCV	880,000	10,000
Rigid	110,000	19,000
Artic	20,000	57,000

WA

15% of national load

8bn kilometres travelled

62% of travel is within urban or regional areas

	No. of Vehicles	Avg annual km
LCV	340,000	11,000
Rigid	4,000	17,000
Artic	1,000	35,000

SA

7.2% of national load

4bn kilometres travelled

50% of travel is within urban or regional areas

	No. of Vehicles	Avg annual km
LCV	230,000	12,000
Rigid	30,000	16,000
Artic	10,000	49,000

TAS

2.6% of national load

2bn kilometres travelled

50% of travel is within urban or regional areas

	No. of Vehicles	Avg annual km
LCV	115,000	10,000
Rigid	14,000	17,000
Artic	2,000	49,000

NT

1% of national load

749m kilometres travelled

48% of travel is within urban or regional areas

	No. of Vehicles	Avg annual km
LCV	53,000	12,000
Rigid	5,000	12,000
Artic	1,000	73,000

ACT

0.5% of national load

630m kilometres travelled

82% of travel is within urban or regional areas

	No. of Vehicles	Avg annual km
LCV	30,000	16,000
Rigid	3,000	19,000
Artic	180	22,000

Figure 6 Freight statistics by state

As outlined above, the Eastern States of NSW, Queensland, and Victoria see the largest proportion of national freight movements. As such these states are also the location of the busiest freight routes, particularly the Melbourne – Canberra – Sydney – Brisbane corridor, which represents the busiest freight route in the country.

Figure 7 illustrates the volume of freight traffic seen across the national freight network.

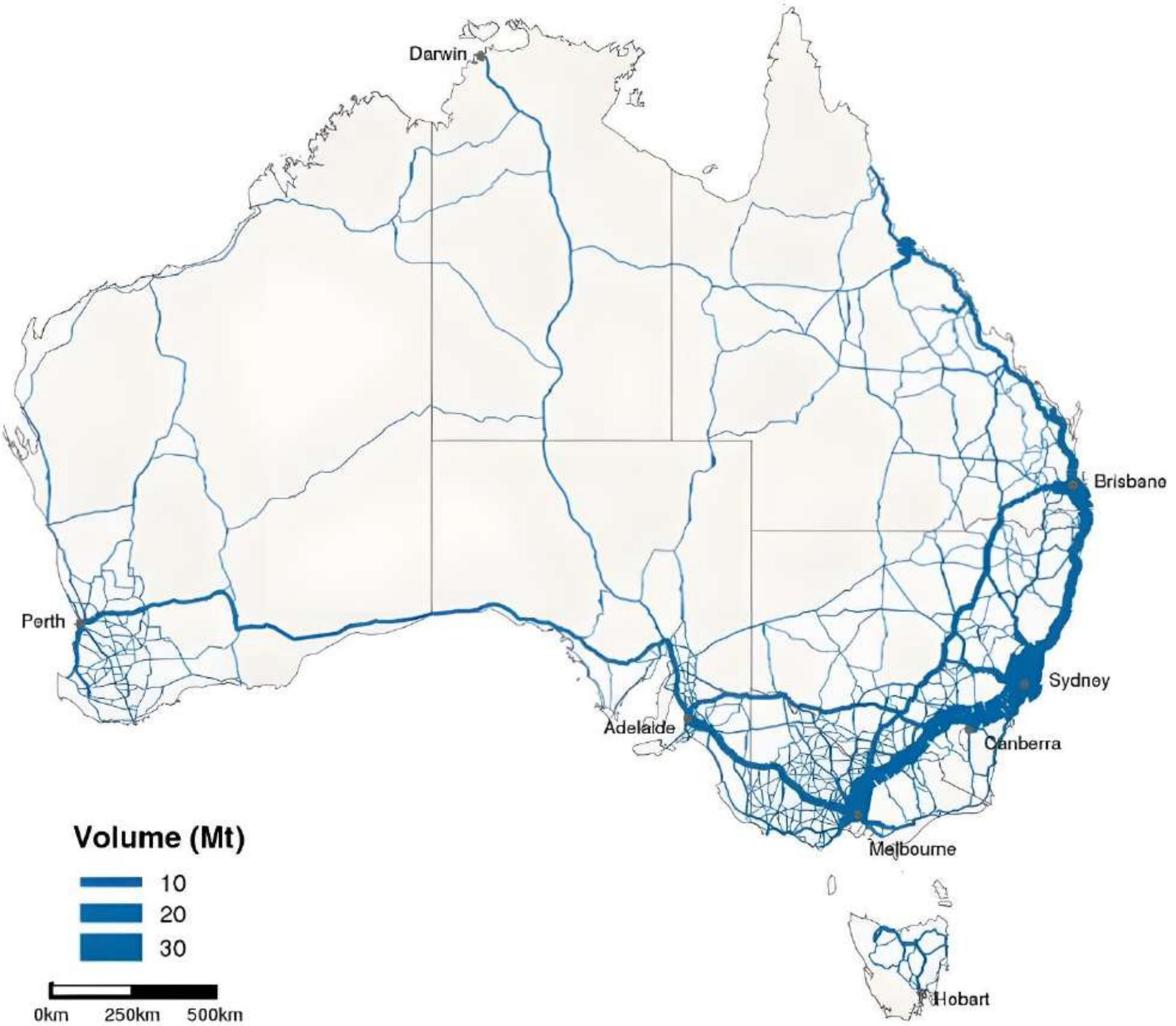


Figure 7 Freight Route Volume (Source: BITRE)

Operating Models

Recognising that operational requirements are one of the major potential barriers to EV adoption. EV charging must be able to efficiently slot into current operational structures in terms of location and timing. Allowing vehicles to maintain their uptimes and, if possible, even improve efficiencies – especially in the early stage of the transition as firms are less familiar with BEV's.

To capture the wide variety of operational approaches that exist, and to understand how EV solutions may align, it can be helpful to consider three broad operational models based on typical trip origins-destinations and journey patterns of freight vehicles. Broadly, these are:

- **Back to Base Operations**
- **Base to Hub Operations**
- **Hub-to-Hub Operations**

Figure 8 outlines some key aspects of each operating model, including typical trip origins, destinations, storage, and distances, as well as examples of potential trip purposes that can be related to each.

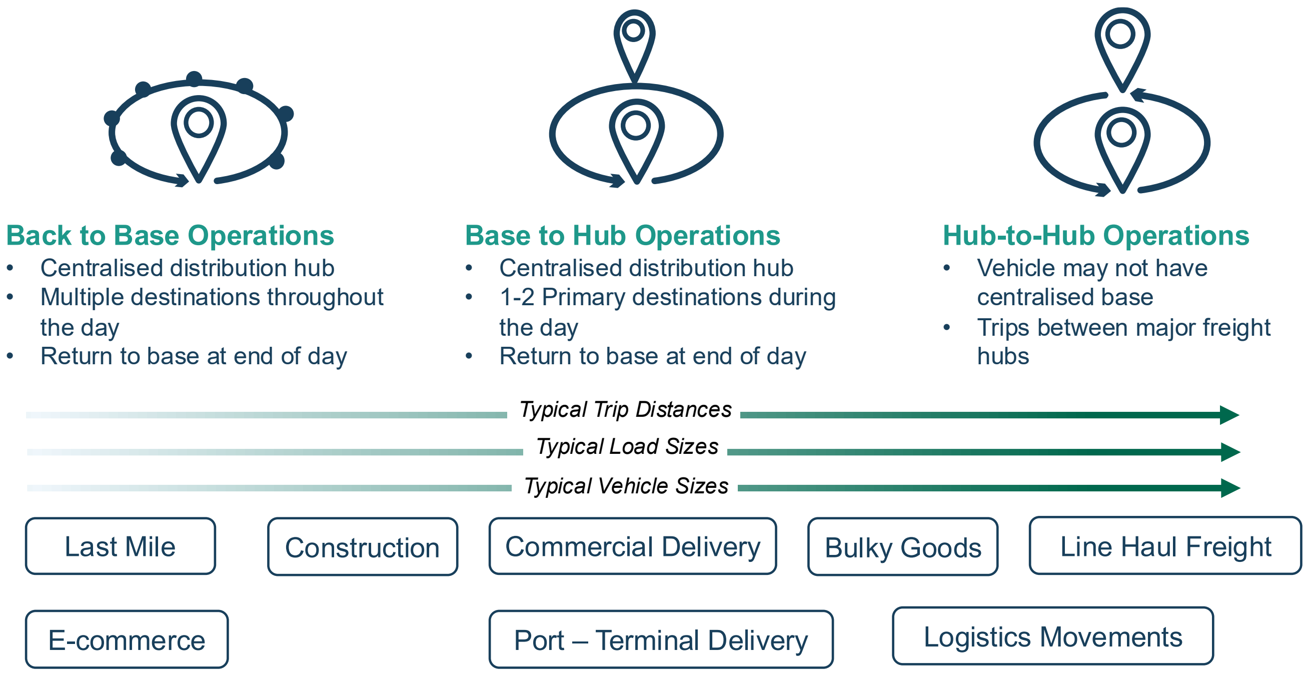


Figure 8 Road Freight Operating Models

The road freight industry in Australia is a highly varied, and dynamic sector, with a range of operators with different operating models to match.

–

Electrified freight must work with and align with operating requirements if it is to be adopted.

The Ever-Growing Freight Task Ahead

Australia's freight task is projected to increase significantly between 2024 and 2050 with road freight meeting the majority of the future freight demand growth (Figure 9).

While rail will remain the largest single mover of freight nationally, road freight is expected to see the most significant growth in the coming decades, particularly with other modes expected to stagnate or see minimal increases in demand.

	Road	Rail	Coastal	Air
2020	229 billion	443 billion	111 billion	30 million
2050	393 billion	457 billion	110 billion	60 million
% Change	77%	6%	-1%	100%

Figure 9 BITRE Future Freight Forecasts in billion tonnes-kilometre

Given that road freight currently represents 35% of our national emissions profile, should road freight quantities increase without a transition to a zero-emission fleet, overall emissions are likely to grow due to the significant increase in demand.

Any future transition of the road freight industry to battery electric vehicles will need to consider the growth in the underlying freight fleet to understand future demand.

Road-based freight - Use cases

As road freight can take many forms, and serve many purposes, any effective categorisation into overarching use cases must take a high-level approach to capture the whole of the sector. In order to assess the sectors capacity for change and to identify common challenges, three central use cases can be identified[23] - these being, **Intrastate Freight**, **Interstate Freight**, and **Urban Freight** (Figure 10).

	Trip type examples	Typical vehicle type	Typical travel distance per day/journey
Intrastate Freight	Delivering agricultural goods from regional farms to urban distribution centres	Rigid and Articulated	200-800kms
Interstate Freight	Transporting bulk commodities (e.g., minerals, fuel, or manufactured goods) between states	Articulated	800-4000kms
Urban Freight	Last-mile delivery of parcels to residential areas or transporting construction materials within a city	Light Commercial Vehicle	0-200kms

Figure 10 Freight use typical characteristics[24]

Of note are some overarching general characteristics to consider.

For instance, light commercial vehicles outnumber other freight vehicles in all use cases, this is largely due to data categorisation processes by the ABS, which includes all vehicles of this type regardless of use. However, due to their smaller payloads, their use as dedicated freight vehicles is predominantly to meet the high demand for last mile delivery, in high value commodity transport, or commodities unsuitable for large scale delivery – which most aligns them with the needs of urban freight.

Approximately 3.5 million vehicles operate within this urban use case making it the largest use case by vehicle numbers.

Conversely, the total number nationally of rigid and articulated trucks is significantly lower than light commercial vehicles, however, their payloads are substantially larger, lending themselves more towards larger and bulkier loads seen in Intrastate and interstate movements.

Due to the size of Australian states and territories, intrastate journey distances can vary widely. This use case has a mix of freight vehicles skewing marginally towards rigid and articulated trucks rather than light commercial vehicles.

The interstate use case has a smaller fleet than urban or intrastate uses but features the longest journeys and largest payloads. The mix of vehicles in this use case skews more towards the articulated trucks.

[23] Noting that in addition to these core use cases, specialised freight use cases also exist with unique needs and demands, however publicly available data for this small proportion of overall movements is limited.
[24] Use cases have been identified though an analysis of background data research and publicly available data taken from both BITRE and ABS.

Intrastate Freight

Overview of Use Case

The intrastate freight use case is the most blended of the use cases. Journeys range from short hauls between regional towns, to long-distance routes comparable to interstate transport This use case is critical to regional economic activity as it links regional towns and resource hubs with major centres or cities.

Typical Vehicle typologies

The intrastate use case is heavily varied with trips ranging from 200 to 800 kilometres. As such, typical vehicles can range from vans to rigid trucks and articulated trucks. However, in terms of freight task undertaken rigid and articulated trucks are most associated with the intrastate use case.

Number of Vehicles

There are 1.49 million vehicles associated with intrastate use.

Average Distances

Intrastate freight operates long travel distances with articulated trucks averaging 61,000 kilometres annually. Rigid and light commercial vehicles also operate intrastate freight to a lesser extent, with around 15,000 and 12,000 kilometres travelled annually respectively.

Operational Considerations

The Intrastate use case can be correlated with the base-to-hub and hub-to-hub operational models. Trips can be longer, requiring drivers to adopt more frequent fatigue breaks. For example, if a driver is operating over a period of 11 hours, they must have rested for a total of one hour (in blocks of 15 continuous minutes) during that time.

Key Routes

Key intrastate freight routes are the regional centre to capital city routes such as Toowoomba to Brisbane. This would broadly align with a regional hub to base movements, and utilises both the national and state freight networks.

Interstate Freight

Overview of Use Case

The interstate use case has relatively smaller fleet numbers compared to the other use cases, however, the kilometres travelled per vehicle are significantly higher than in the urban or intrastate use cases. Interstate road-based freight faces the most competition with rail, air and sea. This is the use case that connects Australia, crossing vast distances between cities, and is key to national logistics.

Typical Vehicle typologies

Articulated trucks undertake the majority of the freight task in the interstate use case with generally larger vehicles being more associated with this use case.

Number of Vehicles

There are 338,000 vehicles associated with Interstate Freight.

Average Distances

Interstate freight travels the longest distances, with articulated trucks averaging 87,000 kilometres annually. Rigid trucks and light commercial vehicles also operate interstate freight to a lesser extent, with around 15,000 and 10,000 kilometres travelled, respectively.

Key Routes

Key interstate freight routes include primary capital-to-capital corridors such as Sydney to Melbourne. These typical key freight routes broadly align with hub-to-hub movements. As such they predominantly utilise the major highways of the national freight network.

Operational Considerations

The interstate use case aligns most with the Hub-to-Hub operational model and features the most energy demanding operations due to the heavy payloads as well as long distances. Supporting infrastructure particularly rest stops provide a crucial portion of many interstate movements, providing respite and space for drivers to comply with rest restrictions.

Urban Freight

Overview of the Use Case

Urban freight is the largest use case in terms of vehicle numbers with millions of vehicles in operation. The urban freight use case primarily features smaller vehicles to navigate urban areas and handle last mile freight in large population centres. Urban freight supports our local economies and enables rapid consumer delivery.

Typical Vehicle typologies

Typical urban freight vehicles include vans and light utility vehicles.

Number of Vehicles

There are 3.3 million vehicles associated with the urban freight use case.

Average Distances

Urban freight operates the shortest travel distances with trips typically averaging below 200km.

Key Routes

The urban use case encompasses a wide variety of vehicle trips including high volume urban freight corridors but also dispersal into local streets for last mile delivery.

Operational Considerations

Urban Freight often align with Back-to-Base operational models, and so typically sees shorter trips with drivers often able to operate in single day shifts without extensive downtime and fatigue management requirements. However, this use case is also most subject to urban congestion and route complexity.

Illustrating the Road Freight System – From Port to Doorstep

From Port to Distribution Hub (Intrastate)

Consider an online purchase, bound for a typical home in Sydney. Like many consumer goods it's manufactured overseas and placed on a cargo ship bound for Australia.

Arriving at the Port of Brisbane, the package is collected and delivered from the port to the freight centre outside Brisbane via articulated truck.

The truck arrives at the port fully fuelled with diesel and drives some 50km to the facility where it is unloaded and sorted, before the package is redirected to a delivery bound for a Sydney Distribution Centre.

Crossing State Lines (Interstate)

Our package continues its journey, as it is loaded onto a new truck and sent on the roughly 10-hour trip from Southeast Queensland to Sydney.

The truck travels along the Pacific Highway, one of the busiest freight routes in Australia. The truck - filled with a full tank of diesel at the distribution hub - may only need to stop and refuel once along the way (depending on the truck and load).

However, the driver will need to stop for at least a total of 1 hour (four 15 minutes breaks) to adhere to fatigue management regulations.

Arriving at the distribution hub in Greater Sydney, the packages are offloaded, while the truck is refuelled and reloaded for its next trip.

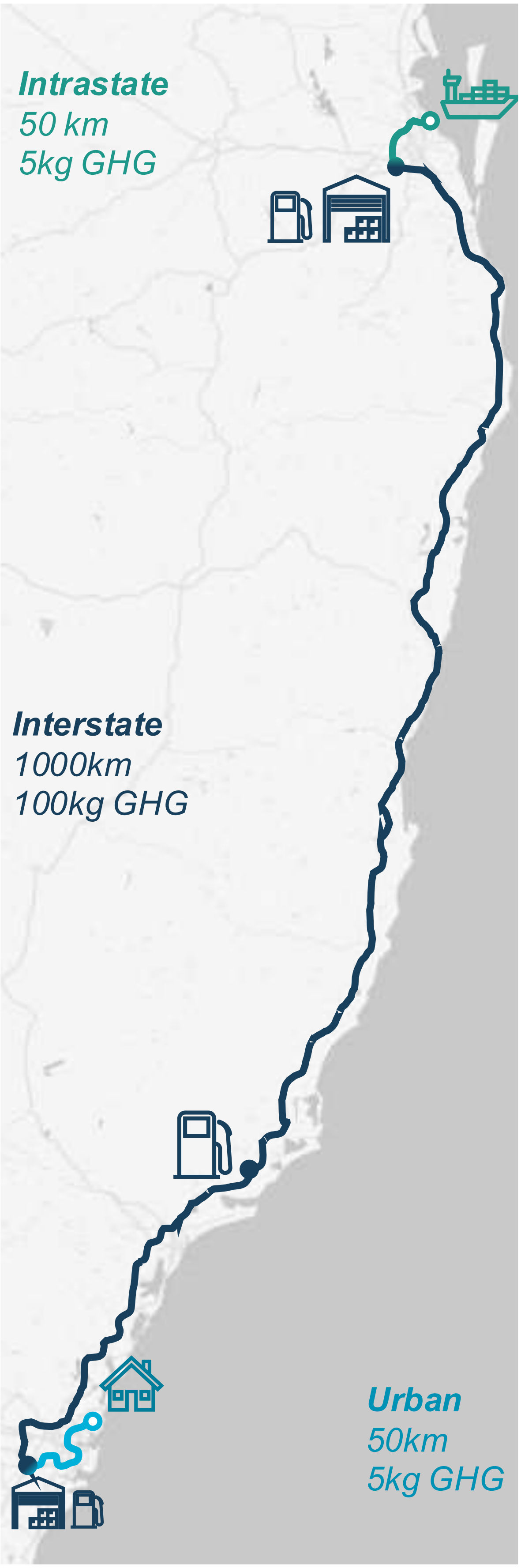
Making the Last Mile Trip (Urban)

At the Sydney distribution facility, the package is scanned and sorted based on its final destination. Joining other packages bound for the same local area.

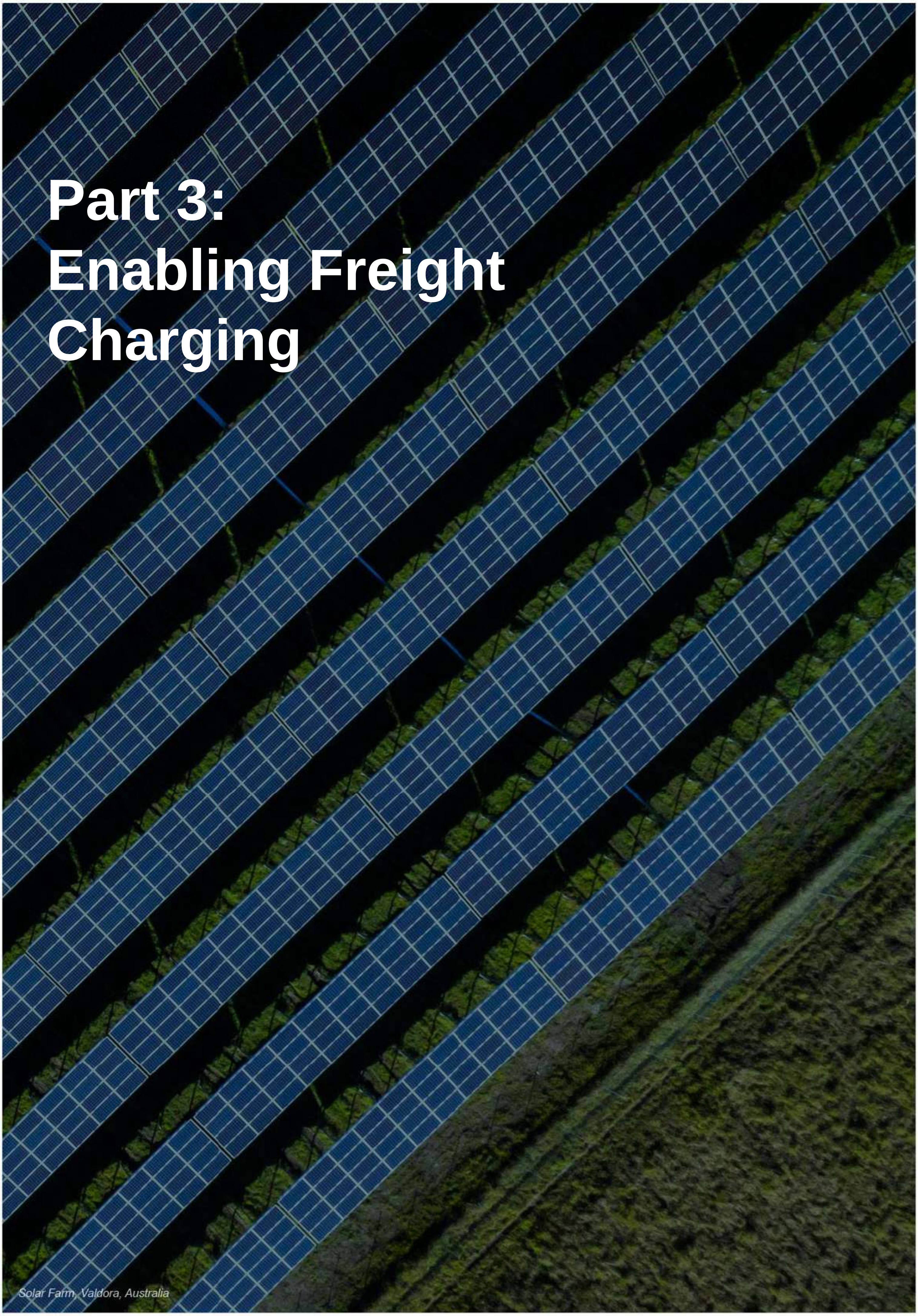
It is again loaded into a new vehicle, for the last mile delivery, potentially a small panel van or truck, or even a 'gig' economy drivers passenger vehicle. The vehicle itself is likely fuelled at the start of the day, either onsite, or by the driver on the way to facility.

