January 2022

Addressing barriers to zero emission trucks in Queensland to 2025

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transport energy environment

QTLC
QUEENSLAND TRANSPORT AND LOGISTICS COUNCIL

About the Queensland Transport and Logistics Council

The Queensland Transport and Logistics Council (QTLC) is a cooperative industry and government advisory body that provides advice to industry stakeholders and state and federal governments on the development, planning, regulation and operation of freight and logistics transport, infrastructure and services in Queensland.

The QTLC advocates for the provision of infrastructure, regulation, and policy that will support sustainable freight transport and logistics in Queensland.

The QTLC supports the efficient movement of freight to support sustainable and productive economic development and prosperity via:

- appropriate and ongoing investment in supply chain infrastructure
- integrated regional and urban planning frameworks that secure land for current and future freight corridors
- an access policy and regulation environment that facilitates productivity and innovation
- efficient integration and linkage of freight and logistics systems across the whole supply chain.

The QTLC works towards operational and strategic solutions to impediments and issues within the freight supply chain with both long term and immediate benefits for industry.

More information on the QTLC and its activities can be found at www.qtlc.com.au or email admin@qtlc.com.au

About MOV3MENT

MOV3MENT is an advisory firm specialising in the three E's (energy, environment, and economics) of cleaner vehicles and fuels.

Our knowledge and advice are built on practical, cost-effective improvements that benefit vehicle users and the community. This includes a specific focus on heavy vehicle operators, suppliers, and policymakers.

Beyond practical fleet improvements, we help governments develop programs and policies that leverage this knowledge to overcome barriers to improvement, demonstrate real-world benefits, and increase awareness and knowledge. This includes innovation projects that accelerate the transition to renewable energy, and which use information to transform the market – like our world-first Smart Truck Rating.

We're also fiercely proud of the things that set us apart: our independence, our principled approach, and our evidence-based advice. Find out more on our website www.MOV3MENT.com.au

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EXECUTIVE SUMMARY

QTLC engaged MOV3MENT to work with the Queensland freight and logistics community to explore the challenges and opportunities in transitioning to Zero Emission (ZE) trucks. This report considers the current market for ZE trucks in Australia, the market potential to 2025, and the factors that are constraining growth as well as those that would enable it. The analysis considers the technical, economic, and cultural elements associated with purchasing ZE trucks. It also considers the influence of freight customers and corporate social responsibility drivers for change.

ZE trucks are those that can run on electricity or hydrogen, both of which can be sourced from renewable sources and can eliminate tailpipe emissions. These technologies provide a path to reducing emissions from road freight to mitigate an increasing freight task that would otherwise drive-up emissions. ZE trucks will be required to meet the Queensland Government's commitment to Net-Zero carbon emissions by 2050 and contribute greatly to clean air and energy security.

Queensland has a handful of ZE trucks on the road and a few projects in the pipeline, but the share is well below 0.5% of new sales. The Queensland freight task can provide great early deployment opportunities for ZE trucks – particularly in urban operations where rigid trucks carry out 70% of their activity by kilometre.

Of the many barriers identified in the project, model availability and compatibility, economic suitability, and confidence-building reliable information remain the main stumbling blocks. Despite these there are already technical and economic sweet spots for ZE trucks. This paper finds that in 2025 (or before) battery electric trucks can be technically and economically viable in the following applications:

High confidence of compatibility for battery electric trucks in 2025	Urban delivery trucks	Low frequency stopping waste compactors
Moderate confidence of compatibility for battery electric trucks in 2025	Regional delivery trucks	High frequency stopping waste compactors

Hydrogen trucks are not expected to achieve economic viability in Queensland this side of 2025 despite many segments of the truck market being technically viable. The cost of hydrogen vehicles and refuelling equipment is expected to continue to be the main hurdle.

The premise of this paper is that potential uptake in these viable segments is not being met due to an underdeveloped market. Most fleets and supporting organisations that joined the consultation workshops were keen to engage in the transition to ZE trucks when fit-for-purpose models are available and if it makes financial and organisational sense. However, these conditions already exist today in some applications, yet only a handful of ZE trucks were added to Queensland's roads in 2020.

The remaining market maturity and cultural barriers to satisfy the uptake potential are shown below.

Each barrier is unique but inter-related. For example, the confidence barrier must be resolved for transition to occur, and resistance to change will hinder growth in confidence. These barriers can be resolved by developing the market with more vehicle options, supportive regulations, and information that builds capacity and confidence in those making fleet investment decisions.

The paper provides recommendations for various stakeholder groups in the road freight ecosystem. Actions are considered as either:

- Foundational – required to achieve much more than organic uptake of a few trial ZE trucks.
- Supporting policy – enabling actions to overcome barriers and normalise ZE trucks.
- Accelerative – provides a boosting effect on the organic baseline ZE truck uptake.

Details can be found in Section 9 but are summarised in the image below by stakeholder group.

Recommendations

All stakeholders: Define heavy vehicle duty cycles. Collaborate with each other.