As just one of several packages for delivery, the journey to the destination is not direct, but likely somewhat circuitous, this adds additional kms to the trip but is unlikely to require a top up on fuel by the driver until the end of the day.

Finally, the driver arrives, and the package reaches the doorstep, after having travelled around the world, and experienced the full breadth of Australia's freight network.



Part 3: Enabling Freight Charging



Solar Farm, Valdora, Australia

Zero Emission Technology Review

Understanding the Electric Truck Market

Zero emission freight vehicles are an emerging market globally, and as such there are generally fewer models available for BEV variants than traditional ICE models. Australia has seen limited BEV truck uptake, and domestic availability is lagging compared other nations. Despite this, there has been growth in BEV freight vehicles coming to market in Australia primarily in the light commercial vehicle and rigid truck categories.

Electric LCV's and rigid trucks availability is limited in Australia although several brands have begun offering their first full BEV's. It is expected that market conditions will continue expanding in the future with more variety in the LCV and rigid truck market particularly. While there is a very limited battery electric long-haul articulated vehicle market currently, some recent models have been made available. Figure 11 illustrates the comparison between global availability and domestic markets.

A full list of all commercially available electric freight vehicles is presented in Appendix A.

	Light Commercial	Rigid Trucks	Articulated
Globally Available	129	156	125
Domestically Available	13	15	6

Figure 11 Number of BEV models available (Source: EV Council[25] and Calstart[26] - global availability)

Exploring Future Vehicle Trends

While past estimates have previously predicted BEV freight vehicles – particularly Utes and Vans - to reach purchase price of equity with ICE models as early as 2023[27]. To date this has not occurred, although prices for BEV LCV's have continued to drop, and may reach parity in the near future.

Likewise, vehicle availability for electric LCV's has progressed, and is expected to continue growing in the near future.

As vehicle masses grow however, pricing and availability compared to ICE vehicles is expected to be comparatively limited. While gains are being made in the rigid vehicle class, articulated vehicles are expected to remain a challenge for some time. However, technical improvements continue to progress with current top end ranges for articulated trucks are presently averaging about 600km.

As such it appears that smaller LCV based freight use cases, chiefly urban freight, are the most likely to see rapid opportunity to electrify.

The Urban Freight sector is already seeing the greatest opportunity for BEV's in both pricing and availability

[25] EV Council, State of Electric Vehicles 2024
[26] Calstart, Data Explorer
[27] Boston Consulting Group, The Future of Buses and Light Commercial Vehicles Is Electric – With Cost Parity Just Around the Corner

Charging Solutions

As with the entire BEV industry there are rapid developments in the charging of EVs.

Currently, both charging technology and infrastructure favour light vehicles as these can operate with smaller battery sizes and less energy-dense solutions. Additionally, most higher power charging facilities in Australia are physically developed to accommodate smaller passenger vehicles, indicating an additional physical and design barrier to use by larger trucks in the current state.

Available charging solutions for freight vehicles include DC wall, fast and ultra-fast charging systems which range in capabilities and are outlined in Appendix A.

What is the Future of Charging?

Work continues at pace around the world to improve electric charging systems' energy output and thus reduce recharge times. As many vehicles within the road-freight industry, particularly interstate trips, will require high-capacity charging. An emerging area is the development and deployment of Megawatt Charging System (MCS). The development of standards for MCS, being led by a Charging Interface Initiative (CharIN) Task Force, aims to develop a holistic system based on the Combined Charging System (CCS). The CharIN MCS task force represents the full value chain of the Heavy-Duty Vehicles industry segment and ensures that all perspectives are considered.

Megawatt Charging Systems will provide significantly greater energy flow, enabling charge rates greater than 1 megawatt. This would enable larger rigid and articulated trucks to recharge in only a fraction of the time that it may take for a lower voltage charger, enabling shorter stops and greater vehicle uptimes.

Australia must develop megawatt charging solutions to enable heavy electric trucks and connect our vast distances.

Figure 12 Trucks charging via Megawatt charging system (source: zerovatech.com)

While megawatt charging has not yet been deployed in Australia, such systems have begun to be provided in initial demonstration and early deployment phases overseas.

Already, theoretical systems have been demonstrated to be capable of 3.75-megawatt capacity. In the short-term, higher-powered systems such as Terra 360kWh charger can provide the fastest commercially available charging output[28]. Future charging systems will likely improve speeds but will incur significant energy demands and infrastructure development to manage.

[28] GRIDSERVE, 2024. Introducing the newest and fastest High Power charger on the GRIDSERVE Electric Highway.

Connecting Freight Operations to Charging Solutions

Based on available charging technology and feedback from industry the relationship between freight operating models and charging solutions is identifiable.

This relationship, as outlined in Figure 13, outlines that the need for more energy intensive and on-road charging infrastructure is directly connected to operating models requiring longer, heavier trips, and with less frequent access to a base.

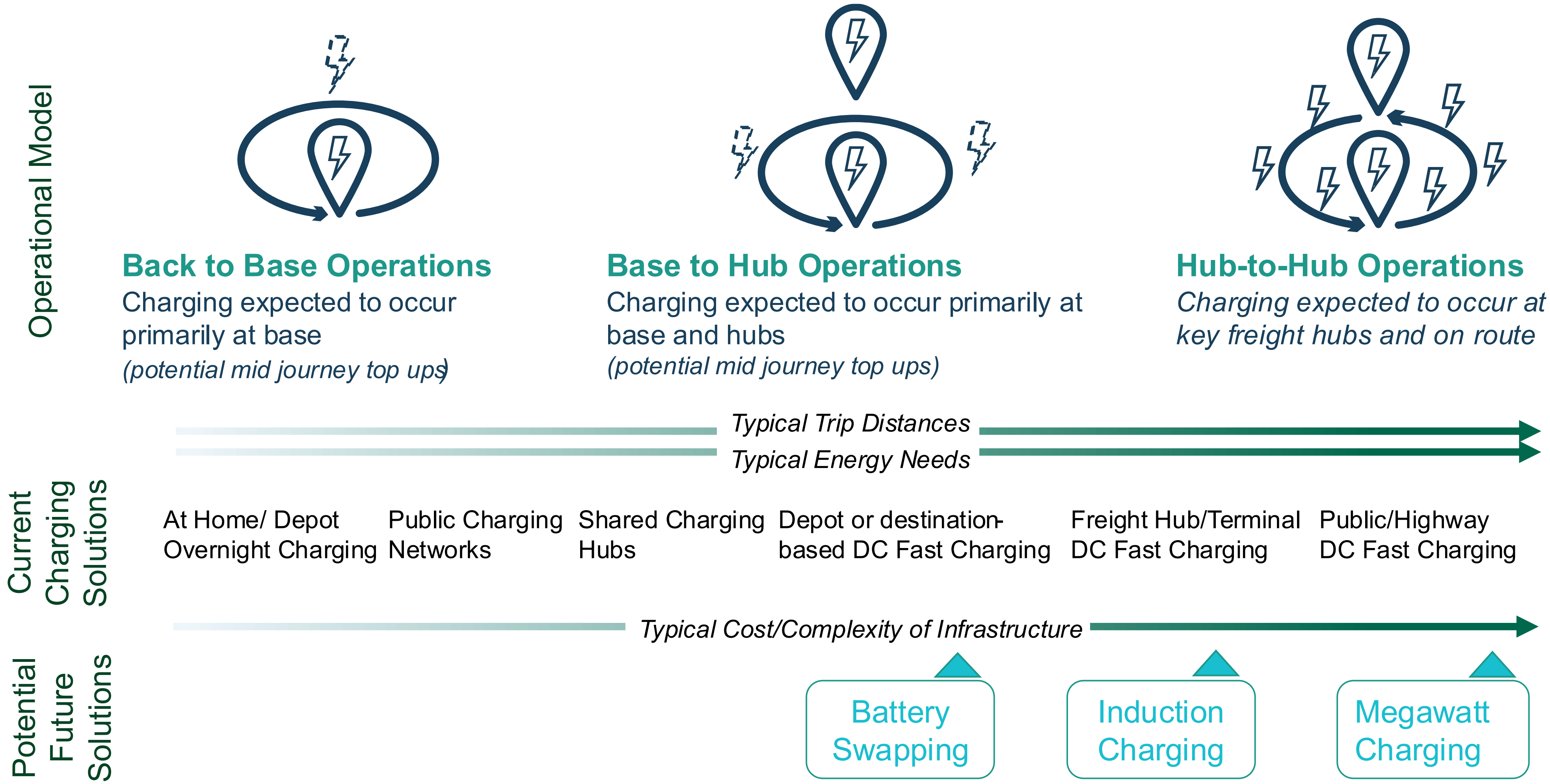
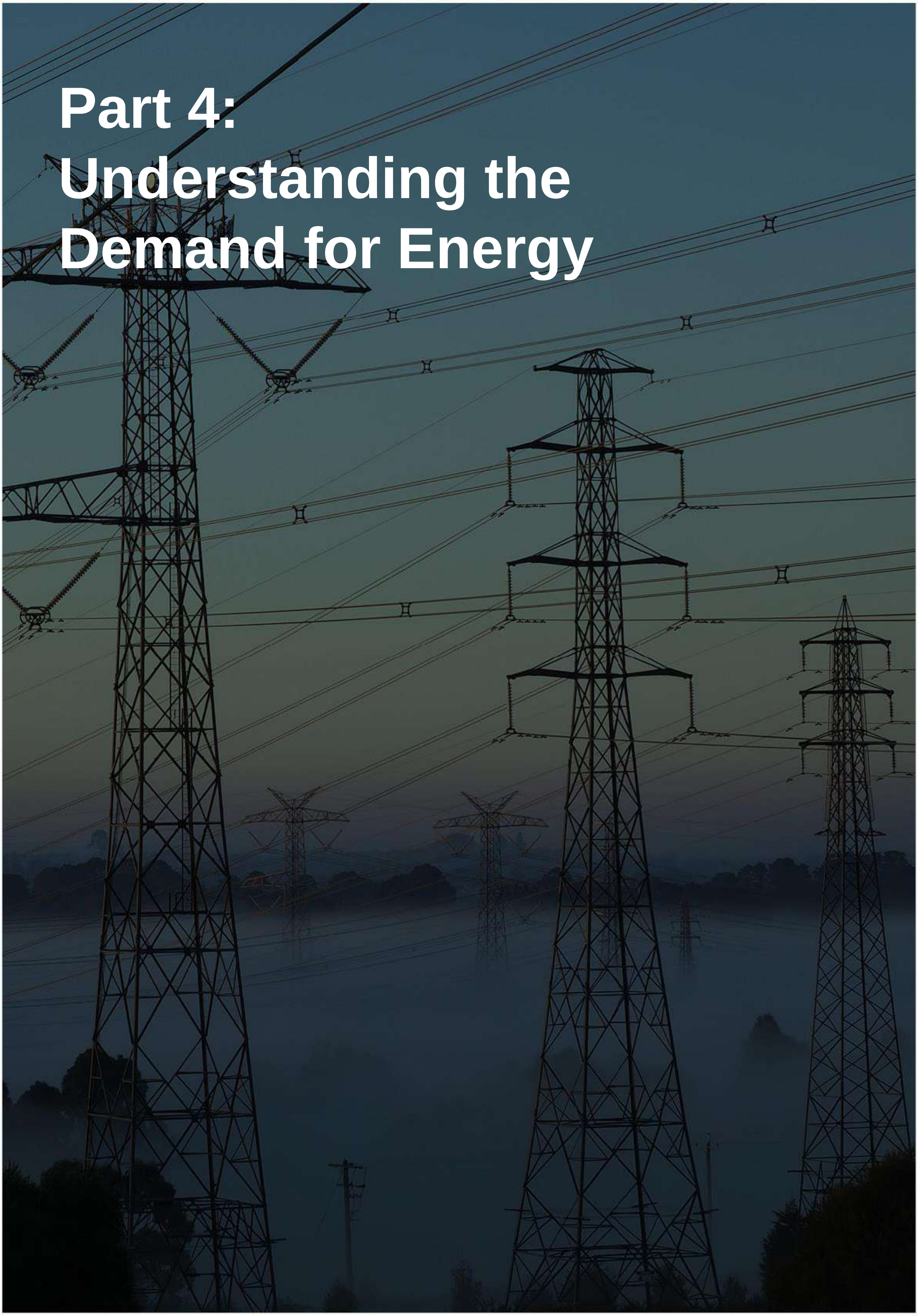


Figure 13 Relationship between operating model and charging solutions

Part 4: Understanding the Demand for Energy



What will it take to Charge Freight?

By understanding the various freight operational models, vehicle fleets, and potential charging solutions available, we can answer two core aspects of the transition.

Charging Solutions Matching charging solution to the most suitable use case, we can understand what and where infrastructure is likely to be needed around the country, and how this can be serviced by existing energy networks.

Energy Demand Understanding the current and future needs of each use case we can forecast the potential future energy demand which the road freight industry may place on the energy grid, and to plan accordingly.

How will Road Freight Use Cases Charge?

Based on a review of available technologies, operating models, fleet requirements, as well as input from stakeholders an outline of charging locations and solutions has been developed for each use case.

Urban

Urban Freight is most associated with some form of back-to-base operations. As such charging is expected to primarily occur at centralised depots, or at drivers' individual homes.

Due to the relatively smaller distances and the typically smaller vehicles - overnight charging will likely be the primary charging delivery systems allowing for relatively slower charging speeds.

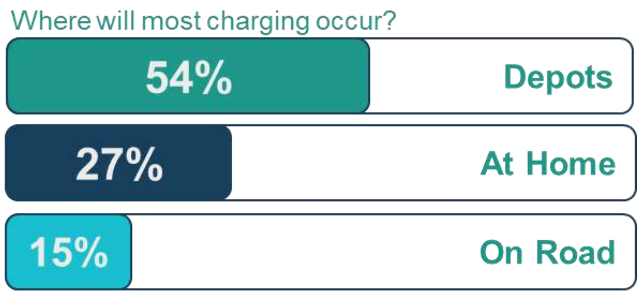


Figure 14 Stakeholder input on likely of urban charging

Intrastate

While Intrastate freight is likely to also have access to a depot or base for charging, as trip distances can be quite variable (between 200-800 km), on road charging is also likely to be a requirement to enable BEV's to operate.

As such while slower overnight charging at depots may still be applicable, faster charging solution both on road, as well as at customer or destination sites will be increasingly important as distances from urban centres rises.

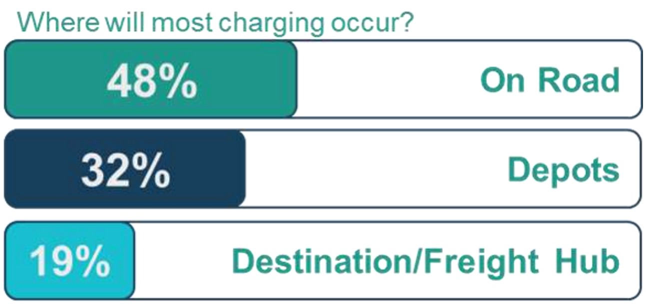


Figure 15 Stakeholder input on likely intrastate charging

Interstate

Interstate freight aligns closely with the Hub-to-Hub model, indicating that most charging is likely to occur on road. As this use case primarily involves larger vehicles carrying heavier loads over longer distances higher-capacity energy systems will be required, particularly to ensure vehicle downtime due is minimised.

This use case will likely see as ultra-fast on-demand charging systems and on-road charging methods.

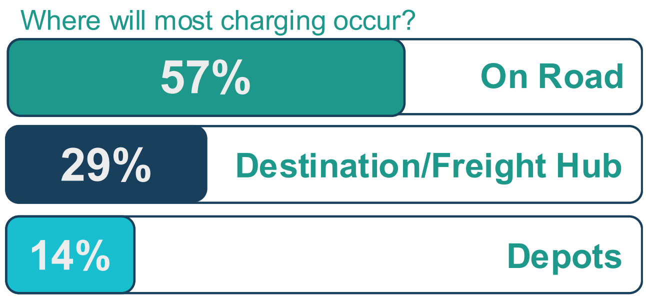


Figure 16 Stakeholder input on likely interstate charging

Key Considerations for Charging Solutions

Stakeholder input provided insight into the most likely charging solutions for each freight use case. However, in doing so, some key challenges emerged which will need to be considered.

How to support small operator charging?

As much of the industry is made up of small firms, many operators do not have access to a centralised depot or vehicle facility to charge overnight.

A transition plan that relies on depot conversions would likely to miss a large portion of the market. This may cause future challenges as BEV's purchased by larger fleets may not be attractive to smaller operators in the used vehicle market or could impact the residual value of fleet vehicles.

Accordingly, there is a need to develop solutions to allow for operators to charge freight vehicles at other facilities either under a shared facility approach, or through access agreements with other facilities.

Likewise, even smaller operators with dedicated depots, may find the cost of providing new infrastructure may not be commercially viable to provide.

How to Incentivise charging at client sites?

Feedback from industry has suggested that electrification must also see support from clients. Noting that many freight vehicles spend extended time periods at client sites.

Clients themselves will need to be supported both financially and to access to knowledge as to how to best provide suitable charging equipment.

Notably this may require additional third-party support as client sites may often be leased, and therefore the underlying asset owner – who is removed from the freight process – will need to be supported to install necessary infrastructure.

How to enable charging at freight nodes?

Freight nodes (intermodal terminals, ports, and airports) are critical centres serving as important centres for distribution.

Freight vehicles spend considerable time accessing and waiting at these sites, which if electrified would provide opportunity for vehicle recharging. However, these facilities are often operated by third parties not directly involved in the operation of freight vehicles. As such they may not necessarily see direct commercial benefit from the provision of BEV infrastructure.

How to Electrify rest stops?

Long haul freight will require charging on-route in order to facilitate full journeys. In many locations this will require upgrades at existing heavy vehicle rest areas to provide power supply and other facilities.

However, many rest stops have limited existing infrastructure, with some having only a pull off lane for vehicle storage. Identification of suitable sites and provision of infrastructure including power supply will be a central challenge to enabling use cases.

How to enable Secondary route charging?

Many secondary freight routes, or routes servicing inland and regional or isolated communities and resource hubs often have minimal existing infrastructure.

Facilitating electrical supply to these locations will be a challenge and may require connections be staged for future waves of upgrades.

A summary graphic of charging solutions and challenges can be found in Appendix A

How Much Power Will be needed?

As the road freight industry electrifies, increased demand will be placed on the energy grid across Australia. Understanding the quantum of energy required to fulfill this task is therefore a key task if we want to understand how the grid may respond to this additional burden.

To do so a freight specific methodology was developed to calculate a high-level Future Energy Estimate. As shown in Figure 17, this approach gathered data and input from both publicly available dataset as well as input from stakeholders and Subject Matter Experts.

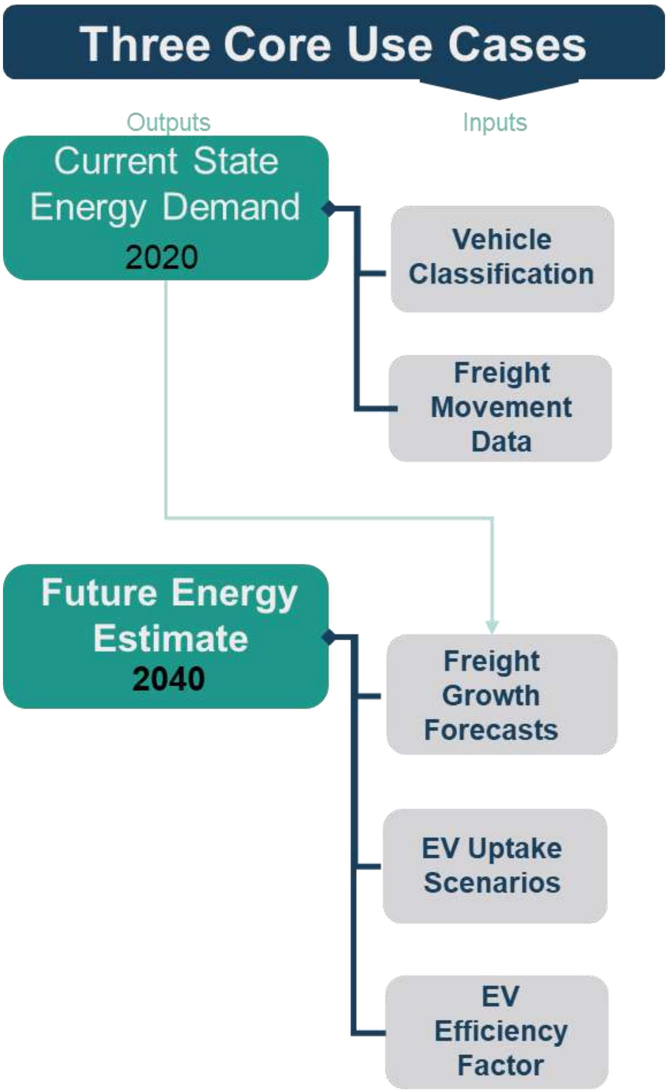


Figure 17 Energy Estimation Methodology

Current State Energy Demand

Underlying freight movement data was sourced from public datasets to identify key measures of freight movement such as distances and fuel usage.

This data acted as an effective proxy for additional contributing factors such as topography or driver behaviour.

This was segmented by vehicle class across each use case to identify the current total energy demand being provided by fossil fuels today.

Future Energy Estimate

Future energy estimates extrapolated current energy demand to a future scenario based on future freight forecasts using a reference year of 2040.

Two scenarios were run with varying EV fleet uptake based on input from stakeholders, international trends, and SMEs to understand what proportion of the future freight task could be served by BEV's.

An efficiency factor was overlaid on vehicle energy demands, to account for the greater energy efficiency of electric motors compared to ICE motors.

Scenario setting

Of note is the need to consider a set of EV uptake scenarios. While current forecasting from AEMO of EV adoption across the range of ABS vehicle classifications does exist, it was noted that this appears to have taken a relatively conservative approach, with minimal uptake of EV's into the future.

However, for the purposes of testing grid and infrastructure capacity the AEMO scenario does not provide the scale of potential uptake necessary. As such two additional scenarios were developed, these used alternative approaches to consider a much more rapid heavy vehicle EV uptake by 2040.

1. High Uptake Scenario

A scenario based on Stakeholder and SME input to estimate EV uptake assuming considerable public and private investment.

EV Uptake (2040)*	LCV	Rigid	Articulated
Urban Freight	100%	100%	100%
Intrastate Freight	80%	70%	60%
Interstate Freight	60%	50%	30%

2. Moderate Uptake Scenario

A blended scenario - with LCV uptake based on forecast domestic adoption of passenger vehicles and Rigid and Articulated adoption informed by international Subject Matter Expert's.

EV Uptake (2040)	LCV	Rigid	Articulated
Urban Freight	80%	50%	35%
Intrastate Freight	70%	40%	30%
Interstate Freight	70%	40%	30%

**Refers to the percent of battery electric vehicles operating within each use case by 2040.*

Based on these scenarios two unique energy demands can be quantified and tested at a national level, as well as on a state-by-state basis, including an assessment of the role of each use case in contributing to state energy demands.

Scenario 1
Stakeholder Input Scenario

74,710
GWh Annually

National

Scenario 2
Market Trends Scenario

53, 790
GWh Annually

For the purposes of this assessment Scenario1 was used for further analysis so as to further 'stress test' the capacity of the grid.

Urban Freight	Intrastate Freight	Interstate Freight
43,620 GWh Annually	25,400 GWh Annually	5,690 GWh Annually

NSW	VIC	QLD	WA
23,080 GWh Annually	19,080 GWh Annually	16,490 GWh Annually	7,820 GWh Annually

SA	TAS	NT	ACT
5,000 GWh Annually	2,280 GWh Annually	500 GWh Annually	460 GWh Annually

Figure 18 Total energy demands

Identifying the Infrastructure Required

Transport Infrastructure Requirements

The rollout of high-capacity EV charging stations throughout Australia has accelerated in recent years with 229 ultra-fast charging locations available at the end of 2023[29]. However, to meet the future demands of an electrified road freight industry, continued expansion of the charging network is required, alongside the provision of freight specific charging infrastructure.

At a minimum there will likely need to be additional charging at three core types of locations.

Freight Nodes

These are key centres of the freight distribution system involved in the importation or exportation of goods including major national ports or international airports. Or are important sites for local or regional freight distribution – regional airports, ports, and intermodal terminals.

These sites see a high volume of freight across a range of vehicle types. There is a high likelihood of vehicle queuing which provides an opportunity for charging. However, charging solutions will likely need to support rapid charging to avoid impacting on operations.

✓ **Urban** ✓ **Intrastate** ✓ **Interstate**

Heavy Vehicle Rest Stops

On route charging will facilitate freight movements on our national highway network. Heavy vehicle public charging locations must respond to vehicle ranges on key routes. As such a distribution of no more than 600km has been used in this assessment. This reflects the current top end vehicle range, which, while currently limited in availability, is likely to become standard as technology improves.

These sites are also likely to require supporting infrastructure for drivers to access food, showers, and space to rest, improving convenience and the likelihood of utilisation.

Charging equipment is expected to preference high-capacity rapid charging to reduce vehicle downtime, although some slow charge equipment may also be provided to take advantage of longer driver fatigue rest times (7 hours plus).

✓ **Intrastate** ✓ **Interstate**

Freight Centres

Freight centres are typically located in urban centres. These are privately owned freight depots responsible for the sorting and distribution of freight at distribution hubs or at major warehouse centres. Due to the large quantity of such facilities nationally, for the purposes of this assessment, only clusters of such freight and logistics centres have been identified in major cities in this analysis.

These facilities will need to be able to service a range of vehicle types, reflective of their function in taking inbound freight and redirecting it to end customers. As such charging solutions are likely to require the full range of charging equipment, largely dependent on the type of vehicles and use cases being serviced by the facility.

✓ **Urban** ✓ **Intrastate** ✓ **Interstate**

[29] EV Council, 2023. Australian Electric Vehicle Industry Recap 2023.

By assessing and mapping each of these locations a high-level network of sites where charging may be required can be identified (Figure 19, Table 2).

This provides an improved understanding of the distribution of charging points, the challenges in servicing charging points, and what gaps may need to be addressed.

Notably this is an initial high-level map, based on servicing major freight facilities and aligned with national freight routes, and represents something like an initial viable product to facilitate BEV freight at scale. It is likely that additional locations will be needed to service locations (e.g. client sites), as well as specific communities and hubs.

An estimated 165 freight charging hubs will be needed to support an electrified road freight industry.

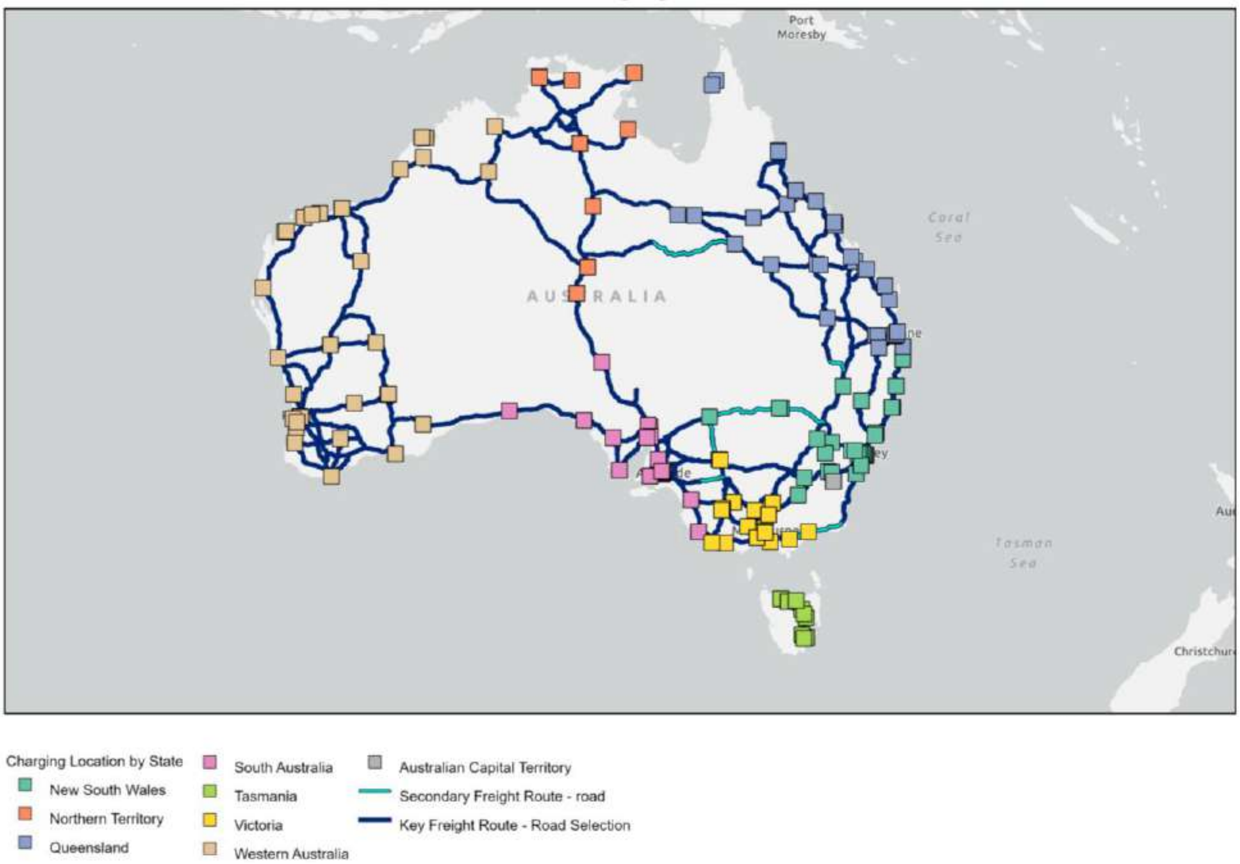


Figure 19 Charging Network Map

Table 2 Estimated Number of Charging Hubs Summary

	NSW	QLD	VIC	SA	WA	NT	TAS	**Total**
Total	32	38	24	18	34	9	10	**165**

Network Staging

This potential future charging network would not emerge overnight. Construction of a network will require extensive planning, preparation, and consultation, as well as significant supporting works to provide localised upgrades and facilities.

Instead, the network is likely to be staged over the coming decades, as the wider industry transitions, and as technology solutions improve and advance. The map shown in Figure 20, outlines how staging may occur. This adopts four distinct stages, based on an assessment of current and future technology timelines, industry capacity, and international trends.

Stage 1: An expansion throughout capital cities and major regional centres to support widescale electrification of urban freight, which has been identified as the most likely use case to electrify first

Stage 2: The development of charging networks along key national highways, focused on the busiest freight routes. This would largely connect the capital cities to one – as well as connect several smaller and regional towns along these routes. This would support an initial tranche of electrification within the interstate and intrastate use cases

Stage 3: Further extension of charging networks along secondary and regional highways, to connect additional destinations and embed greater network resiliency. This would likely finalise interstate use case connections, as well as further improve Intrastate trips

Stage 4: The final stage would seek to connect remaining freight nodes and routes in more remote areas

Figure 20 National Charging Map - Staging

Energy Infrastructure Requirements

To support this network of charging locations, consistent and reliable power supply will be necessary to provide vehicles with enough energy to complete their journeys.

As a first principle this power should ideally be provided by existing electrical grids, to leverage existing infrastructure and reduce costs and complexity.

Figure 21 outlines how the identified locations align with existing electrical transmission networks and indicates a broad alignment of freight charging hubs and existing electrical transmission networks.

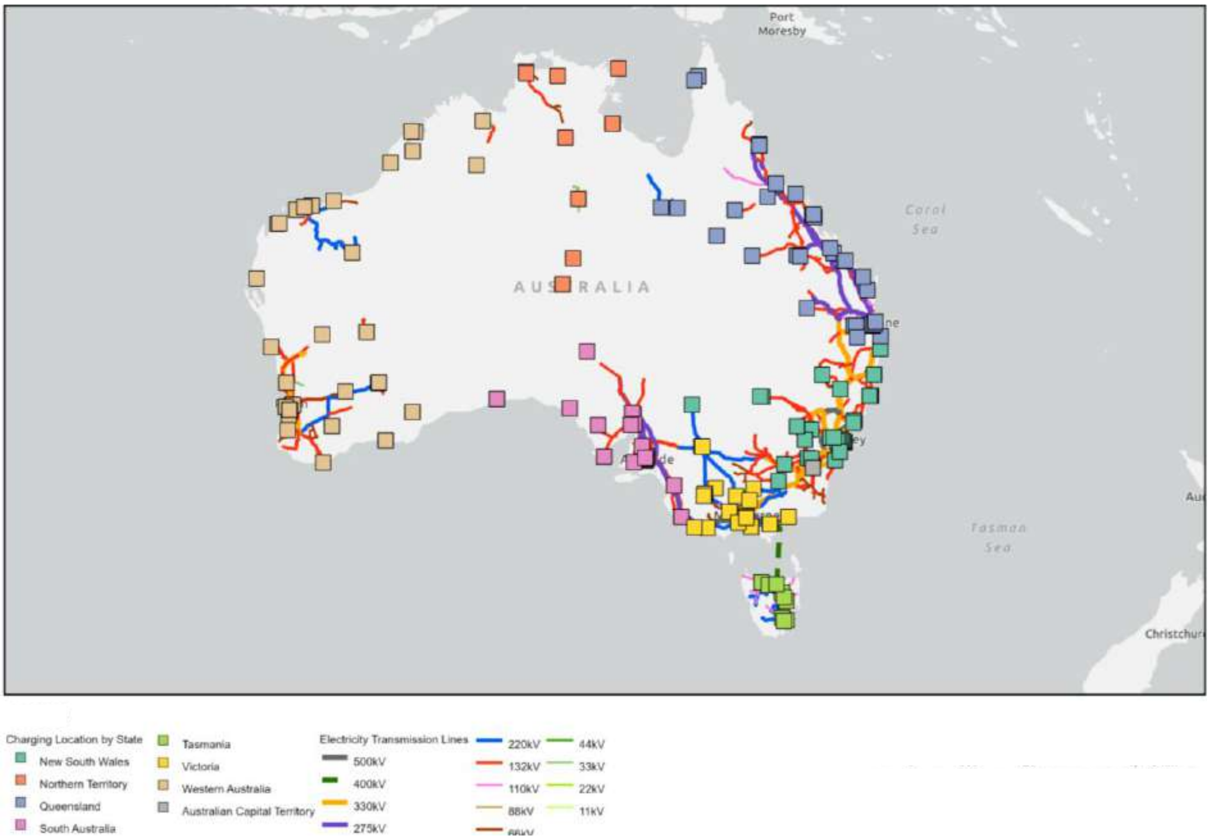


Figure 21 Logistic Hub Location and HV Transmission Lines across Australia

While the location of transmission lines and substations is a useful reference point for some existing infrastructure it does not necessarily equate to availability or ease of connection. Transmission infrastructure is usually at higher voltages and not necessarily suitable for direct connection to proposed charging hubs as this would require large step-down transformers.

Instead, Transmission Substations with existing step downs, particularly to distribution level voltages, or distribution substations, would be more appropriate places for potential connection works if spare capacity is available.

Additionally, Australia has a complex network of transmission network service providers (TNSPs) and distribution network service providers (DNSPs), energy retailers and generators, with varying arrangements in each state – which adds further complexity.

Each Network Service Provider has different rules and requirements for connection to the network. When looking at new technologies and their connection and impact on the network they will also develop different methods at different speeds to manage those connections. This present challenges in providing an Australian wide methodology for the connection of Fast Electric Vehicle Chargers.

Categorisation of Charging Hubs

For the purposes of assessing the likely electrical infrastructure requirements and grid impacts of this future network charging hubs are better categorised based on location specific characteristics, rather than a freight use case basis as shown in Table 3.

Table 3 Hub Location Definitions

Hub location	Definition
Urban	City or large town
Regional	Mid-sized town
Rural	Farming area, small town, or within 10km of existing infrastructure
Remote	Undeveloped area and over 10km to nearest development/town
Isolated	Not connected to the wider grid or electricity marker

By categorising charging hubs based on their location the required electrical infrastructure for Charging Hubs can be explored, as outlined in Figure 22.

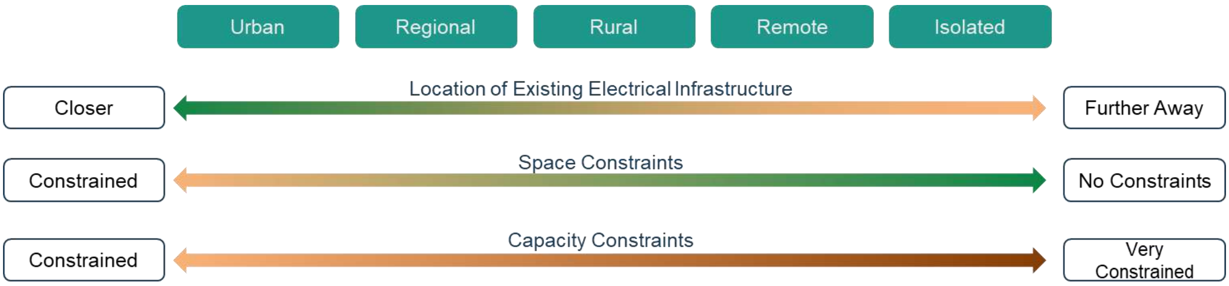


Figure 22 Charging hub constraints by location

Urban Areas

Urban areas pose several challenges for the development of new electrical infrastructure. In high-density areas, space is often constrained, leaving little to no room for new lines and substations. Although networks are typically well-developed, with existing infrastructure located close to potential sites.

Despite this advantage, high-density and aging urban areas may face grid capacity constraints, necessitating upgrades to existing infrastructure.

Regional and Rural areas

By contrast, regional and remote areas typically do not face the same spatial limitations. Instead, offering more room for new lines and substations at the expense of often being located further from existing grid infrastructure, increasing costs and logistical challenges of providing additional energy supply.

These regional and rural transmission/distribution networks also tend to operate with limited capacity. While high-voltage (HV) lines and substations may exist, they are often unsuitable for direct connection, without substantial upgrades. Additionally, networks often lack redundancy, with areas reliant on single transmission lines creating vulnerabilities to outages caused by events like fires, floods, or other disruptions.

Remote areas

These are locations far from towns or developments, and present further challenges. Existing grid infrastructure is typically located considerable distances away from proposed sites, and the networks in these regions- if available - are often already constrained and lack redundancy.

For the purposes of this report Remote locations are sites that are in an undeveloped area and located further than 10kms from the nearest town or development area.

Isolated communities

These are areas which are not connected to the wider grid or the electricity market. They are typically powered by centralised diesel generators which supply the power for the surrounding community.

There are programs to decarbonise these areas and increase renewable generation and battery systems underway to reduce the reliance on delivery of fuel which may be impacted by events like fires, flood, or other disruptions. Installation of charging hubs in isolated communities will pose large challenges and are potentially counterproductive to the broader goal of decarbonisation until the current reliance on diesel generators supplying electricity can be addressed.

Based on this classification of charging hubs the largest proportion of locations are in urban or regional/remote settings. This indicates a broad alignment of the existing electrical grid and freight charging hubs. Although the number of remote and isolated locations will pose potential challenges for some states, particularly in Western Australia and the Northern Territory where they account for a higher proportion of all locations (Table 4).

Table 4 Charging hubs by location classification

	NSW	QLD	VIC	SA	WA	NT	TAS	Total
Urban	13	13	10	6	9	2	4	57
Regional	9	17	10	4	7	1	3	51
Rural	9	4	3	6	13	0	3	38
Remote	0	2	0	1	1	3	0	7
Isolated	0	2	0	1	4	3	0	10
Total	31	38	23	18	34	9	10	165

Other considerations to examine in individual scenarios include who owns and operates the charging hubs. Charging hubs that may be established and run by private entities will need to negotiate with the existing Network Service Provider (NSP).

Additionally, where charging hubs are located in seaports, airports, intermodal terminals, rail lines, mines, or where a third party owns and manages the larger site, additional discussions will be required. These locations often operate private electricity networks and the development of charging hubs in these areas would require additional collaboration from the charging hub operator with the supplying NSP and the site owner.

The NSP would need to provide additional capacity and implement necessary upgrades up to the point of connection with the site, while the site owner would be responsible for the internal upgrades up to the charging hub location, and for overall load management of the whole site.

Charging hub operators in turn would be responsible for the development, installation, operations and maintenance of the charging equipment.

Infrastructure Requirements to Enable Charging

The specific electrical infrastructure required for BEV charging varies depending on equipment type and use case. Factors including charging speed, battery size, number of vehicles, existing infrastructure on site and peak vs off peak charging will greatly influence the upgrades required for the development of Charging Hubs.

Slow Charging

Locations expected to be able to utilise slow overnight charging, will generally have lower requirements for infrastructure - although this will depend on the number of vehicles and size of batteries to be charged.

This approach can take advantage of off-peak electricity periods reducing the demand on the grid, particularly if located at a site that is either closed or reduces operations overnight.