Government
- Review & integrate policy
- Develop & implement effective policies & incentives
- Transport industry funding
- Lead with government fleet & contracts

Suppliers & service providers
- Energy & charging providers engage with fleets
- Financiers & Fleet Management Organisations to tailor ZEV offers
- Provide heavy vehicle refuelling / recharging

Freight supply chain
- Shippers to provide favourable conditions to fleets that operate ZE trucks
- Develop zones & precincts as catalysts for change

Fleets
- Make a strategic choice to lead/follow
- Understand the current diesel fleet & its potential to switch
- Take the first step
- Establish partnerships

Manufacturers
- Provide leadership & differentiation
- Help customers assess suitability
- Develop Partnerships

Two projects are suggested to accelerate transition and demonstrate ZE trucks in action in Queensland. They are prioritised to directly address the confidence barriers that the industry faces.

Accelerator opportunity 1

Establish a zero-emission vehicle funding launchpad

Two factors that consistently emerge as holding back ZE trucks are model availability and fleets having confidence in the overall commercial proposition. In Australia, both fleets and manufacturers need support to make the leap to ZE trucks. One or two trucks on the road can help provide specific learnings, but projects delivering a greater impact should be prioritised and encouraged.

A competitive launchpad fund could be established to provide support via two streams:

Manufacturers – to engineer and develop models for local deployment.

Fleets – to supplement the total cost of ownership gap and provide confidence.

New Zealand has run a similar program over 4 years which has led to dozens of deployments and various new models and body styles of ZE truck becoming available in the market.

Accelerator opportunity 2

Zero emission transport precincts and hubs

Large transport hubs could become ZE transport accelerators to set the stage for early adopters and leader fleets. Demonstrating the technology in action, collecting data, and linking participants, has been one of the best tools to build confidence for decision makers.

- High traffic areas can act as a launch pad by providing:
- aggregated demand for vehicles and fuels
- a hub for fleets to try out ZE models provided by manufacturers
- shared resources & learnings for fleets, industry & government
- a platform to explore infrastructure solutions
- a demonstration leadership in new technology and sustainability

Examples where this concept could flourish: Port of Brisbane, Brisbane Markets, Agtech and logistics hub Toowoomba, InterlinkSQ Toowoomba, other ports, intermodal hubs and logistics centres.

A similar approach is being taken at the Port of Los Angeles with various hydrogen and BEV truck deployments and trials.

A single organisation or group cannot achieve this alone. To move Queensland forward toward the adoption of zero emission trucks will require action from all stakeholders. The earlier all stakeholders start the quicker society, and the economy, will benefit.

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GLOSSARY

ABS	Australian Bureau of Statistics
BEV	Battery Electric Vehicle ("fuelled" by electricity only)
CNG	Compressed Natural Gas
DC	Direct Current
DNSP	Distribution Network Service Provider (electricity poles and wires)
FCEV	Fuel Cell Electric Vehicle (fuelled by hydrogen gas only)
GHG	Green House Gas
GVM	Gross Vehicle Mass
ICE	Internal Combustion Engine vehicle (diesel or petrol fuelled)
LNG	Liquefied Natural Gas
LR	Light Rigid (licencing)
MR	Medium Rigid (licencing)
NACFE	North American Council for Freight Efficiency
NGO	Non-Government Organisation
OEM	Original Equipment Manufacturer
TCO	Total Cost of Ownership
ZE	Zero Emissions (within the scope of this project, either battery electric or hydrogen fuel cell powered trucks).
ZEMO	UK NGO for zero emission mobility
ZEV	Zero Emissions Vehicle

1. Background

1.1. Project Overview

QTLC is a connector for the trucking and freight industry in Queensland and advocates for sustainable freight solutions for the state. Zero Emission Vehicles (ZEVs) are an emerging opportunity for a step change toward this goal. But there is significant uncertainty about the suitability, cost, and timing of these technologies.

The Australian truck market has some unique requirements, and freight tasks vary greatly. ZEVs are likely to be suitable in some applications but not all. Without strong policies or support mechanisms, market acceptance of these technologies is likely to be slow, lumpy, and constrained by various barriers.

QTLC recognises industry's view is paramount to any policy and action development. Meeting fleets where they are in their journey is a critical part of the change process. This project engaged with fleets from across Queensland spanning many freight types, to understand the challenges they face in transitioning to ZE trucks. Across three workshops, the project team consulted with 14 fleets, 4 peak bodies, and 8 service suppliers covering a wide range of the industry in Queensland. Their broad and eclectic views on the present and future potential of ZE trucks provided a 2021 snapshot and deep insights into what they believe they need to begin or continue their transition.

This report considers the current market for ZE trucks in Australia, the market potential to 2025, the factors that are constraining growth and those that would enable it. The analysis considers the technical, economic, and cultural elements relevant to fleets when purchasing ZE trucks. It also considers the influence of customers of freight services and corporate social responsibility drivers for change. The focus is on five critical aspects of the transition:

- Background to why zero emissions trucks are coming to the market and why they are needed.
- The segments of the truck industry where ZE trucks are likely to be most suitable for early adoption (technical sweet spots).
- The types of fleets and operators for which ZE trucks are most suited (commercial sweet spots), including the triggers or hurdles to uptake.
- Gaps between fleet perceptions and reality, to help shape effective policies and actions that make a difference to operators who want to transition to ZE trucks.
- What policies and industry support mechanisms could address the barriers and expedite the transition to ZE trucks?

In its role as an advocate for optimal transport and logistics policy, QTLC hopes this report will help industry, government, and other stakeholders to better understand ZE trucks and support their uptake. This is particularly important in the context of the Queensland Government's commitment to net-zero emissions by 2050 and its development of a zero-emission vehicle strategy.