Potential infrastructure required for this use case is dependent on the existing infrastructure that already exists but would typically include a new padmount substation/s and associated HV lines to the site from closest existing substation with capacity.

Fast and Ultra-Fast Charging

Charging Hubs that require Fast and Ultra-Fast Charging will have different requirements for infrastructure depending on expected frequency of use.

When looking at the uptake in BEV Fast Charging, factors like battery sizes and the capacity of the vehicle to be fast charged should be considered. It is currently highly unlikely that the full demand from all available chargers at a charging station is utilised concurrently with the existing peak demand from the existing site.

While wider BEV uptake and further advancements in batteries may change this scenario. This demand uncertainty can be mitigated with the introduction of Battery Storage Systems and control systems that manage the demand across the site. Generally Fast and Ultra-Fast Charging require large amount of power to be delivered to the site which necessitate dedicated Substations and HV lines. The impact on the surrounding grid may also have to be taken into account with upgrades to or new HV Substations and transmission lines potentially required in some instances.

How to Forecast Energy Impacts

To understand the potential impact on the grid, three core figures were required. Those being

- **Forecast BEV Freight Energy Demand** – Developed as part of this work
- **Future Energy Demand** – The total demand of energy forecast in the future
- **Future Energy Generation** – The total amount of energy forecast to be generated in the future based on current and future energy generation projects

Based on this assessment, and in addition to a state based high level assessment of transmission network capability, a series of state-based grid impact assessments can be considered to determine any potential shortfalls in the electricity network caused by BEV freight.

Figure 23 outlines the general high-level methodology used to calculate this. While this provides an initial overview, specific approaches were developed to respond to data structure and availability for Australia's various regional Electrical markets.

Please see Appendix B for further information on these market-specific methodologies.

Noting that generation and baseline demand data is not available beyond 2034, as such a consistent growth factor is applied for these years to understand how EV freight demand changes may affect energy supply assuming all else remains the same.

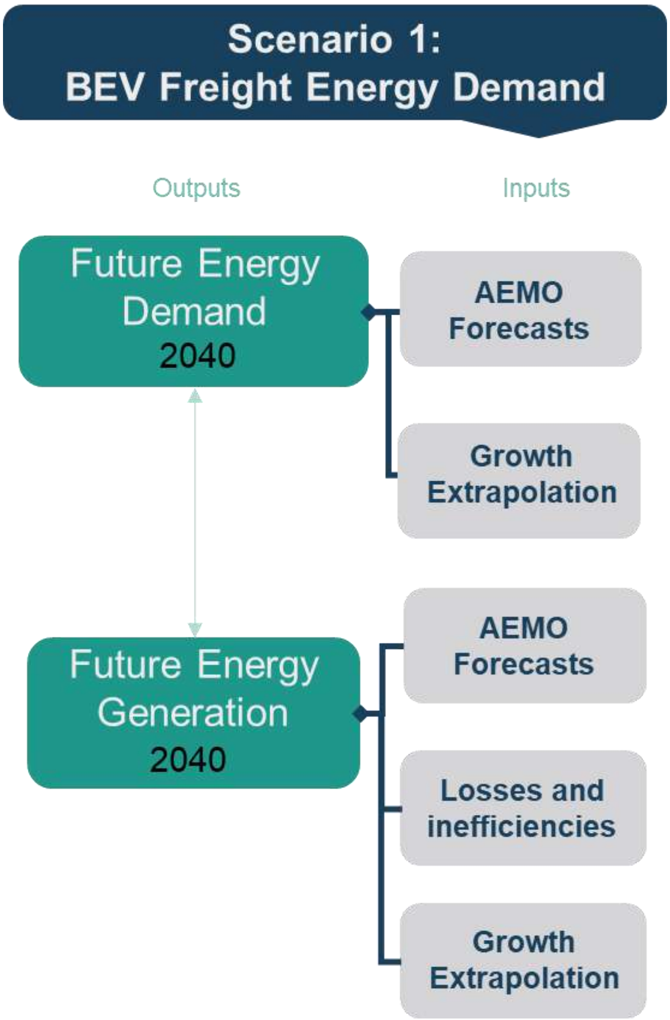


Figure 23 High level Energy Forecasting Methodology Overview

Future Energy Demand

To calculate a potential future energy demand, existing AEMO forecasts were utilised for each state and energy market. Noting that these forecasts only extend to 2034, a growth extrapolation figure was added to extend forecasts to the reference year of 2040. With this in mind, the Future Energy Estimate previously calculated has been included to quantify a potential total demand.

Future Energy Generation

Additionally, existing forecasts prepared by AEMO were taken to understand potential future energy generation out to 2034.

To account for network inefficiencies and losses, a 10% reduction was applied, followed by a growth extrapolation to provide an overall generation figure to 2040.

National Assessment

By assessing the individual energy grids that make up our national energy system, a view emerges of our national capacity to accommodate an electrified freight network. Based on this it appears that while there is a sufficient supply of energy to meet the forecast demand, there is likely to be a degree of capacity tightening as demand grows, particularly in the mid-2030s.

However, it should be noted that available data regarding future generation is limited beyond 2034, and as such while a tightening is illustrated, this assumes only minimal future investment in generation capacity – which is unlikely to occur. Therefore, so long as investment in growing the overall generation capacity continues, any supply side constraints are unlikely to occur.

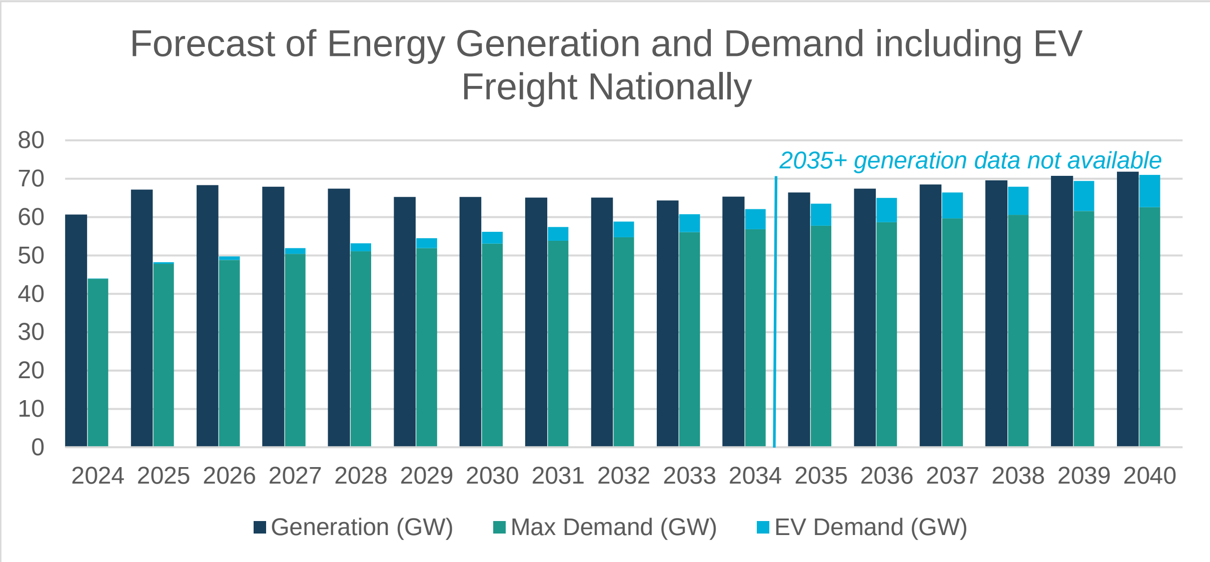
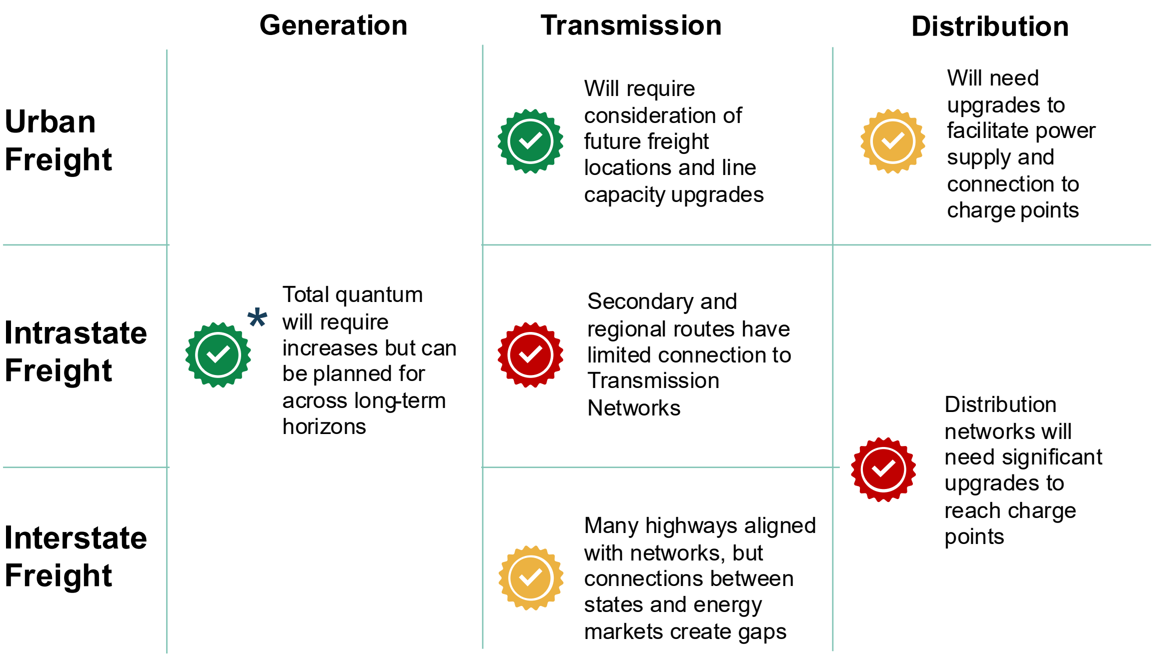


Figure 24 Forecast of Maximum Demand, Generation and EV Demand Nationally

Expanding this assessment to the whole of the energy system indicates that while generation capacity is not likely to be a limiting factor. Aligning transmission and distribution networks to ensure power reaches where it is most needed is likely to be the primary future challenge.



**Some states may see potential energy shortfalls without additional renewable energy supply.*

Figure 25 National Energy Overview

Queensland

The location of the proposed Queensland charging hubs in relation to existing transmission lines is shown in Figure 26 below.

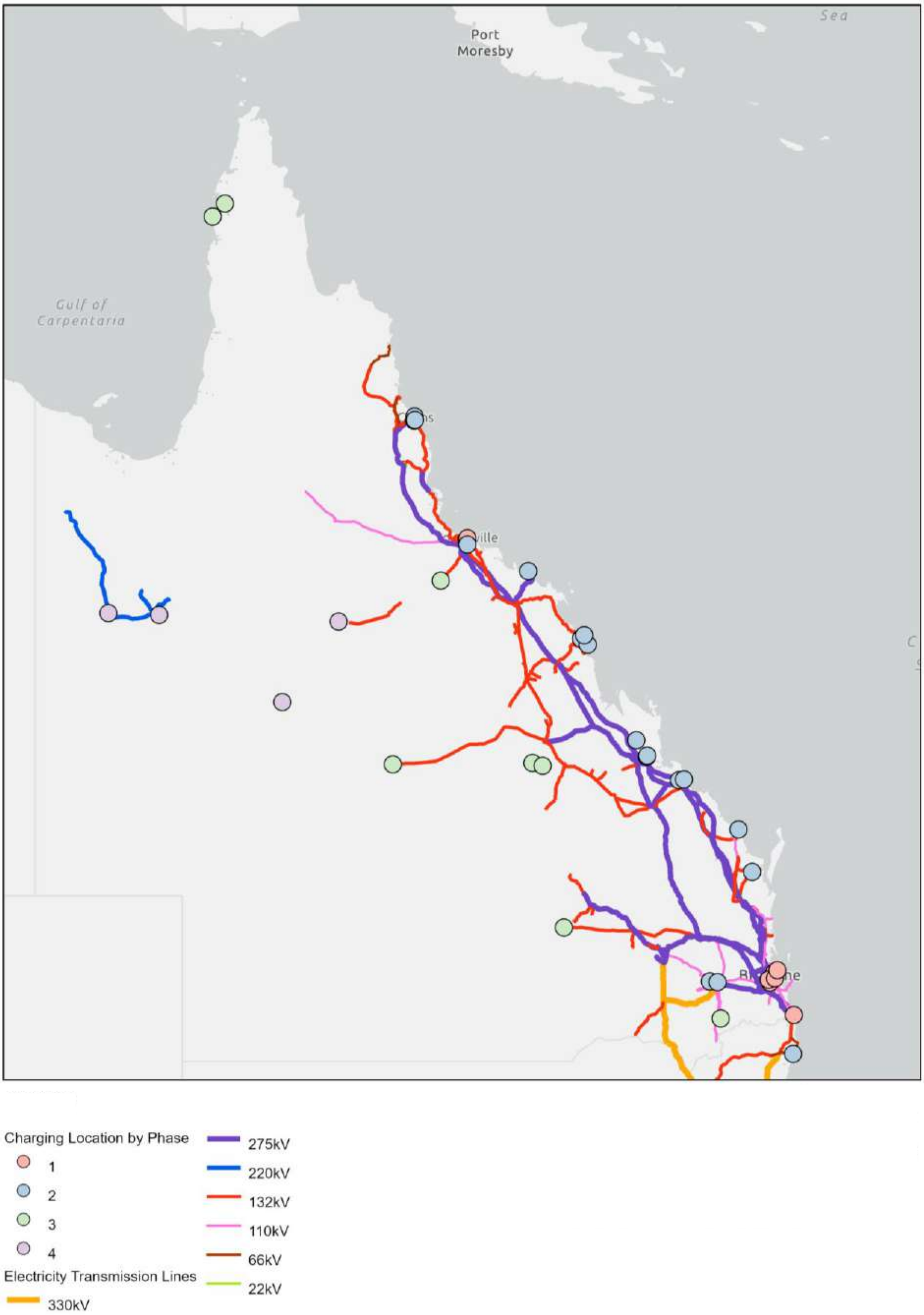


Figure 26 Proposed Queensland Charging Hubs and existing Transmission lines

Transmission Assessment

The majority of sites are located in Urban and Regional Areas which is likely to make for an easier development process for the charging hubs as local electrical grids are reasonably well connected with only a few sites located in Remote and Isolated areas (Table 5). While the two Remote locations are approximately 20kms away from the nearest town.

It is important to note that in addition to these charging hubs Queensland does have a number of isolated communities in terms of electrical networks. Future assessments will be required to determine the need for local charging points in these communities and the need for either additional transmission infrastructure or local generation capacity.

Please see Appendix C for an outline of these isolated communities.

Table 5 Proposed Charging Hub locations in Queensland

Distance to nearest Transmission Substation	Number of sites	Charging Hub Location	Number of sites
0-5 kms	24	Urban	13
5-10 kms	4	Regional	17
10-20 kms	4	Rural	4
20+ kms	6	Remote	2
		Isolated	2
Total			38

Capacity Assessment

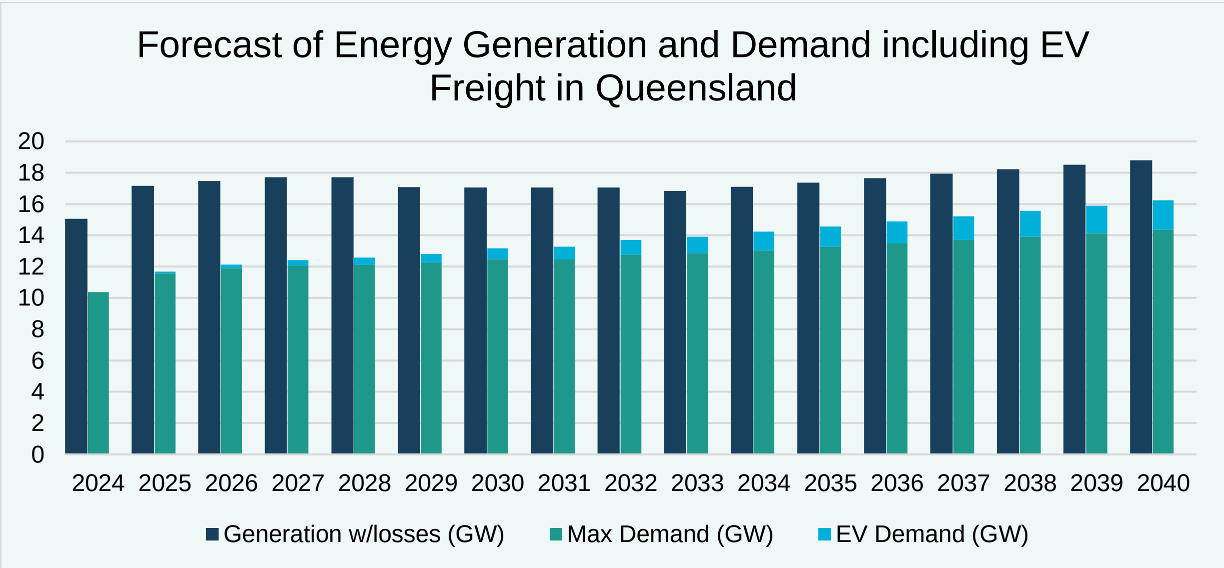


Figure 27 Forecast of Maximum Demand, Generation and EV Demand in QLD[30]

Figure 27 shows a healthy gap between the maximum demand and the generation capacity on the Queensland network even when forecast demand from an electrified freight fleet is considered.

[30] See Appendix B for information sources

Victoria

The location of the proposed Victorian charging hubs relative to existing transmission lines is shown in Figure 28.

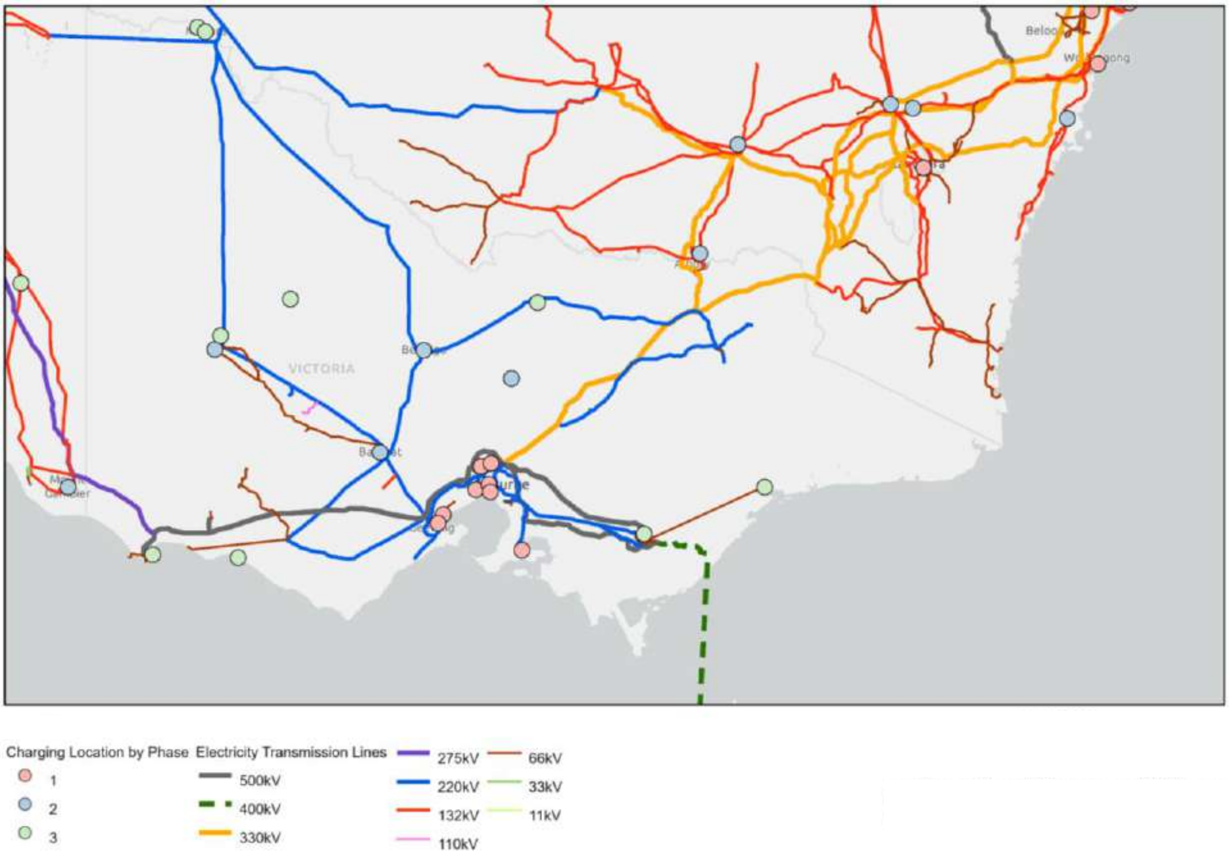


Figure 28 Proposed Victorian Charging Hubs and existing Transmission line

Transmission Assessment

Victoria has a well-developed electricity network across 5 different DNSPs. Table 6 categorises the proposed charging hubs by location, indicating that of the 24 locations identified that all but three are situated in major urban and regional centres (e.g. Melbourne, Ballarat, and Bendigo). Indicating that extensive infrastructure upgrades to connect to local sites are likely not necessary. Of note is the potential need for additional connections along the Hume Highway. There are no remote or isolated charging hub locations in Victoria.