1.2. The Premise

Figure 1 outlines some nested constraints limiting diffusion of ZE trucks into the market. The Australian new truck market is typically around 35,000 trucks per year, and for simplicity it is expected the market will be similar in 2025. In 2020, sales of ZE trucks were around 50 units, mostly light and medium rigid battery electric models, represented by the small red square in the corner of the figure. This tiny volume far underperforms the wider market potential now and is expected to remain that way if left to grow organically.

Of the total market, the *technically capable* volume is that proportion of new trucks that could perform their regular duties with current ZE technology. Technical restrictions are mostly due to payload, range or charging time constraints.

The *economically viable* proportion of the *technically capable* applications are those for which the total cost of ownership (TCO) would be similar to, or less than, a diesel truck. There are several applications where ZE trucks are economically viable or very close today.

The *likely potential* (yellow) box is the proportion of sales that could be ZE trucks in 2025, if all barriers were removed and the ZEV market was sufficiently mature. Many barriers, both real and perceived, contribute to this potential being constrained. The recommendations of this paper are focussed on maximising ZEV uptake to reach this potential by removing barriers and maturing the market.

The difference between economically viable and likely potential represents those fleets that will not be persuaded in this timeframe and will continue to purchase diesel trucks regardless of the economic viability of ZE trucks in their application.

Figure 1 – The barriers that constrain ZE truck uptake in the Queensland market

2. What is a zero-emission truck?

2.1. ZE truck basics

Terminology and definitions are important, because there is some market confusion about differences of new technologies that enable zero emissions operations. A hybrid truck is simply a more efficient version of an internal combustion engine (ICE) vehicle as it recovers a small amount of energy during deceleration, stores it (usually in a battery), and redeploys it when accelerating. However, hybrids are not powered by externally supplied electricity, and they still emit tailpipe emissions. This project considers only vehicles that can operate without producing tailpipe emissions. These are depicted in
Figure 2 below and include:

- a Battery Electric Vehicle (BEV), charged with electricity via cable and plug or other means
- a Fuel Cell Electric Vehicle (FCEV), fuelled with hydrogen to power a fuel cell
- a Plug-in Hybrid Electric Vehicle (PHEV), which combines internal combustion with a small battery and electric motor, but can only drive short distances without the ICE.

PHEVs are common in light vehicles but not trucks, so are not explored in depth in this report.

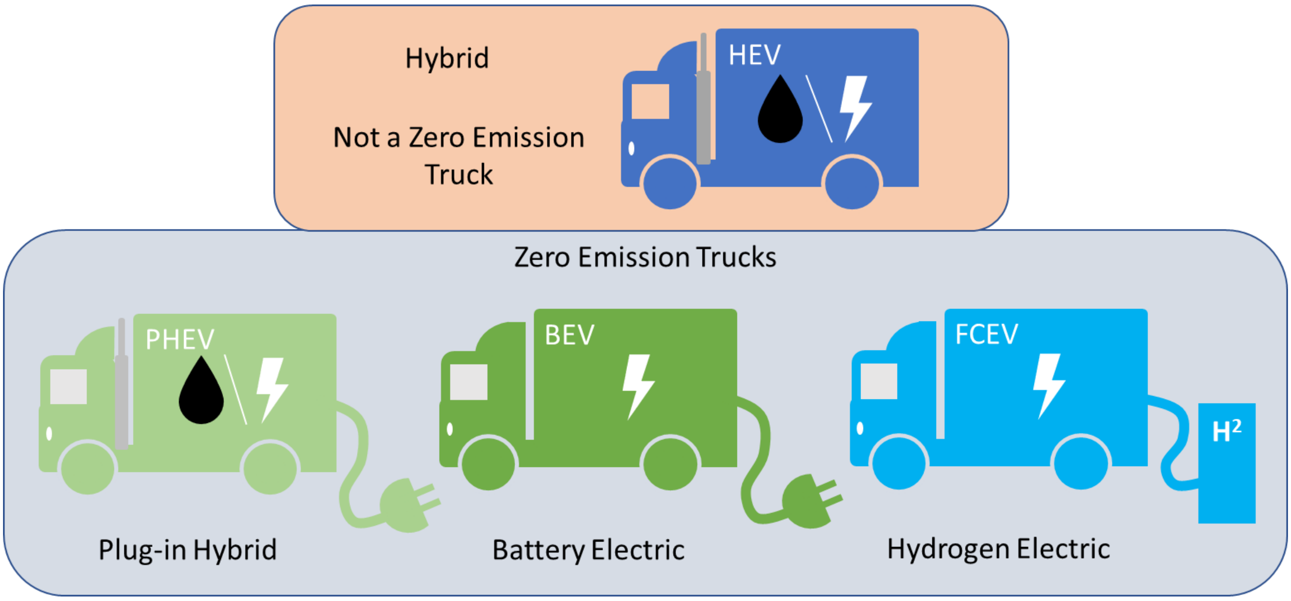


Figure 2 – Different types of electrified vehicle technologies (HEV, PHEV, BEV, FCEV)

Both battery and hydrogen powered trucks are driven by electric motors that turn the wheels. In a BEV, this is supplied with electricity exclusively by a large battery that is externally charged from an electricity supply. In a FCEV, the motor receives some combination of electricity from a (smaller) battery and a hydrogen fuel cell. The fuel cell is fed hydrogen from onboard tanks filled via dispenser at the depot or at a fuelling station, and it combines hydrogen with air to make electricity and producing water as a by-product. Figure 3 provides an example layout of both technologies.