Table 6 Proposed Charging Hub locations in Victoria

Distance to Nearest Transmission Substation	No of sites	Charging Hub Location	No of sites
0-5 kms	11	Urban	10
5-10 kms	3	Regional	10
10-20 kms	3	Rural	3
20+ kms	6	Remote	0
		Isolated	0
Total			23

Capacity Assessment

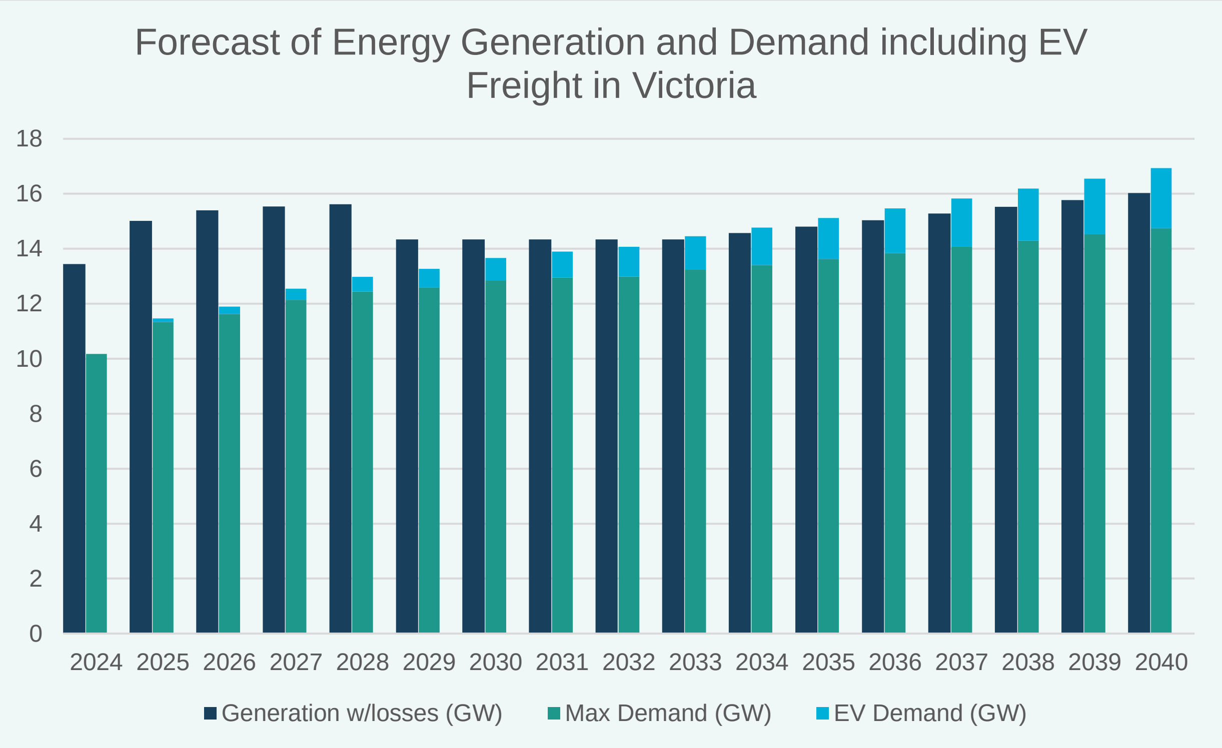


Figure 29 Forecast of Maximum Demand, Generation and EV Demand in VIC[15]

Figure 29 shows a healthy gap between the maximum demand and the generation capacity on the Victorian network for the years up to 2028 - contingent on the approval of new large scale renewables projects.

In 2029 this gap becomes concerningly reduced and by the early 2030's demand may begin to outstrip generation without additional investment in Victorian energy generation. Particularly if planned projects are withdrawn.

However, as Victoria sits within the NEM, this may be offset by additional generation capacity within neighbouring states.

South Australia

The location of the proposed South Australian charging hubs relative to existing transmission lines is shown in Figure 30, with many hubs located in and around the Adelaide region.

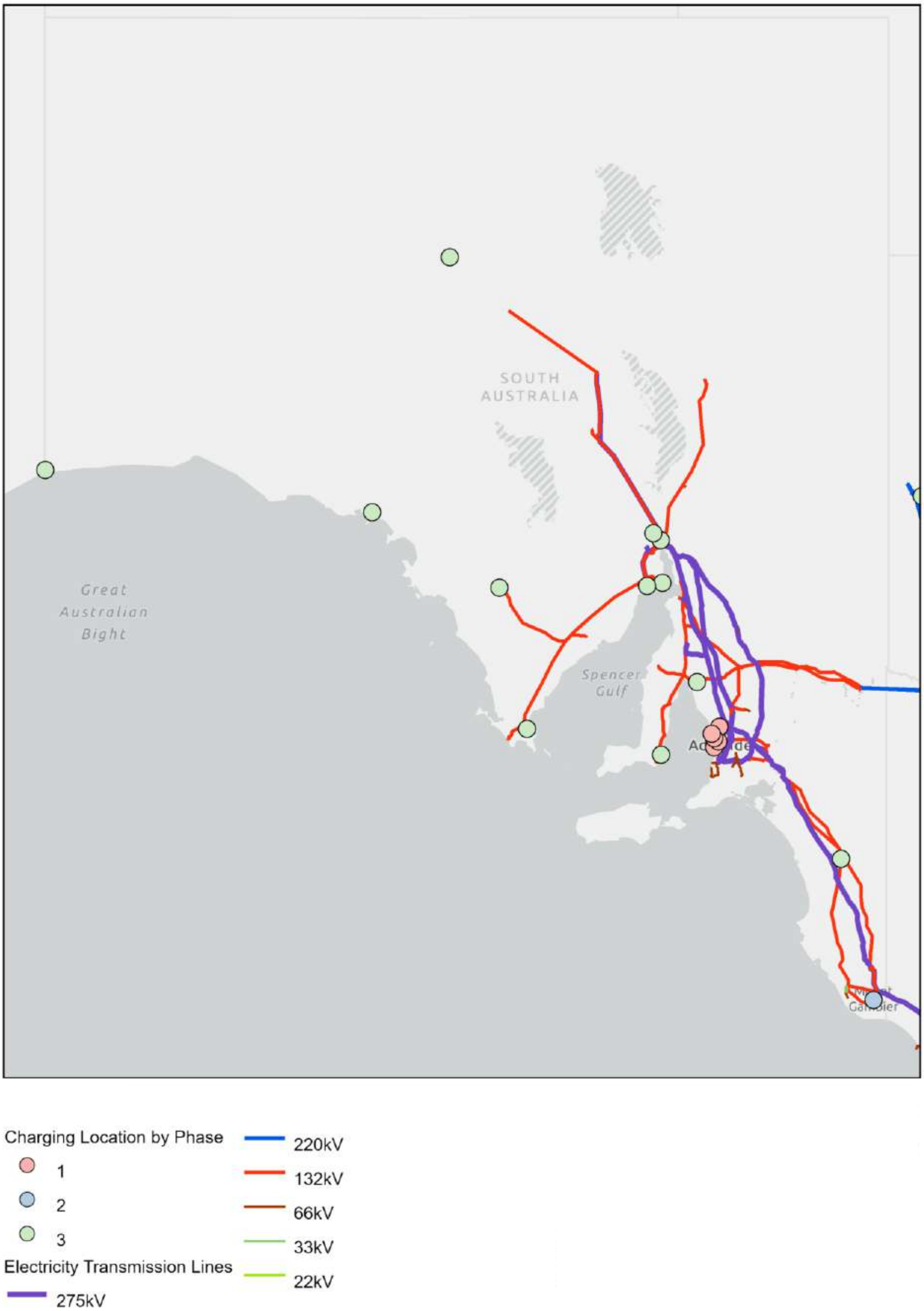


Figure 30 Proposed South Australian Charging Hubs and existing Transmission lines

Transmission Assessment

Table 7 categorises the proposed charging hubs by location, highlighting that most hubs are situated in major urban and regional centres, including Adelaide and Port Adelaide. The one Remote location is located just over 10km from the nearest town.

Of note is that charging hubs on both Northbound and West bound highways, connecting to both Darwin and Perth do not have current connections to a local grid. Whole both routes are targeted for future staging, it does indicate work will need to occur in the intervening period to develop potential solutions.

Table 7 Proposed Charging Hub locations in South Australia

Distance to nearest Transmission Substation	No of sites	Charging Hub Location	No of sites
0-5 kms	7	Urban	6
5-10 kms	5	Regional	4
10-20 kms	2	Rural	6
20+ kms	4	Remote	1
		Isolated	1
Total		Total	18

Capacity Assessment

Figure 31 shows the capacity of generation against the maximum demand and EV demand within South Australia forecasted out to 2040.

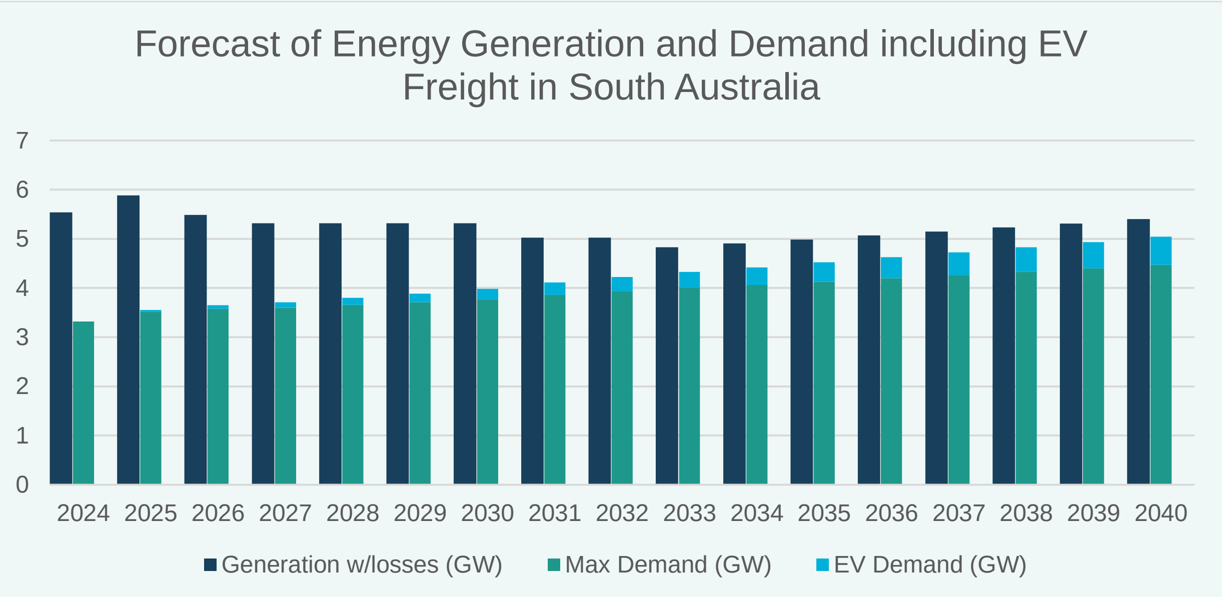


Figure 31 Forecast of Maximum Demand, Generation and EV Demand in SA[15]

This graph shows a healthy gap between the maximum demand including an electrified freight fleet and the generation capacity on the South Australian network.

This gap does begin to become somewhat concerning starting in 2031, with further tightening of supply in subsequent years, but this is likely be due to the lack of planned projects slated for so far in advance.

Tasmania

The location of the proposed Tasmanian charging hubs relative to existing transmission lines is shown in Figure 32, with hubs distributed across urban, regional, and rural areas.

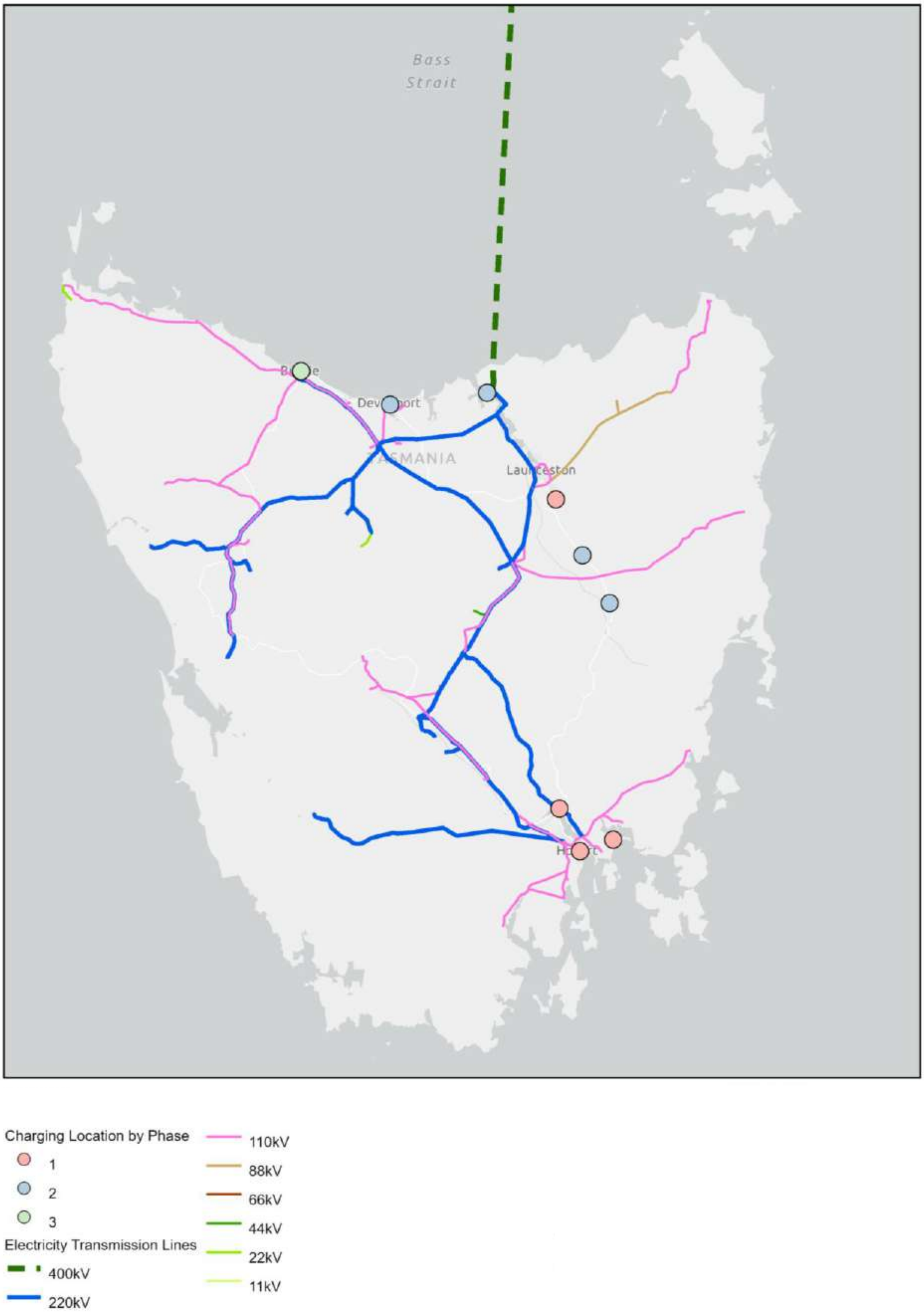


Figure 32 Proposed Tasmanian Charging Hubs and existing Transmission lines

Transmission Assessment

Table 8 categorizes the proposed charging hubs by location, confirming their distribution across major urban, regional, and rural towns and cities. There are no remote or isolated charging hub locations in Tasmania. The largest challenge may be to provide electrical supply along portions of the Midland Highway.

Table 8 Proposed Charging Hub locations in Tasmania

Distance to nearest Transmission Substation	No of sites	Charging Hub Location	No of sites
0-5 kms	6	Urban	4
5-10 kms	2	Regional	3
10-20 kms	0	Rural	3
20+ kms	2	Remote	0
		Isolated	0
Total		Total	10

Capacity Assessment

Figure 33 shows the capacity of generation against the maximum demand and EV demand within Tasmania forecasted out to 2040.

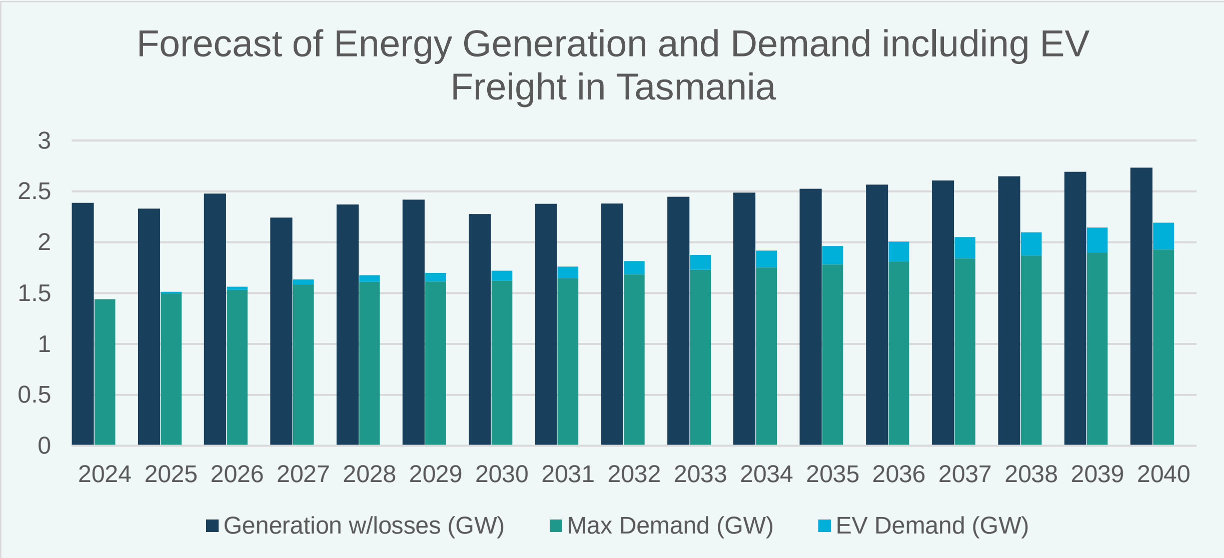


Figure 33 Forecast of Maximum Demand, Generation and EV Demand in TAS[15]

This graph shows a healthy gap between the overall maximum demand even with an electrified road freight sector and the forecast generation capacity on the Tasmanian network.

Western Australia

The location of the proposed Western Australia charging hubs relative to existing transmission lines is shown in Figure 34.

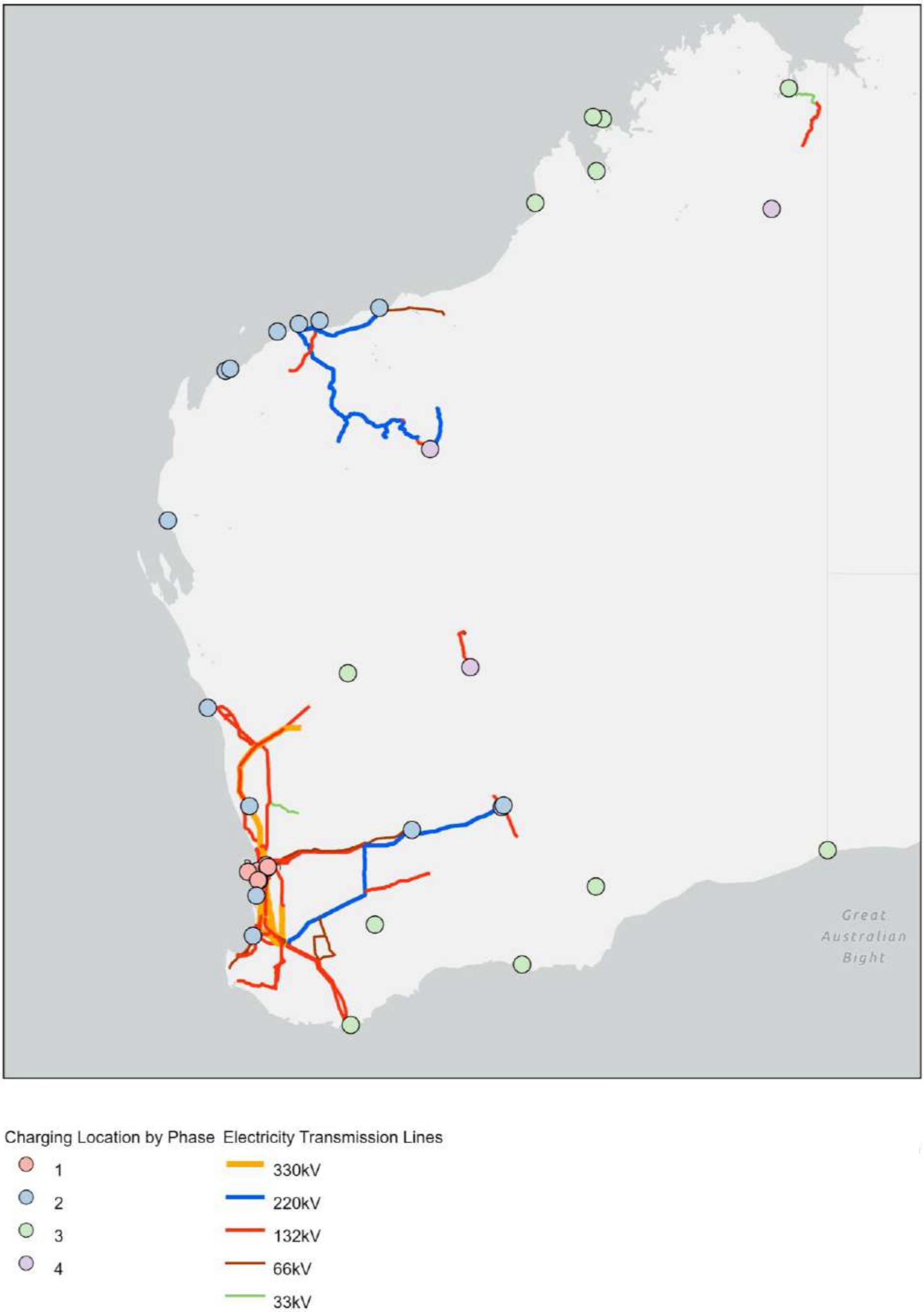


Figure 34 Proposed Western Australian Charging Hubs and existing Transmission lines

Transmission Assessment

Table 9 categorizes the proposed charging hubs by location, identifying most sites located in rural, urban and regional areas. The single remote site is located only 10kms away from a developed area. Each site will face distinct challenges and constraints based on its surrounding infrastructure. As with Queensland, Western Australia also features a significant number of isolated communities lacking central grid connection. This may pose future challenges to provide charging facilities in these areas – see Appendix C for a network map of these communities.