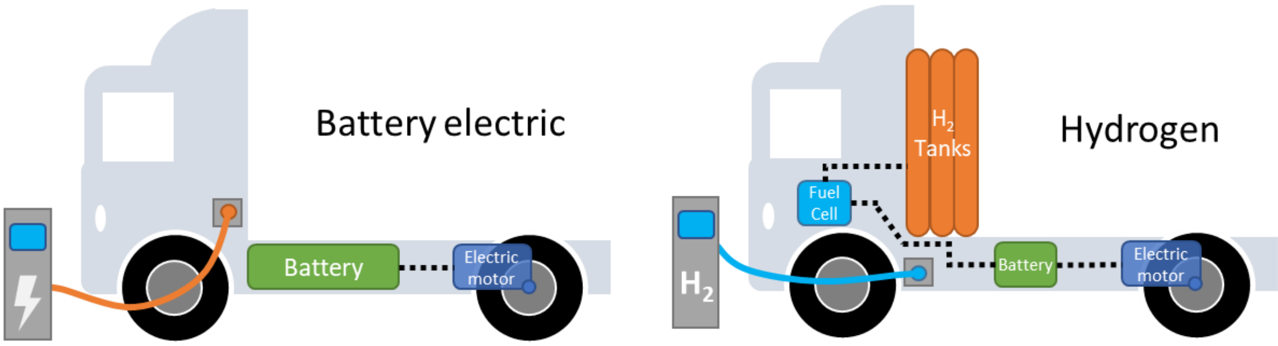


Figure 3 – Technology layout for battery and hydrogen trucks

The Australian truck market currently has a few options for battery electric and hydrogen in different chassis styles and mass categories. There are no plug-in hybrid trucks on offer locally in 2021.

Many more ZE truck models in more mass classes and chassis configurations are available overseas. Overseas ZE models may not be directly transferrable here due to different vehicle standards and many are offered in left hand drive only at this time (incompatible with Australia as a right-hand drive market).

Zero Emissions technologies differ from diesel in many ways, as described in the table below.

- Much higher energy efficiency
- Emissions (carbon, pollution, noise)
- Upfront cost, total operating cost
- Filling time
- Infrastructure requirements
- Payload capacity
- Maintenance
- Longevity

Table 1 – Summary comparison of fuels and technologies

	DIESEL	BEV	FCEV	Additional Information
Energy efficiency (fuel)	39% (1)	>77% (2)	54% (3)	Internal combustion engines are inherently inefficient, losing more than 60% of the fuel energy to waste heat, while electric motors are highly efficient. Batteries lose very little energy in the charging and storage process. Green hydrogen for a FCEV incurs energy losses through generation, distribution, and refuelling (and fugitive emissions from leaks), but is still more efficient than an ICE.
Emissions	X	✓ ✓	✓	ZE technologies produce far less noise than diesel engines and have no tailpipe emissions. Both can be powered from renewable electricity, but it is likely some charging of a BEV will occur from the electricity grid (high carbon intensity in Qld). Most hydrogen available in Australia is derived from fossil fuels[4] with green hydrogen production in its infancy but expected to increase.
Total Cost (TCO combines capital and running costs)	-	Purchase cost higher. Running cost always lower. TCO can be less than diesel.	Purchase cost much higher. Running cost & TCO unlikely to be lower by 2025.	Diesel is relatively cheap in Australia, and diesel trucks are currently 30-50% cheaper than an equivalent new BEV truck. The lower running cost of a BEV can pay back its higher capital costs resulting in a lower TCO than diesel – in some applications. Unsubsidised, hydrogen is expected to be more expensive than all other technologies for the foreseeable future.
Filling time	~10 minutes	Several hours (in dwell time)	Similar to diesel	Diesel filling time is generally around 10 minutes and Hydrogen can be similar. BEV recharging takes longer but may have no operational impact if it can be done in downtime (e.g. overnight).
Infrastructure requirements	In place	Initially depot-based, some sites may be supply limited.	Limited infra-structure, very high cost	Battery electric trucks can be charged at the depot, and this suits most initial (sweet spot) deployments, for which extensive public charging may not be required. For large fleets, depot electricity supply may be constrained, and grid connection upgrades may be required. Hydrogen filling stations are currently rare, and high cost makes depot solutions challenging. Likely to become more widespread by 2025.
Payload impact	-	Mass and Volume	Volume	The chassis space required by both ZE technologies can reduce payload. Large, heavy battery in BEVs will erode more payload potential. Hydrogen tanks can sometimes be packaged successfully but may take up load space. Not all trucks run at mass/volume limits so some will not be affected.
Maintenance	-	Much lower requirement	Much lower requirement	ZE technologies require less frequent, less significant powertrain maintenance than diesel trucks. In applications with high brake wear, regenerative braking reduces replacement intervals by a factor of 6. FCEVs require highly filtered air for the fuel cell which can increase maintenance in dusty environments.
Longevity	-	Batteries degrade over time, will likely need replacing in later life	Batteries and fuel cells degrade. Fuel cell life is not clear.	Lithium-ion batteries degrade slowly as they are charged and discharged and often considered no longer operationally suitable when they reach 70-80% of their original capacity. It is widely considered that a BEV battery life will be around 10 years in operation before needing replacement, but this will vary with charging speed and cycles. Fuel cells lose efficiency as they are used and, like batteries, may require replacement in service life.