Table 9 Proposed Charging Hub locations in Western Australia

Distance to nearest Transmission Substation	No of sites	Charging Hub Location	No of sites
0-5 kms	13	Urban	9
5-10 kms	2	Regional	7
10-20 kms	3	Rural	13
20+ kms	15	Remote	1
		Isolated	4
Total		Total	34

Western Australia has a complex network of distributors, retailers and generators with many overlapping roles. There are two main widespread grids, the Southwest Interconnected System (SWIS) and the Northwest Interconnected System (NWIS). The SWIS is centred on Perth and includes Albany, Kalgoorlie and Kalbarri and the main distributor in this area is Western Power. The NWIS covers the Pilbara region and is overseen by Horizon Power. Horizon Power is also responsible for the operation of systems in regional towns and to remote communities across the state. Ensuring consistent delivery and upgrades across these systems and operators is likely to be a key challenge in WA.

Capacity Assessment

This data for WA is only for the WEM which is the SWIS network in WA. It does not include the NWIS, or any isolated community data – see Appendix B for a methodology outline.

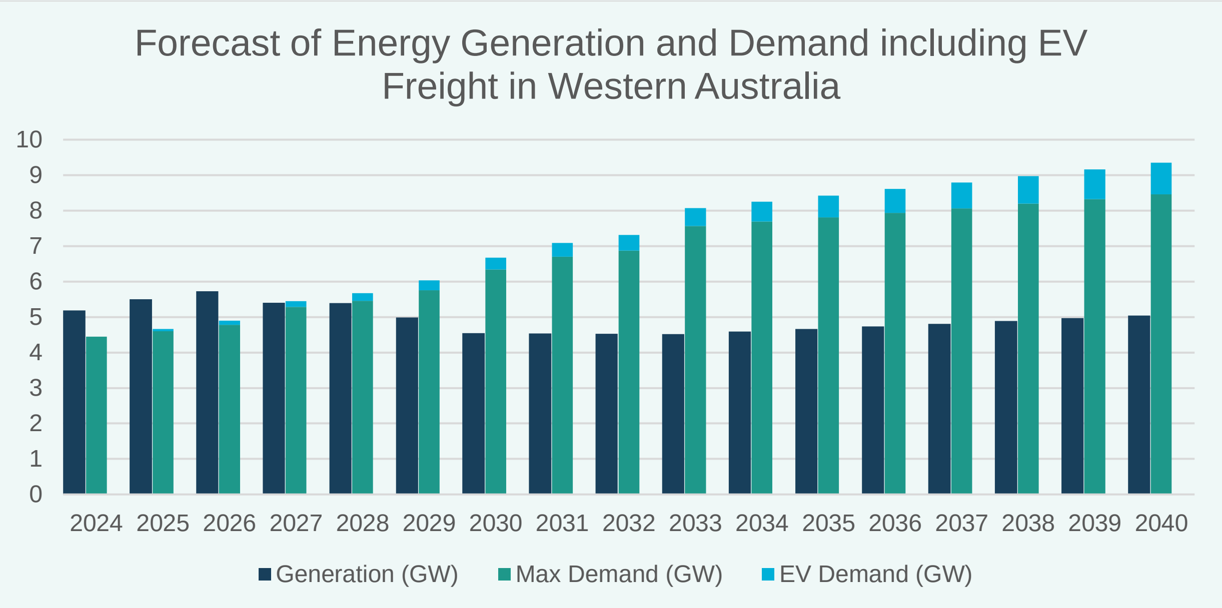


Figure 35 Forecast of Maximum Demand, Generation and EV Demand in WA[15]

Generation in WA appears to drop off severely after 2026 (Figure 35) as data does not include any future generation projects despite the closure of fossil fuel power stations. The ability of the WEM to meet any new demands like those that may be introduced by EVs will depend on the successful delivery of large-scale renewable energy projects.

Northern Territory

The location of the proposed Northern Territory charging hubs relative to existing transmission lines is shown in Figure 36.

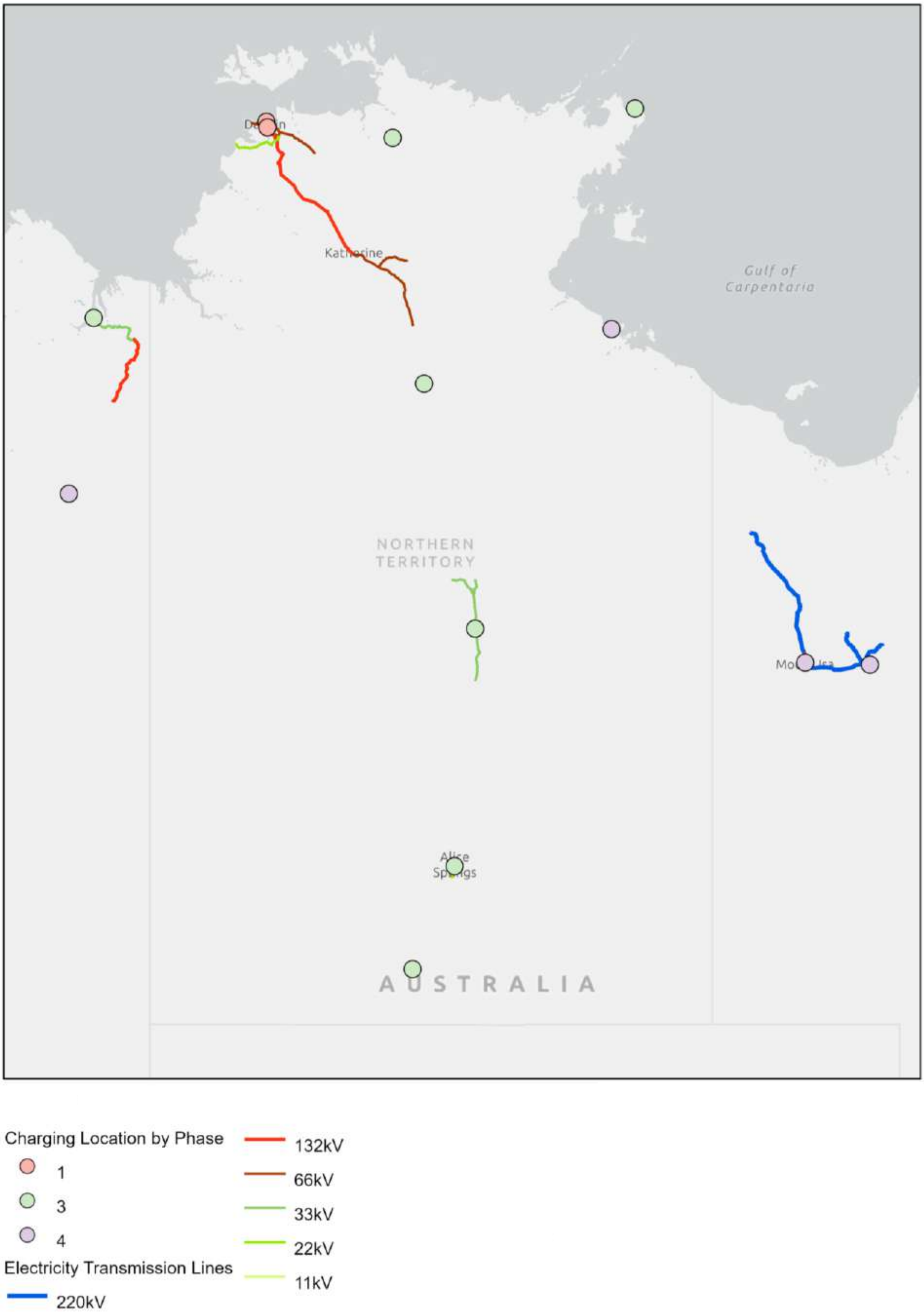


Figure 36 Proposed Northern Territory Charging Hubs and existing Transmission lines

Transmission Assessment

Most proposed hubs are in remote and isolated regions, making network extensions challenging and costly, with only a few in urban and regional zones (Table 10). Additionally, some hubs are near protected Indigenous lands and national parks, introducing further constraints. It's also important to note that two of the remote locations are positioned approximately 150 and 250 kms away from existing infrastructure and while the last is located alongside a 33kv Transmission line is still approximately 60kms from the nearest substation/power station. In line with this network provision there are several communities that are isolated from the electrical grid. These communities depend on freight deliveries for essential supplies, as such the need for local energy for BEV trucks will be of importance.

Table 10 Proposed Charging Hub locations in Northern Territory

Distance to nearest Transmission Substation	Number of sites	Charging Hub Location	Number of sites
0-5 kms	2	Urban	2
5-10 kms	1	Regional	1
10-20 kms	0	Rural	0
20+ kms	6	Remote	3
		Isolated	3
Total		Total	9

Power and Water is the main Network Service Provider for Northern Territory. They have three separate, regulated grids including Darwin -Katherine, Tennant Creek and Alice Springs. Outside of these areas they operate several smaller grids that are unregulated by the AER. They also have a subsidiary Indigenous Essential Services specifically for managing isolated Aboriginal communities outside of these grids

Capacity Assessment

This data was sourced from the Northern Territory Electricity Outlook Report 2023 – see Appendix B for a methodology outline.

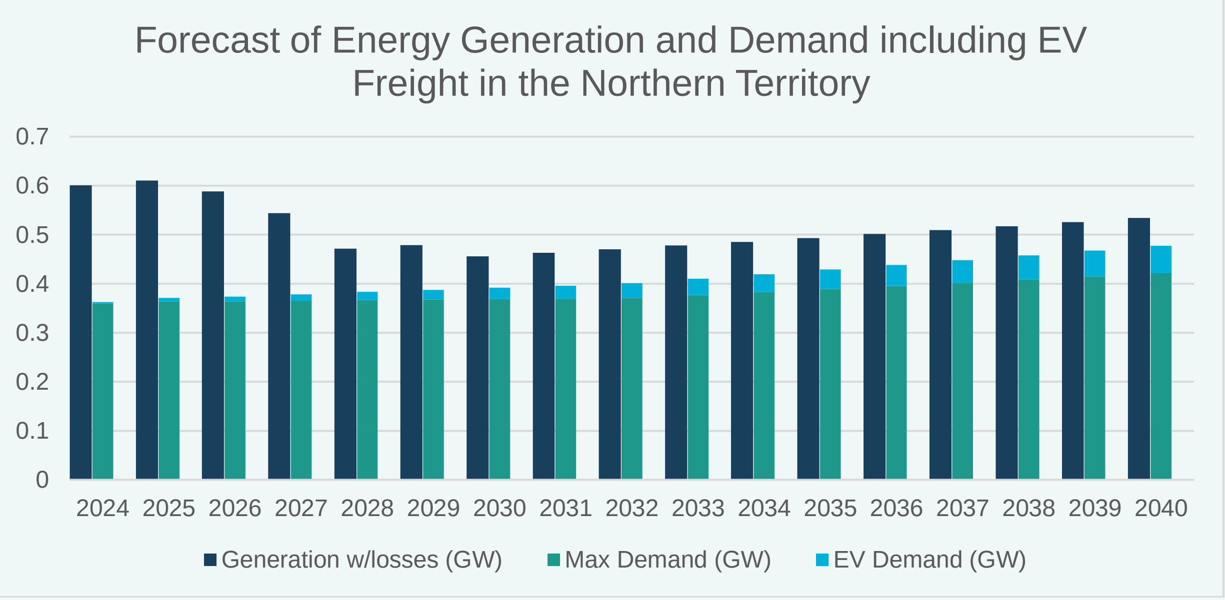


Figure 37 Forecast of Maximum Demand, Generation and EV Demand in NT[15]

Generation in NT drops off after 2026 as data does not include any planned generation projects but does include the closure of fossil fuel power stations. While generation capacity does appear to meet potential future demand, including from EV freight, the separate NT grids may see localised variances, and will likely require additional large-scale renewable energy projects.

New South Wales/ACT

The location of the proposed New South Wales/ACT charging hubs relative to existing transmission lines is shown in Figure 38.

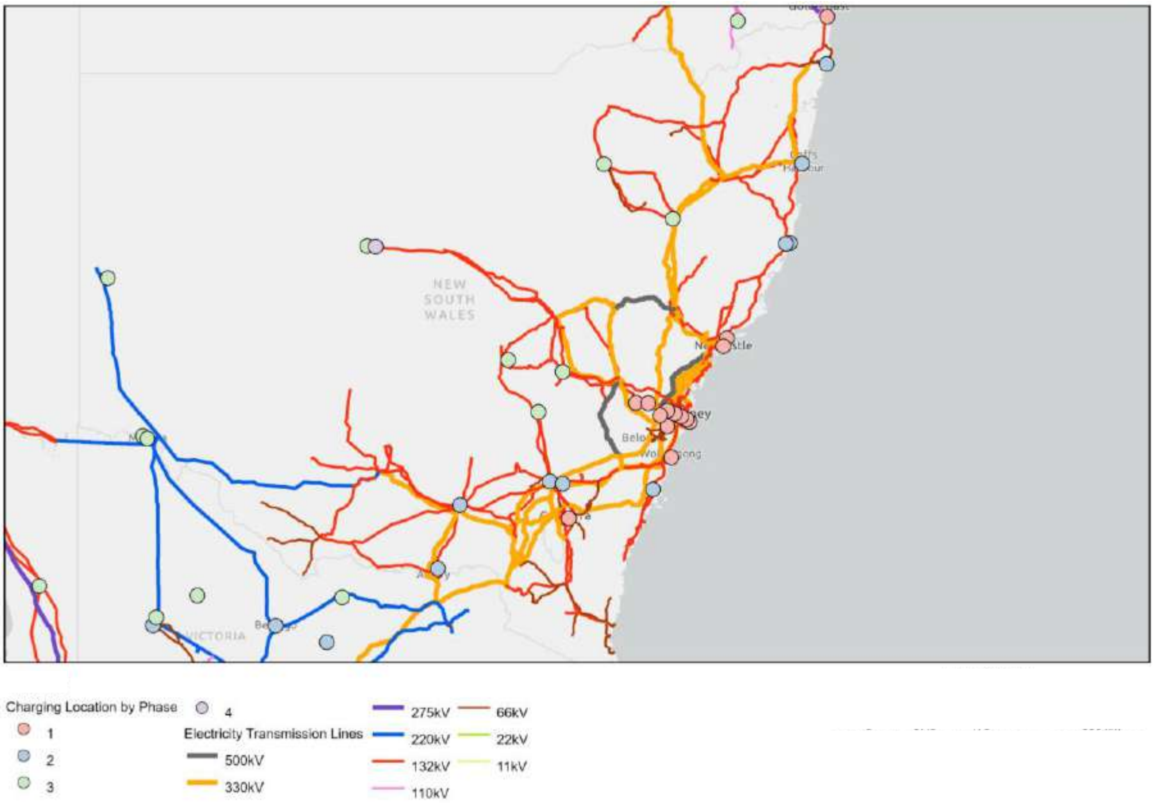


Figure 38 Proposed New South Wales Charging Hubs and existing Transmission lines

Transmission Assessment

New South Wales has a well-developed electricity network across much of the state, as illustrated in Table 11 which identifies that all the identified charging hubs in NSW are located in either Urban, Regional, or Rural areas. No proposed sites are in Remote or Isolated Areas.

Table 11 Proposed Charging Hub locations in New South Wales/ACT

Distance to Nearest Transmission Substation	No of sites	Charging Hub Location	No of sites
0-5 kms	21	Urban	13
5-10 kms	7	Regional	9
10-20 kms	1	Rural	9
20+ kms	2	Remote	0
		Isolated	0
Total		Total	31

Capacity Assessment

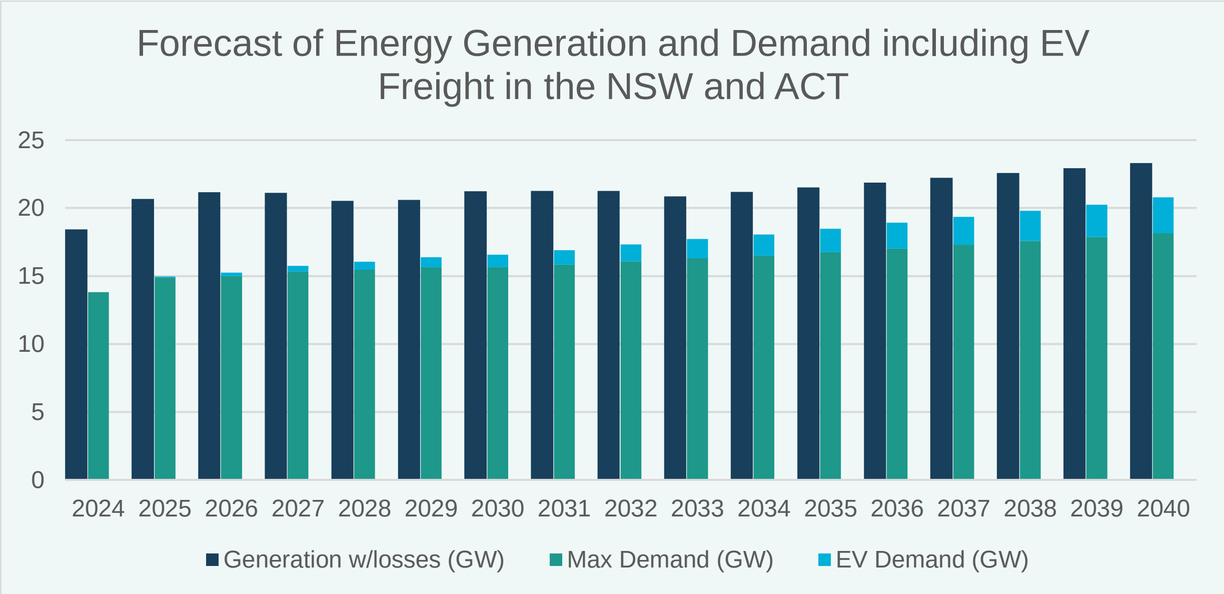


Figure 39 Forecast of Maximum Demand, Generation and EV Demand in NSW[15]

Figure 39 shows a healthy gap between the maximum demand and the generation capacity on the New South Wales network.

Electrification In Practice

From Port to Distribution Hub (Intrastate)

In the future, packages arriving at the Port of Brisbane, are placed on new battery electric trucks. Instead of idling while waiting, the truck instead charges in queue, providing a quick top up. With much of the Port's freight traffic electrified the area is now quieter, with cleaner air.

As the truck travels from the port to the distribution hub, it loses very little power, arriving with a still well charged battery, enabling it to carry on for another trip.

Crossing State Lines (Interstate)

Loaded onboard a fully charged truck, the package gets on the road. The truck belongs to a small operator, who is using an older model EV truck, with a range of 600km.

While this means needing to stop part way to charge, the operator has found that the lower maintenance costs, and not being affected by the price of diesel, that they operate more effectively with an improved margin.

The driver pulls into a roadside charging hub outside Port Macquarie to use the new Megawatt charger. With the new equipment, their time off road is only a few minutes, and they can make the most of their downtime charging to also take a fatigue rest.

Finally, the truck pulls into the NSW distribution hub, with a BEV truck's reduced noise, the truck can arrive much later in the evening than it could in the past.

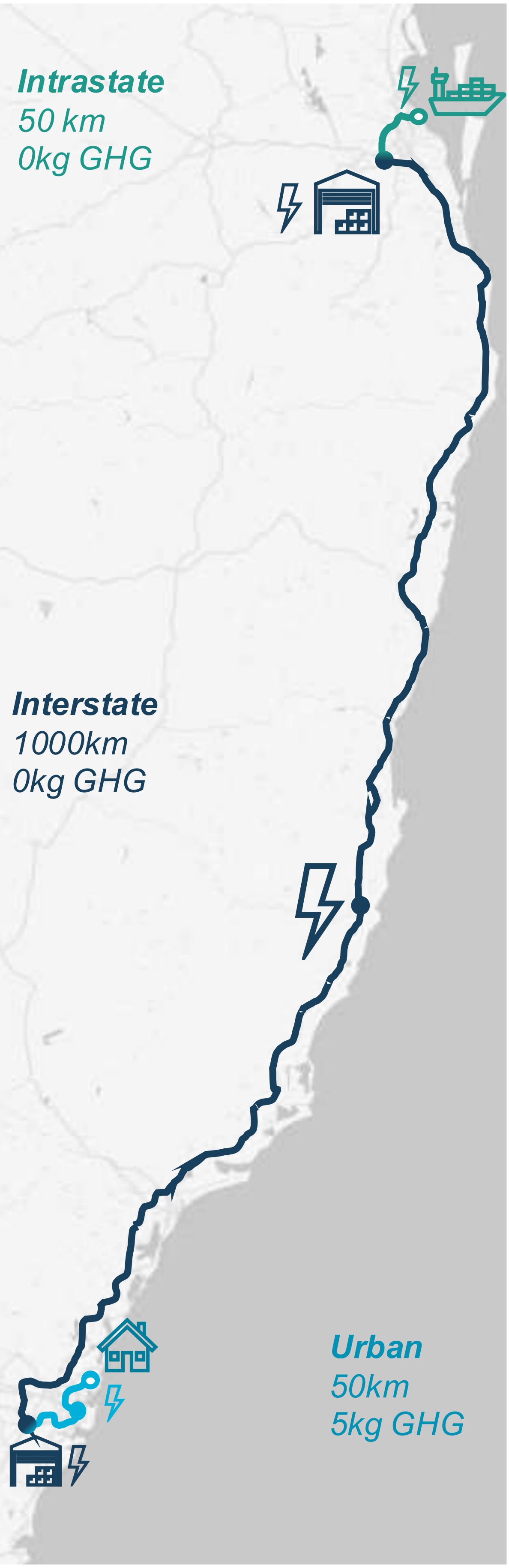
Making the Last Mile Trip (Urban)

The package arrives at a fully redesigned distribution hub in Sydney. With the advent of electrified fleets, facilities can be redesigned to take advantage of the reduced tailpipe emissions, allowing freight vehicles to fully enter the facility, driving right up to warehousing stacks, allowing improved operational efficiencies.