2.2. Trucks are diverse

Being fit-for-purpose is a critical requirement for any truck and each application has very different demands. Because of this, trucks vary greatly in how they look and what they do. Different aspects are shown in the diagram below. Firstly, size, weight, and axle configuration affect roads and traffic compatibility, so these are usually regulated (left-side green wedge) – from small 2-axle trucks at 4.5 tonnes, to multi-trailer road trains over 130 tonnes. Secondly, the freight and/or equipment carried determines the type of body or trailer (bottom black wedge): these include fully enclosed bodies, flat trays, tankers, tippers, multi-level decks, and powered equipment. A third consideration is the work trucks do, or the duty cycle (right-side blue wedge). Combined with vehicle size and weight, the duty cycle is most important in determining a vehicle's energy use. These different applications also entail very different routes and distances per day.

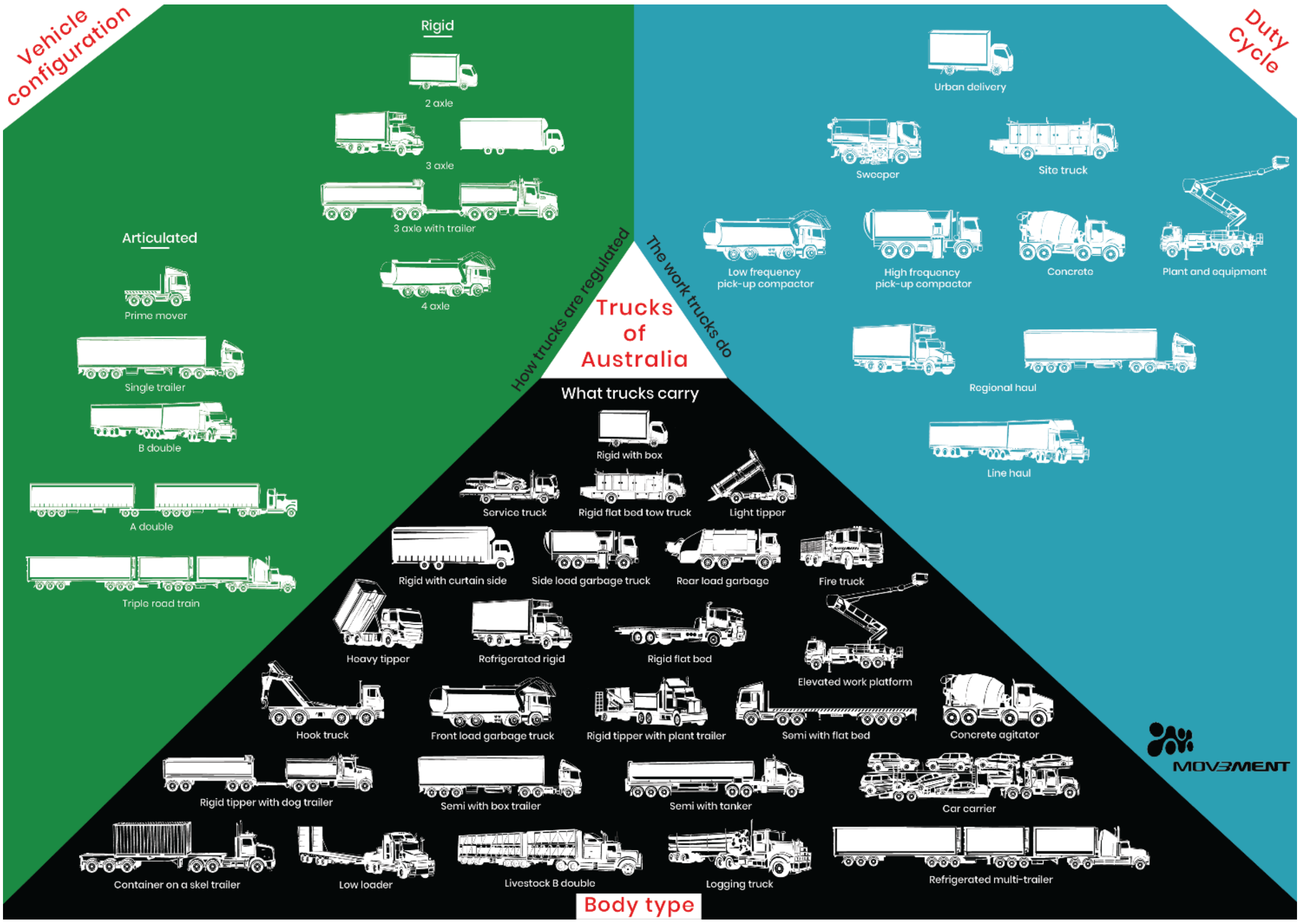
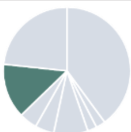
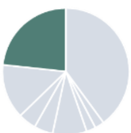


Figure 4 – Trucks of Australia: by configuration, duty cycle and body type

The various demands generate different energy requirements. This is not normally a constraint for diesel, but ZE trucks (particularly BEVs) are energy-limited – or the amount of energy they need to carry defines their suitability for specific tasks in terms of payload constraints, energy access, and top-up time. A better understanding of ZEV suitability therefore requires a segmented analysis of different applications.