The package is loaded on another small operator's van. While the driver can't charge at their unit, they can use a shared charging hub overnight. Leaving the van charging in a safe secure space all night.

Driving right into the facility the vehicle is loaded and on its way. Despite the full charge, it's a busy day with a lot of deliveries, so to be safe the driver uses a public fast charger. Recharging is quick, before getting back on the road and dropping the package at its destination.

Its journey has taken over a thousand kilometres in Australia alone, passed through numerous hands, and multiple facilities, but arrives in time and without a single gram of tailpipe emissions.



Part 5: Summary and Recommendations

Summary and Recommendations

Based on this assessment, it is clear that there is a strong opportunity to undertake a wide-scale and targeted program to electrify the road freight industry. However, in doing so, a wide cross section of the arms of government will need to be engaged with and directed to target road freight electrification as a key priority.

A set of core actionable themes have been identified:

- **Delivering Demonstration Projects**
- **Strategy and Policy Changes**
- **Market Support and Shaping Activities**
- **Funding Electrification Initiatives**
- **Infrastructure Delivery**

In enacting these recommendations, industry will face significant challenges and require consistent government support, any significant further delay is likely to create potential challenges in our ability to decarbonise the industry in time to meet our net-zero 2050 targets.

The key takeaways are:

1. Urban freight is the most feasible use case to electrify initially, but will need a focused program to support widescale electrification of capital cities and major regional centres
2. Energy generation is not likely to be the key determining factor in road freight electrification. Instead focus should be placed on ensuring transmission and distribution networks as well as underlying energy policy and markets are fit for purpose to support future freight electrification
3. Work should continue at pace to explore and identify solutions to enable charging along major highways to support intrastate and interstate freight
4. The Commonwealth Government should work with State and Territory Governments to further develop and refine network analysis particularly for more localised solutions
5. Significant cross-Government focus will be required to update policy and regulatory settings to enable and support BEV freight, including additional funding support for pilots, innovation, and research

Data and Knowledge Sharing Recommendations

In the development of this report multiple sources of data were identified as of potential value. However, due to existing data arrangements only a limited amount of specialised freight data is easily available.

In lieu of this, publicly available data was used, however this too poses some challenges as suitable datasets previously collected begin to age and become less reliable.

This varied data can be challenging to use in conjunction with each other, or to integrate with other data sets. Sources including the ABS, BITRE & NHVR each report on different and shared aspects of road freight in Australia.

Further, stakeholders have reported a desire for an improved data ecosystem nationally, which would improve operational efficiency and decision making by industry.

Electrification efforts would be greatly advantaged by further collaboration between government data agencies. presents digital infrastructure recommendations with actions that can be enacted in the short-term and actions which can be investigated further and implemented in future years (Table 12).

Table 12 Data actions for consideration

To Do Today	To do Tomorrow
Improve accessibility of freight movement data nationally	Ensure EV truck data including movements and charging are captured by National Regulators
Data capture of smaller freight vehicles to understand needs	Align national energy data with freight data
Maintain and align motor vehicle usage for historical tracking	Improve alignment between future energy forecasts and EV freight demands

Policy, Regulation, and Market Shaping Recommendations

The increasing success of electrifying passenger vehicle has advanced in line with the increasing provision of charging infrastructure. The provision of infrastructure for electrified freight vehicles is likely to be a key item to unlocking the industries potential.

However, while infrastructure will remain a central pillar, the freight sector, even more so than passenger vehicles will require a wider range of supporting actions, and policy adjustments to maximise the impact of such infrastructure.

To enable a more seamless transition to battery EVs, a broader view is required to undertake a holistic transition planning process. There are several avenues of change which would reduce barriers for operators and encourage the uplift of the electric freight vehicle market.

Policy

Managing heavy vehicle and freight electrification requires a coordinated approach. Establishing a more consistent policy and strategic environment for the sector would be an important first step in establishing a consistent transition plan

Potential Changes

- Establish both National and State policy positions for freight electrification to act as central backbone of targeted transition planning
- Review energy policy approaches to consider future need for energy supply to freight locations outside of, or between current energy markets

Regulatory

A comprehensive review of existing regulatory settings should be conducted by both Commonwealth and State Governments, to identify regulatory barriers to EV adoption, and seek to develop consistent approaches to encourage fleet transitions

Potential Changes

- Amend licencing regulations that may unintentionally discourage electrification
- Seek to establish greater alignment of state regulations to ease electric adoption
- Consider changes to Design Rules that limit EV model importation or usage

Market Shaping

Establish targeted funding and market support mechanisms to encourage freight fleet electrification and charging solutions in a targeted manner to grow market capacity and confidence

Potential Changes

- Identify pathways to encourage freight customers to decarbonise supply chains.
- Provide targeted support for infrastructure and asset owners to provide charging infrastructure
- Identify solutions to support small freight operators to electrify
- Take a targeted approach to enhancing EV skills and training for freight workers

Infrastructure and Delivery Recommendations

Core to our ability to electrify road freight is of course the provision of the infrastructure that will act as the central pillar of an electric future.

As outlined, this is likely to require the development of at least 165 dedicated freight charging hubs across Australia, located on both public and private land, and servicing a wide range of potential users. In doing so we can focus on two core areas.

Demonstration Projects

To capitalise on industry interest and early initial investments, a handful of targeted demonstration projects can be considered which would allow for immediate investment and develop greater project delivery knowledge in key areas.

An Urban Shared Charging Project

Designed to demonstrate the viability and develop learnings of the delivery of shared charging facilities for small operators in urban areas.

Potential regions to consider include

1. **Western Sydney**
2. **North Melbourne**
3. **Western Brisbane**

A Regional Highway Charging Project

Designed to leverage early adoption of electric trucks by some operators, as well as to connect important local trips, while also developing key learnings of delivery (Figure 40).

Potential regions to consider include

1. **Brisbane to Gold Coast – The Electric Coast Highway**
2. **Sydney to Newcastle – The Pacific Powered Highway**
3. **Melbourne to Ballarat – The Western Charged Highway**

Figure 40 Potential Demonstration Project Locations

Long Term Infrastructure Delivery

In addition to demonstration projects, work should be quickly on establishing a long-term infrastructure pipeline to support freight electrification. This should focus on

- Establishing a staged program focusing on early wins in Urban areas, followed by future delivery of highway and regional charging hubs as outlined in this report
- Preparatory work to confirm site identification for future charging points and ensuring long term corridor protection and enabling works are advanced
- Energy network upgrades delivered with freight energy demands in mind, and processes outlined with network providers to enable future efficiencies in delivery
- Solutions developed and tested to enable remote location energy supply

Action Plan to Electrify Road Freight

Based on the above a set of actions have been developed which are intended to help guide Governments in supporting electrification.

Theme		Action	Timeline
Demonstration Projects	1	**Urban Project** Consider a potential rapidly developed demonstration project within a key urban centre offering shared charging solutions to freight operators/drivers without a dedicated depot. Look to rapidly deploy and develop to gain immediate lessons *Potential locations - Western Sydney – North Melbourne – Western Brisbane*	**1 - 2 years**
		Regional Project Consider a potential rapidly developed demonstration project along a key freight corridor to facilitate extended trips out of major urban centres. Look to rapidly deploy and develop to gain immediate lessons *Potential Locations - Pacific Powered Highway, Sydney to Newcastle - Electric Coast Highway, Brisbane to Gold Coast, Western Charged Highway, Melbourne to Ballarat*	**1 - 2 years**
Strategy and Policy	2	Develop a National Freight Electrification Strategy, including use case specific transition targets	**1 - 2 years**
	3	Work across all levels of Government to review the outcomes of this study and to develop localised approaches to state networks	**1 - 2 years**
	4	Work across all levels of Government to align regulatory pathways for Electric Vehicle use and remove potential barriers or provide regulatory incentives to adopt Electric Vehicle models (e.g. Licencing, Design Controls, Access)	**1 - 2 years**
	5	Develop Electric Vehicle standards and targets for Government owned freight assets and operators (e.g.: Intermodal terminals, Ports)	**1 - 2 years**
	6	Look to establish a Heavy Vehicle electrification tracking program, and how to best capture Electric Vehicle freight data as part of national data provision requirements	**1 - 2 years**
	7	Develop process standards for facilitating electrical upgrades and connections to logistics hubs, considering state/DNSP and demand	**1 - 2 years**

Theme		Action	Timeline
Market Support and Shaping	8	Develop a central portal for industry to access both with skills training resources and to facilitate industry access to Australian firms with electrification expertise	**1 - 2 years**
	9	Establish regular and routine knowledge sharing between Government and Industry to explore pilots, identify challenges, and leverage opportunities	**1 - 2 years**
	10	Engage directly with Owner-Operators and drivers to assist with change management	**1 - 2 years**
	11	Work with DNSPs to understand transition pathways, demand levels, and timelines for freight electrification and leverage learnings from development of Electric Vehicle infrastructure for fleets and bus depots	**1 - 2 years**
Funding Electrification	12	Fund local vehicle manufacturing to support Electric Vehicle uptake and explore opportunities to fund or support small operator access to vehicles	**2- 5 years**
	13	Continue to fund specific use case pilot projects and share lessons learnt	**Ongoing**
	14	Investigate funding options to support freight customers and freight hubs to electrify assets	**1 - 2 years**
	15	Explore renewable energy solutions (Solar, Wind, BESS) for Electric Vehicle freight charging in remote and isolated locations	**2- 5 years**
Infrastructure Delivery	16	Identify core freight routes along the suggested network staging and investigate route requirements and corridor preservation needs	**1 - 2 years**
	17	Identify charging locations on key routes and consider preparatory works or alignment with the delivery of other energy projects	**2- 5 years**
	18	Deliver charging hubs along major freight routes, including driver facilities	**5 - 10 years**
	19	Support regular collaboration between DNSPs and Logistics operators with a focus on early identification of remote or large-demand locations	**Ongoing**
	20	Explore network redundancy and resiliency in terms of the number of locations and energy supply (particularly for remote locations) and prioritise interventions in line with recommendations of this study (i.e. focusing on national corridors)	**5 - 10 years**
	21	Deliver renewable energy solutions in remote and isolated locations	**10+ years**

Appendix A

Freight Vehicle and Charging Equipment Availability

Appendix A

Freight Vehicle Availability

Class	Sub class	Current models	Maximum charging rate / Battery size
Light commercial	Ute	LDV eT60	88.5 kWh
		Ford F150 Lightning	98 & 131kWh options
		BYD Shark 6	80kWh
	Van	LDV eDeliver	77 & 88kWh options
		Merecedes EQV	90kWh
		Mercedes-Benz eVito	85kWh
		Peugeot e-Partner	50kWh
		Peugeot e-expert	75kWh
		Renault Kangoo E-Tech	33 kWh
		BYD T3	50.3 kWh
		ACE Cargo Light	23.2kWh
		EC11	73.6kWh
		SEA E4V	88kWh
Trucks		Volvo FM (rigid or articulated)	450-540 kWh, 5-6 batteries
		Volvo FE (rigid)	280-375 kWh, 3 to 4 batteries
		Volvo FH (articulated)	450-540kWh
		Volvo FMX (rigid or articulated)	450-540kWh
		Volvo FL (rigid)	280-375kWh
		Volvo FH Aero (articulated)	450-540kWh

	JAC N55 (rigid)	97kWh
	JAC N75 (rigid)	107kWh
	JAC N90 (rigid)	107kWh
	Mercedes eActros300 (rigid or articulated)	336kWh
	Mercedes eEconic (rigid)	336kWh
	SEA 300EV (rigid)	138kWh
	SEA500EV (rigid)	280kWh
	JANUS Electric Kenworth T403 (Truck conversion)	600kWh
	Foton T5 (rigid)	81kWh
	Fuso eCanter (light, medium, heavy rigid)	41.3, 83, 124 kWh
	Hyundai Mighty (rigid)	115kWh
	Scania 25P (rigid)	165kWh

Charging market conditions

Power level	Common name	Power	Availability	Current Deployment	Relevant vehicle	Example
Level 1	Socket charger	2.3kW	Readily	Mature	LCVs	
Level 2	AC fast charging	3.5kW	Readily	Mature	LCVs & Rigids	
		7.4kW	Readily	Mature	LCVs & Rigids	
		22.1kW	Readily	Mature	LCVs & Rigids	
Level 3	DC wall charger	25kW	Readily	Mature	LCVs & Rigids	
	DC fast charger	50kW	Requires specialist	583 Australian locations	LCVs, Rigid and Artics	
		100kW	Requires specialist		LCVs, Rigid and Artics	
		150kW	Requires specialist		LCVs, Rigid and Artics	
	Ultra-fast charger	>350kW	Requires specialist	229 Australian locations	LCVs, Rigid and Artics	

Based on stakeholder feedback and an assessment of available technology and charging solutions, the below overview of likely charging solutions has been developed.

Where are we assuming most charging occur? | What type of charging would be required?

Urban Freight	Intrastate Freight	Interstate Freight	Charging Location	AC Charging	DC Charging	DC Fast Charging	DC Ultra-Fast	Alternative Solutions
1	1		Depots/ Base	✓	✓	✓	✓	Battery Swaps Megawatt Charging
1			At Home	✓	✓			Shared Charging Hubs
2			City Public Charging		✓	✓	✓	
2	2	2	Customer Sites		✓	✓		Induction Charging
	1	1	Public Highway		✓		✓	Megawatt Charging Battery Swaps
2	2	1	Freight Hubs			✓	✓	Induction Charging Megawatt Charging

Key Challenges

- How to support small operators and drivers charging at home or without centralised bases
- Incentivising charging facilities at client sites
- Providing charging at key freight hubs
- Secondary freight routes (particularly Inland have limited Infrastructure)
- Charging points on route will be challenging to support at existing rest stops

Appendix B

Energy Forecasting Methodology

Appendix B

Energy Forecasting Methodology

National Energy Market

The value for maximum demand in 2024 is the actual peak demand value for summer 2023/24[31]. For the years 2025 to 2034, maximum demand data is retrieved from AEMO[32]. The data is filtered using the following parameters: ESOO 2024, Category - Operational (As generated), Region – [state name], Scenario - All, Season - Summer, and Probability - 10%. For the years 2035 to 2040, the data is extrapolated at an annual growth rate of 1.6% based on the previous year's value.

Generation data for the years 2024 to 2033 is obtained from AEMO[33]. To account for losses and inefficiencies, the total value is reduced by 10%. For the years 2034 to 2040, generation data is extrapolated at a growth rate of 1.6% per year, with the same 10% reduction applied to account for losses and inefficiencies. The NEM Generation Data includes scheduled closures of power stations as well as planned generation projects. Planned generation projects may not ultimately connect to the network or for the same capacity value that they were planned for.

It is important to note the increase in renewable generation creates a difference in the capacity and actual generation available. Currently, fossil fuelled generation like gas fired power plants can quickly increase in generation up to the total capacity value when required. Renewable sources of electricity do not have the same ability as they are limited in their generation by the availability of the renewable resource. When this occurs in conjunction with maximum demands on the network this can cause shortfalls even though the capacity is much higher. EV Demand Data is as per the totals given in section titles 'How Much Power Will Be Needed'.

For the analysis in this section the highest uptake forecast for 2040 was used. This was assumed to be a linear growth from 0 to the final value in 2040. The data was originally developed as a whole demand across the year and so an average value was used in this analysis. It would be difficult to predict the peak demand value in one year given uncertainties in the various aspects that would contribute to that number.

WEM

The maximum demand data for the years 2024 to 2033 is sourced from AEMO[34] which provides actual and 10% POE summer peak demand forecasts under three scenarios from the 2023 and 2024 for the WEM, spanning the period from 2018-19 to 2033-34 (measured in MW). For this analysis, the 2024 High Scenario is used. For the years 2034 to 2040, maximum demand data is extrapolated at a growth rate of 1.6% based on the previous year's value.

Generation data for the years 2024 to 2033 is also obtained from AEMO[35] which outlines the forecast supply-demand balance under the Expected demand growth scenario for the period from 2024-25 to 2033-34 (measured in MW). The forecast for available Reserve Capacity under the Expected Scenario is utilized. For the years 2034 to 2040, generation data is extrapolated at a growth rate of 1.6% from the previous year's value. The Generation data does not include any proposed or probable generation projects, only committed ones.

This data for WA is only for the WEM which is the SWIS network in WA. It does not include the NWIS, or any isolated community's data. It is important to note the increase in renewable generation creates a difference in the capacity and actual generation available. Historically, fossil fuelled generation can quickly increase in generation up to the total capacity value when required. Renewable sources of

[31] AER, Seasonal Peak Demand – regions,
[32] NEM forecasting and planning data portal, 2024-08-29,
[33] NEM Generation Information October 2024,
[34] 2024 WEM ESOO Report
[35] 2024 WEM ESOO Report h

electricity do not have the same ability as they are limited in their generation by the availability of the renewable resource. When this occurs in conjunction with maximum demands on the network this can cause shortfalls even though the capacity is much higher. EV Demand Data is as per the totals given in section titles 'How Much Power Will Be Needed'

For the analysis in this section the highest uptake forecast for 2040 was used. This was assumed to be a linear growth from 0 to the final value in 2040. The data was originally developed as a whole demand across the year and so an average value was used in this analysis. It would be difficult to predict the peak demand value in one year given uncertainties in the various aspects that would contribute to that number.

Northern Territory

Maximum demand data for the years 2023 to 2032 was calculated using information from the Northern Territory Electricity Outlook Report 2023. All data was collected using the POE10 scenario. For the years 2033 to 2040, maximum demand data is extrapolated at a growth rate of 1.6% from the previous year's value.

The generation data was sourced from the Northern Territory Electricity Outlook Report 2023. In the report, generation data is categorized into three regions: Darwin/Katherine, Alice Springs, and Tennant Creek. The data was obtained for the year 2023, and then for the years 2024 to 2040, generation data is extrapolated by increasing the previous year's total by 1.6% annually. If any generators are decommissioned in a given year, their capacity is subtracted from the total summer capacity for that year. The generation data does not include any planned generation projects.

Appendix C

DNSP Reference Maps

Appendix C

DNSP Reference Maps

Queensland

Figure 41 is from Ergon, the Distribution Network Service Provider in rural Queensland. It shows the distribution network in darker blue while areas in the lighter blue operate as isolated communities.

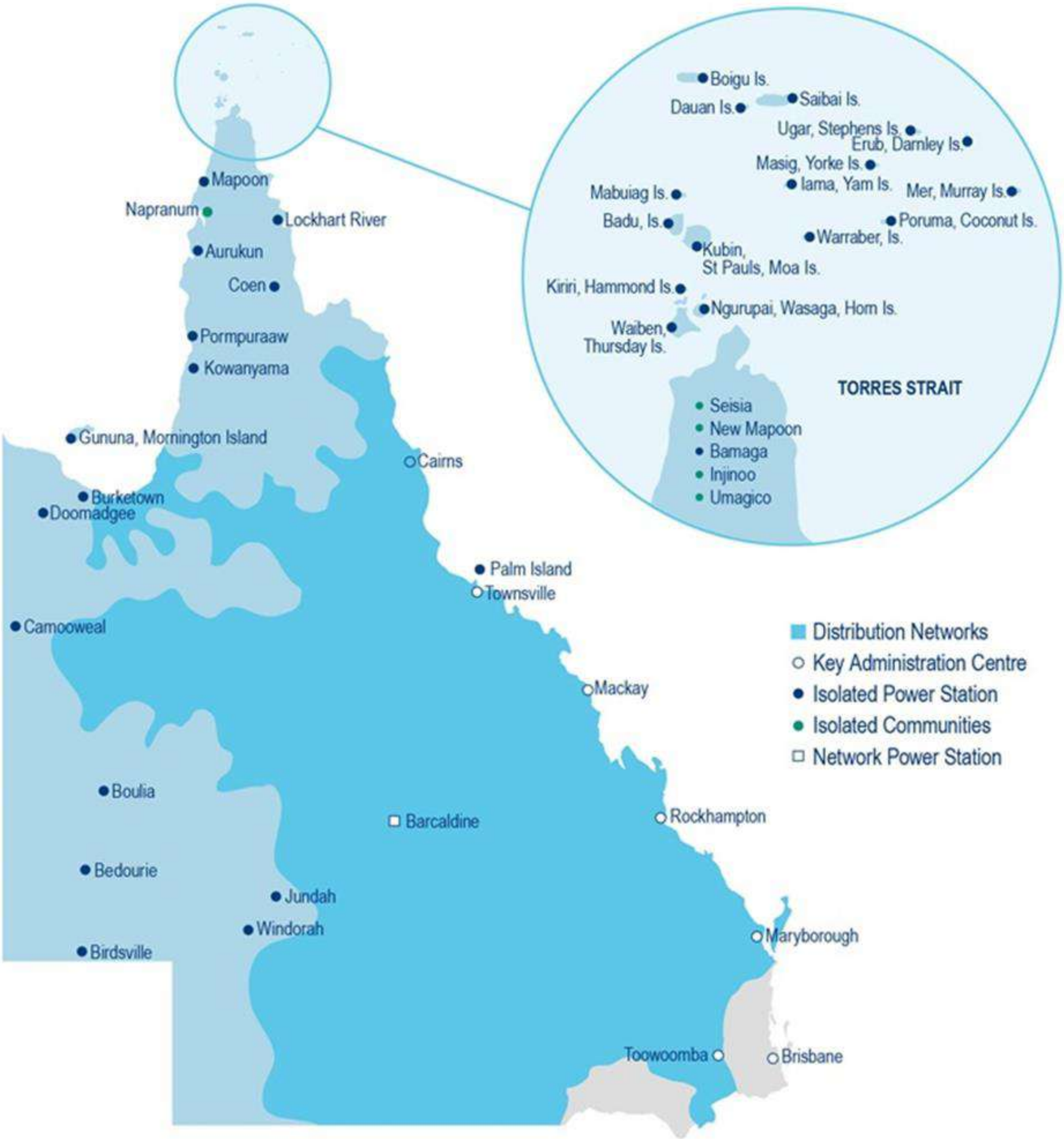


Figure 41 Ergon Network map

South Australia

Figure 42 illustrates SA Power Networks electricity network including their isolated communities.