In the absence of a nationally agreed framework, this project defined the truck fleet into nine segments to consider the suitability of ZE technology, as outlined in the table below. These segments describe different duty cycles which are not necessarily defined by the size of the truck but by the work it does, consistent with the approach used in several state and national fleet energy/emissions programs.

Table 2 – Truck segmentation

Segment	Share of new sales	Explanation	Example
Urban delivery		• Predominantly low speed driving • Frequent stopping • Low average speed	• Residential grocery delivery • Parcel delivery • Fast moving consumer goods (FMCG) distribution
High frequency pick-up compactor		• Waste truck stopping at each house • Lifts hundreds bins per shift • Very high fuel & brake use	• Side-lift or rear access residential waste collection
Low frequency pick-up compactor		• Waste truck stopping tens of times per load for larger lifts/bins • Higher average speed	• Rear access parks and garden waste collection • Front forklift industrial waste compactor
Site truck		• Primarily carries tools/equipment to site • Similar to urban/regional but stops at site for long periods	• Construction worker's truck • Mechanic/service truck
Concrete		• Dedicated concrete agitator with high ancillary energy requirements	• Concrete agitator/mixer
Plant & equipment truck		• High proportion of the vehicle's energy is used for ancillary work (not driving)	• Pump truck • Elevated work platform truck • Crane
Sweeper		• Rigid truck with wash/vacuum body, very high fuel consumption	• Municipal road sweeper
Regional haul		• More highway than urban driving • Only a few delivery stops • Single shift	• Brisbane to Toowoomba • DC to DC • DC to single end user delivery
Line-haul		• Vast majority highway/high speed driving • Multi shift away from base • High amount of energy carried onboard	• Intra- and inter-state line-haul

3. Why transition to zero emission trucks?

Emissions

Transport is the third largest contributor to Queensland's greenhouse has (GHG) emissions, at 13%. Heavy vehicles are the second largest source of road transport emissions but, unlike cars and light commercial vehicles, their emissions are expected to continue rising over the coming decade (Figure 5). This growth will be driven by an increasing road freight task fuelled by growth in the economy and population. Simply continuing with the same fuels will see emissions rise in lock step with the growing road freight task.

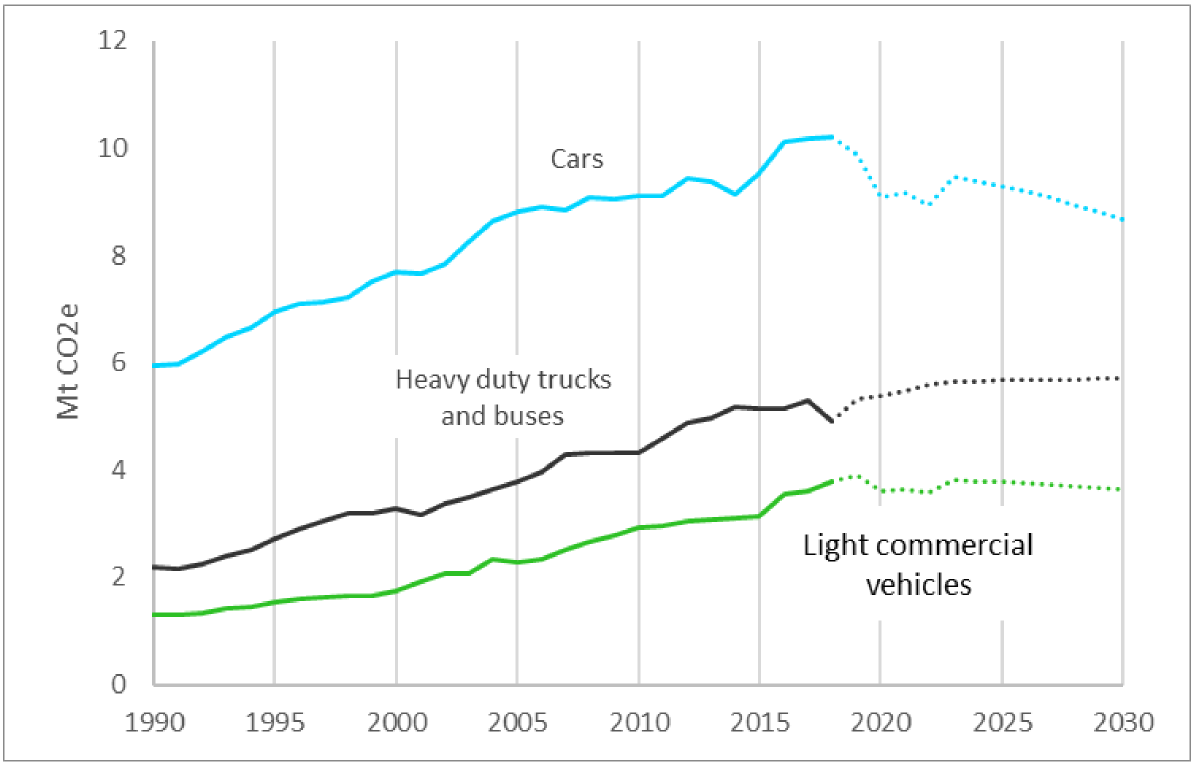


Figure 5 – Queensland's major transport emitters, based off (5), (6)[1]

The Queensland Government has committed to net-zero emissions for the state by 2050, a target the transport sector will not meet without significant adoption of ZE vehicles powered by renewable energy.

Energy security

Diesel trucks burn 3,029 million litres of diesel in Queensland each year, the vast majority of which is imported. This reliance on a supply chain and commodity susceptible to price shocks and supply disruptions leaves the sector dependent and vulnerable. Zero emission trucks offer operators more control over their energy, a lower-priced fuel, potential self-sufficiency, and support for the local economy instead of offshore beneficiaries.

[1] Historical values from Queensland data, future values based on national projections.

Cleaner air

Tailpipe emissions comprise both greenhouse gases contributing to climate change, and diesel exhaust contributing to air pollution. Heavy diesel engines also emit noise that impacts the community. A recent Austroads study found that heavy freight vehicles in Australia caused over $800 million in pollution-related health costs in 2019 (7). Most of this burden is in urban areas and is borne by the state health system, leading to lower economic productivity. In contrast, zero emissions trucks emit no tailpipe emissions.

Trucks caused over $800 million in pollution related health costs in 2019

Trucks have long been a source of noise pollution, but the electrified powertrains in zero emission trucks are much quieter than diesel engines, particularly at lower speeds and when accelerating and braking.

Potential to reduce costs

Fleet purchase decisions are largely driven by the whole-of-life costs with environmental considerations a lower priority. ZE trucks need to be a lower cost vehicle to own than diesel trucks if they are to be widely adopted. This is already the case for BEVs in some applications today and will expand to other applications with new models and lower prices.

Social responsibility and competitive advantage

During the industry consultation for this project, participants recognised that ZE trucks offer several benefits to truck operators and society at large. Of those, it was the leadership and branding benefits that stood out strongest. Operators and their customers can benefit from the messaging and signal that ZE trucks send. Participants also recognised the potential emissions reductions, operating cost savings, and operational simplification that ZE trucks can unlock.

The workshops participants resoundingly agreed that:

> *Long-term success of the trucking industry is dependent on a transition to ZE trucks. But emissions reduction was not as front-of-mind in fleet purchase decisions as it could be.*

Many of those who have bought ZE trucks to this point have done so for either:

- **Industry leadership** (City of Sydney, ACT government, Moreland Council), which could be environmental leadership, technology leadership, corporate social responsibility, knowledge generation, preferential supply, competitive advantage, or just looking to new business models.

OR

- **Supporting/complying with customer's leadership ambitions** (e.g., IKEA contract spurring Kings and All-Purpose Transport to invest in electric delivery trucks).

4. Current state of play for ZE trucks in Queensland

Zero emission trucks, and alternative fuels more broadly, represent a fraction of the new truck market in Australia, struggling well below 0.5% market share even at their peak over the last decade. While there was a slight uptick in sales in 2020, the Australian market is yet to exceed more than 100 sales per year for all alternative fuelled and powered trucks including hybrid, CNG, LNG, EV and hydrogen – as shown in