Figure 42 SA Power Networks coverage in South Australia

Western Australia

The NWIS covers the Pilbara region and is overseen by Horizon Power. Horizon Power is also responsible for the operation of systems in regional towns and to remote communities across the state. Figure 43 shows the areas serviced by Horizon Power.

Figure 43 Horizon Power Supply Areas

Northern Territory

Figure 44 shows the diesel generation locations for the Indigenous Essential Services isolated communities.

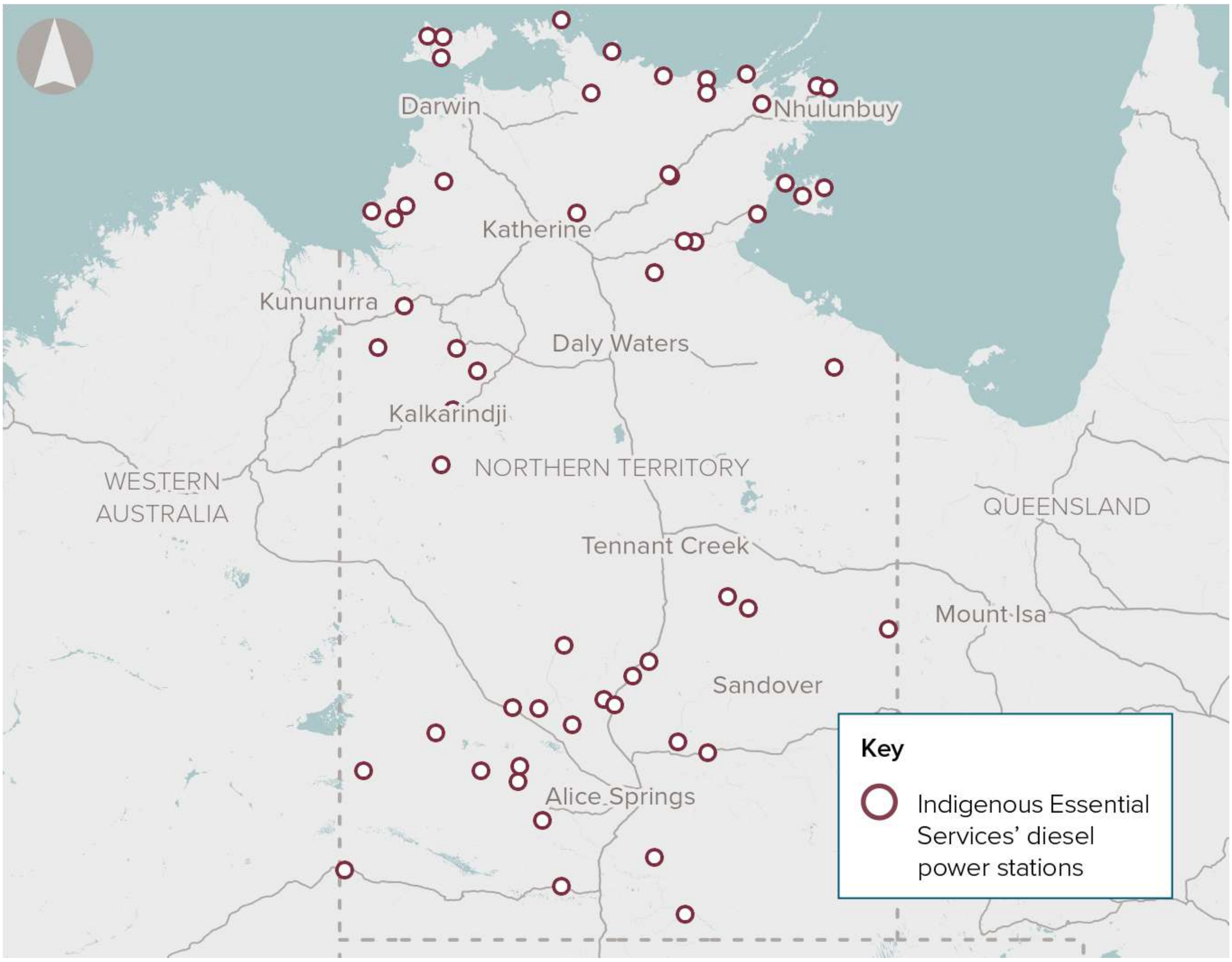


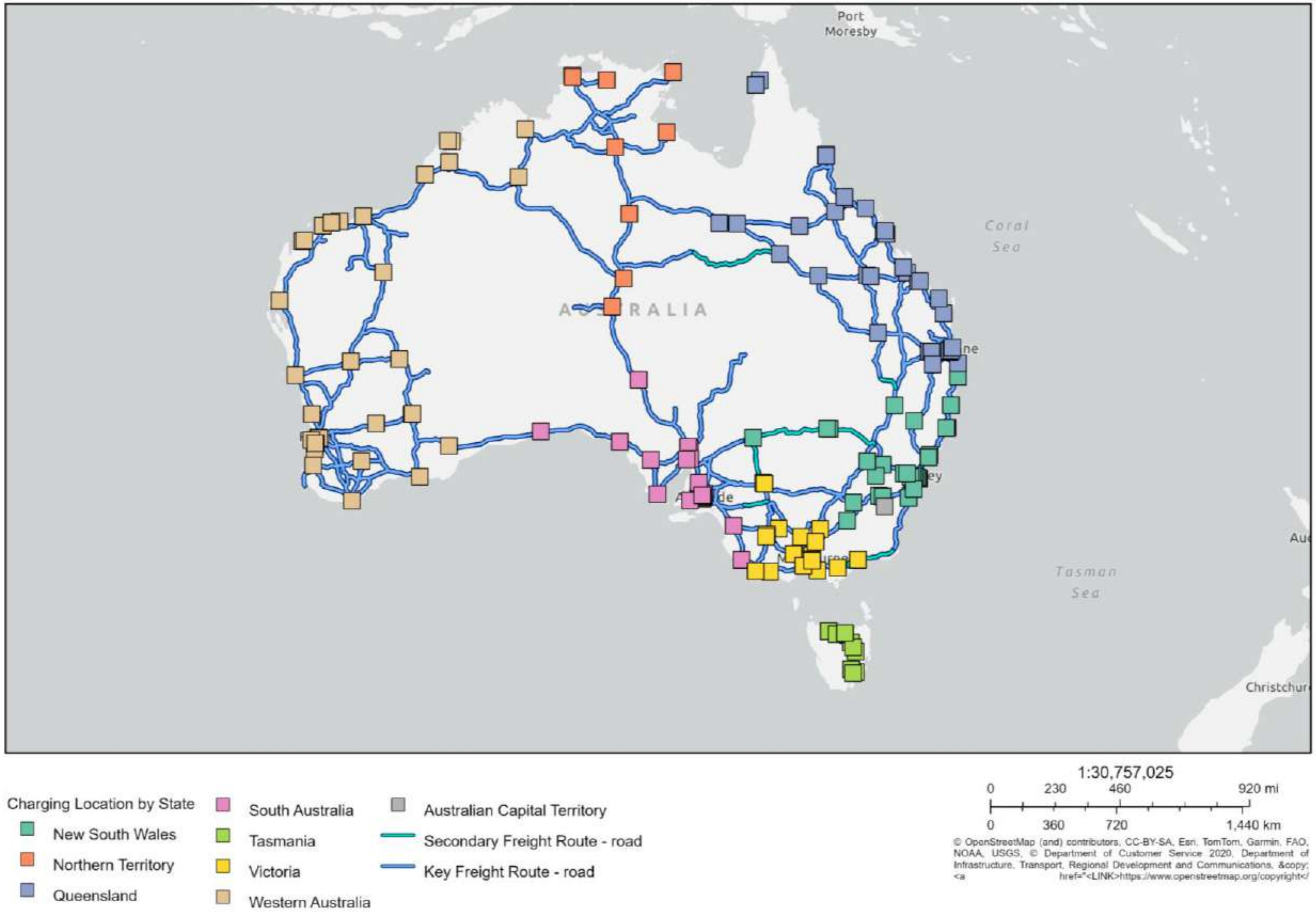
Figure 44 Isolated Communities in Northern Territory

Appendix D

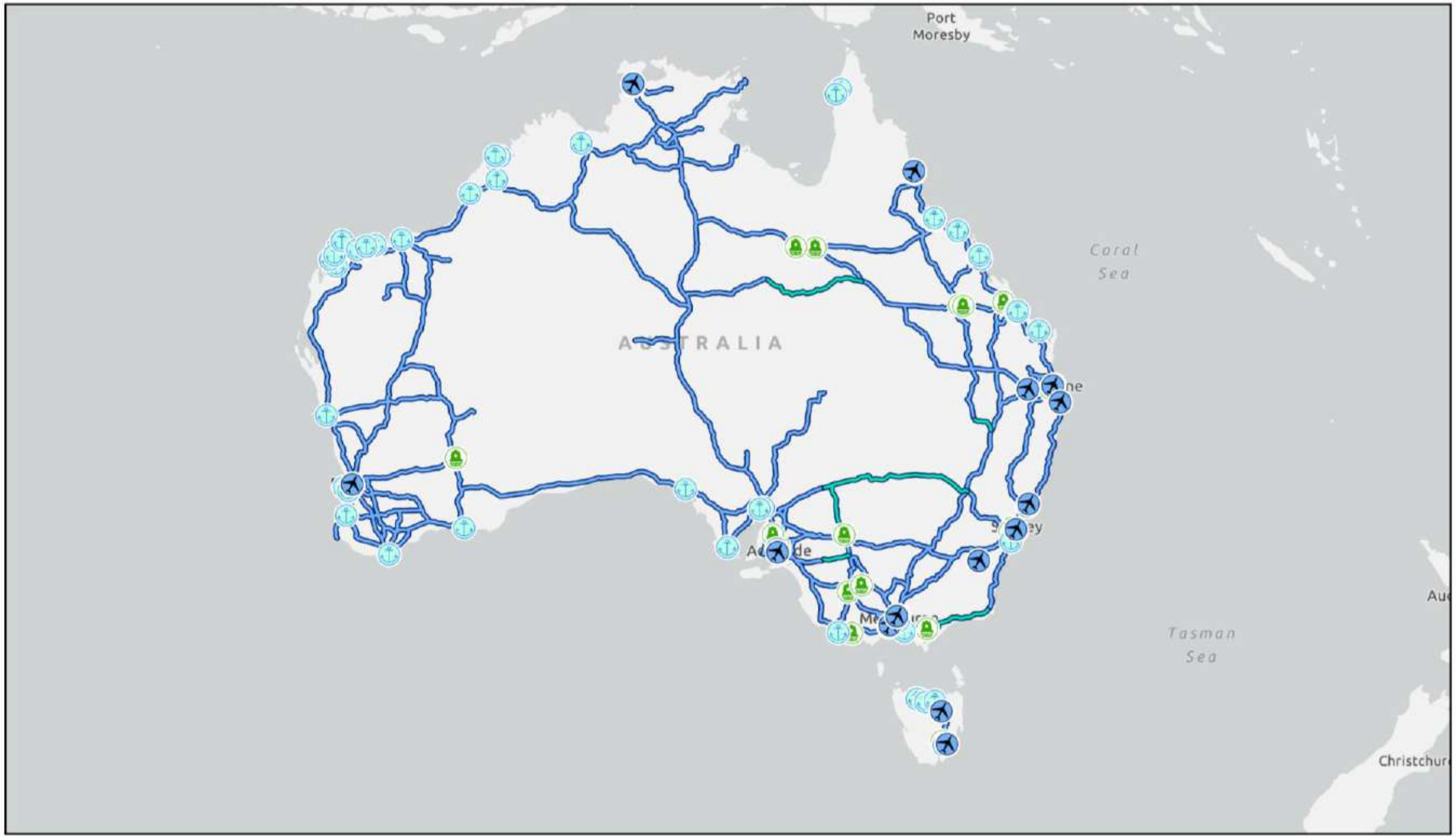
Freight Charging and Network Maps

Appendix D - Map outputs

National Charging and Freight Network Map



National Freight Networks and Sites



Major Airport

Major Seaport

Intermodal Terminal

Secondary Freight Route - road

Key Freight Route - road

1:30,757,025

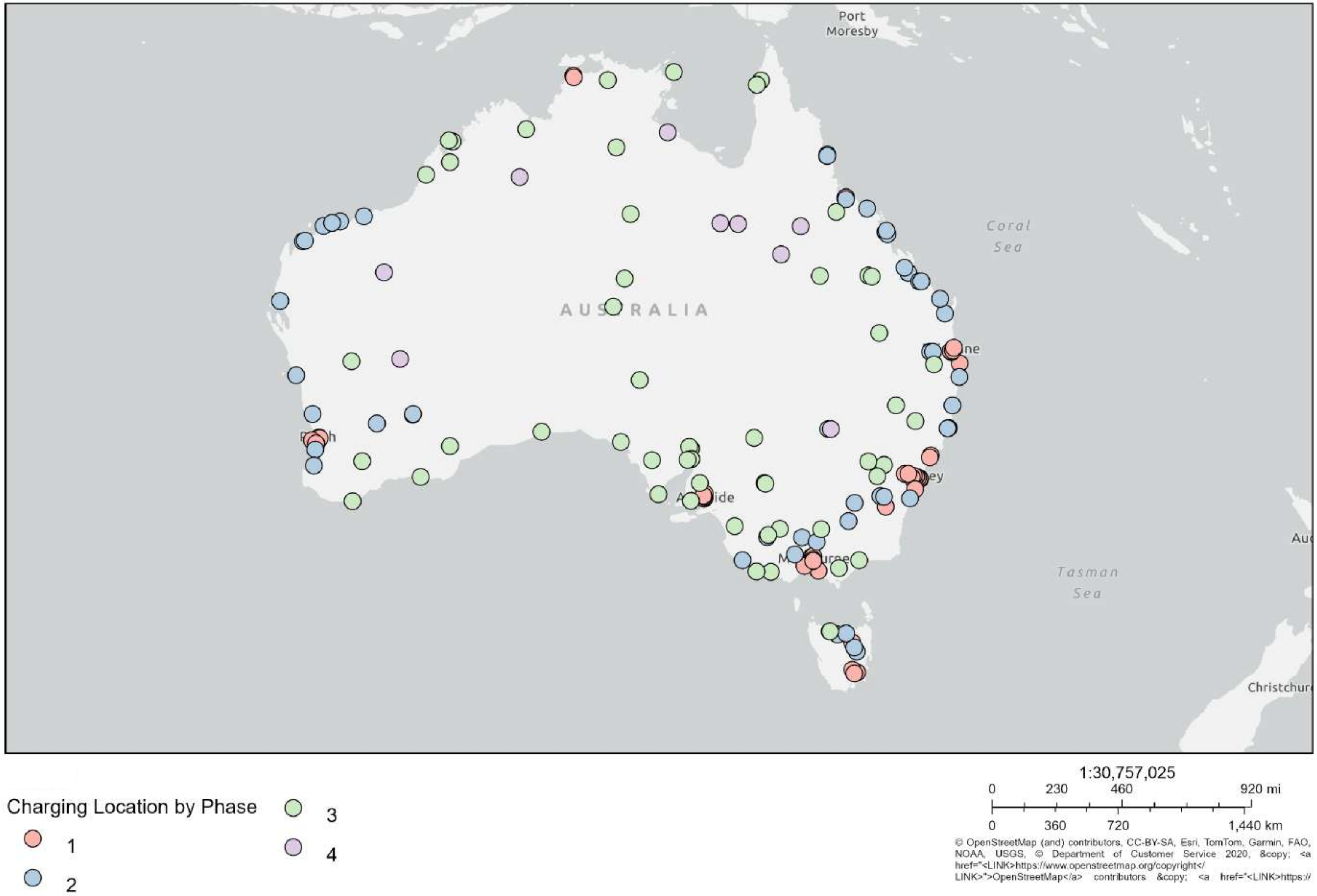
0 230 460 920 mi

0 360 720 1,440 km

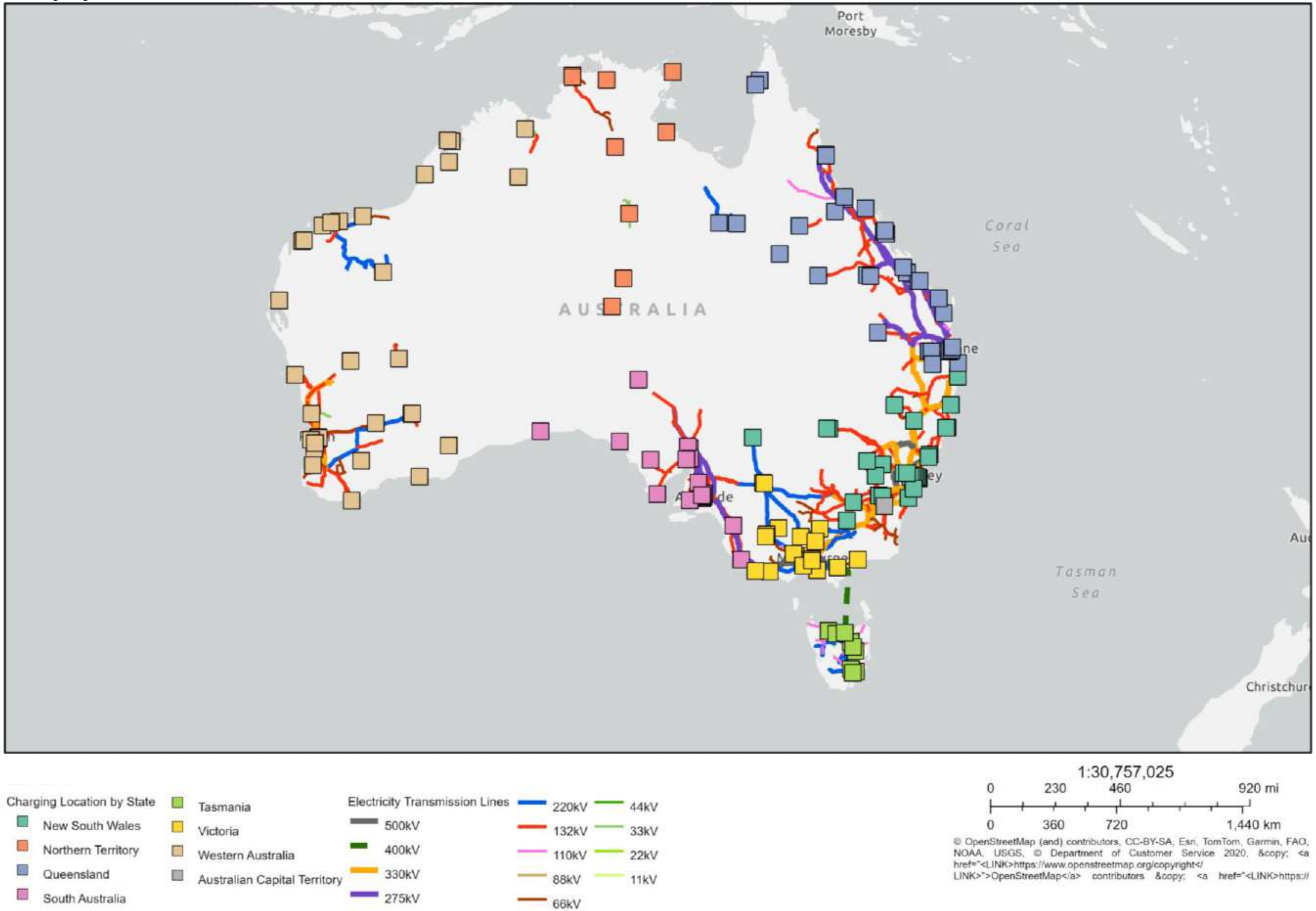
AECOM

National Freight Charging Network

Staging of Charging Network



Charging Hubs and Transmission Networks



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