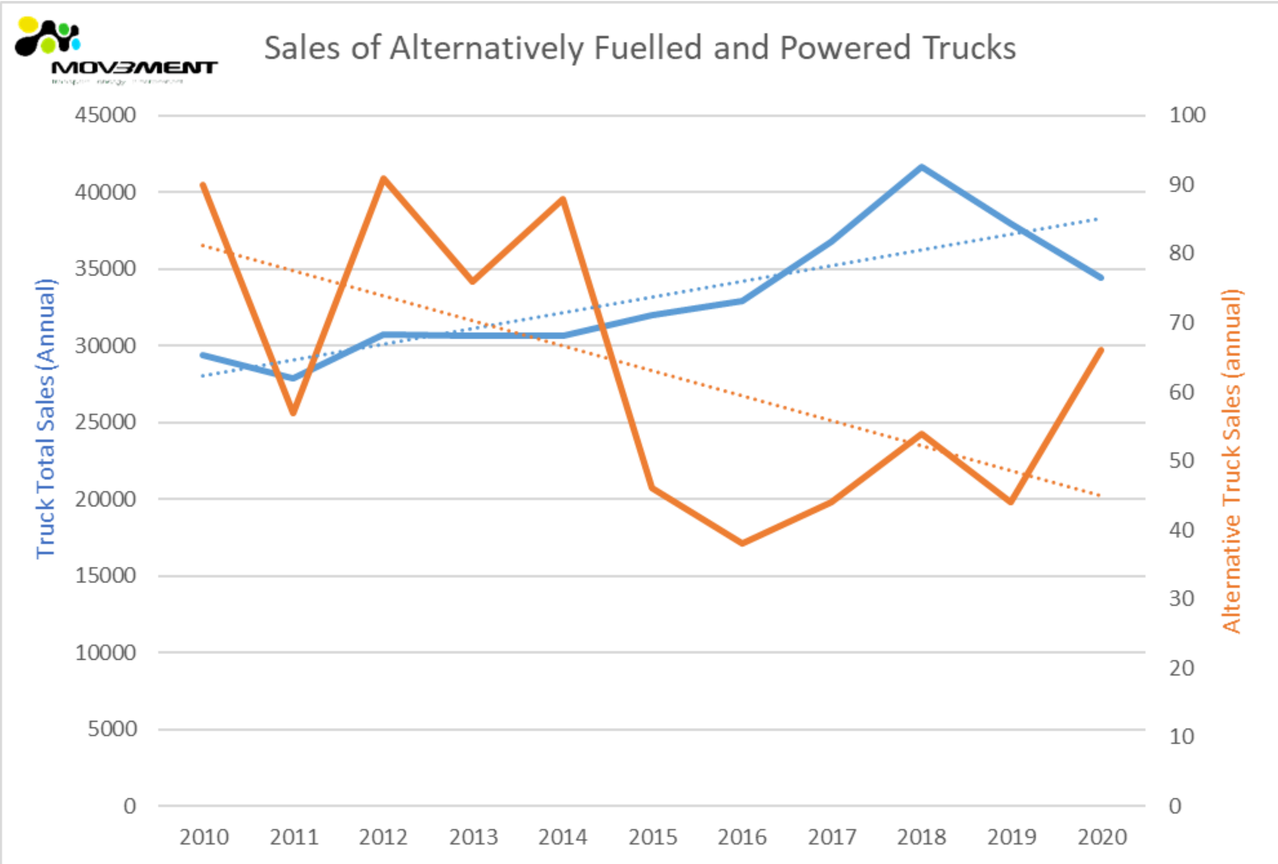


Figure 6.

Figure 6 – National sales of alternatively fuelled and powered trucks

Uptake of zero emission trucks in Queensland

There are currently three publicly known ZE trucks active in Queensland servicing municipal works, infrastructure services, and general freight markets. A hydrogen deployment is expected in the near future in a resource logistics operation (Figure 7).

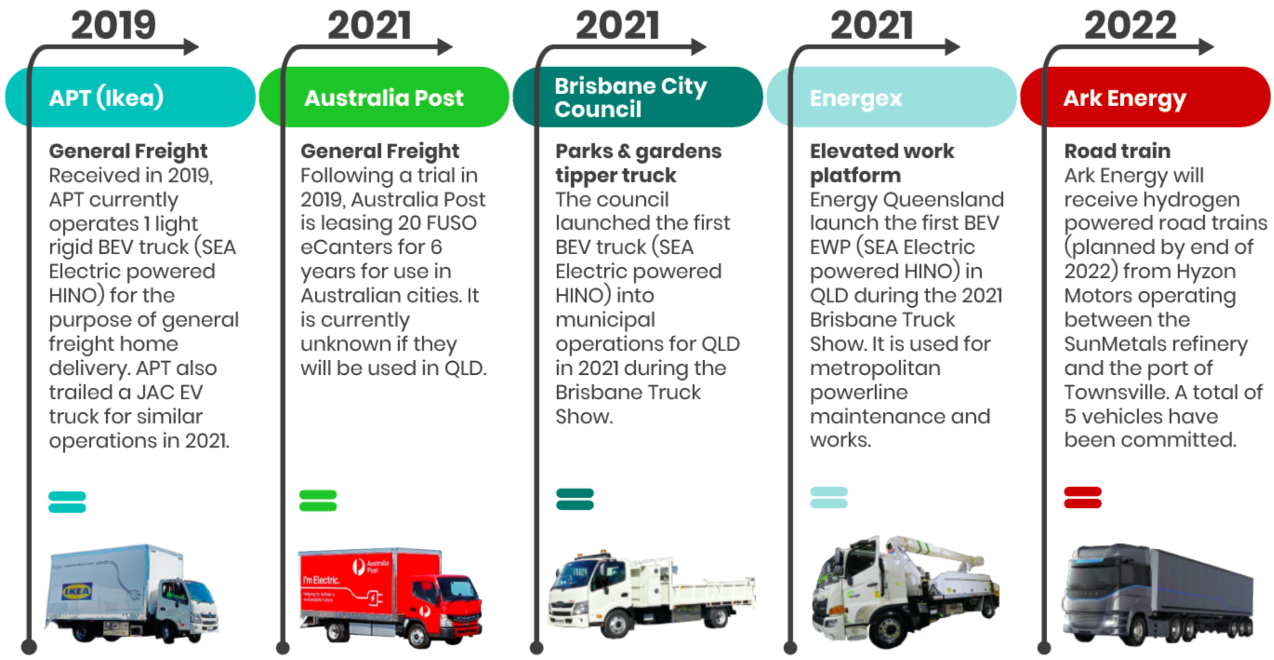


Figure 7 – ZEV Truck uptake in QLD: Major Fleet Actions

Availability in the Queensland market

SEA Electric and Volvo Trucks are currently the only Original Equipment Manufacturers (OEMs) offering a BEV model for sale via a dealer network in Australia, with other offerings currently being distributed directly from the manufacturer/importer or only available on a restricted lease basis. This presents a significant challenge to operators looking to purchase a model as it represents a perceived risk for effective aftersales support. Even for models that are available, regional dealers are not necessarily qualified to service BEV vehicles, and this may present a challenge to regional freight operators. These arrangements may challenge operators as a deviation from their normal practice, with both large and small operators having long-term and mutually beneficial partnerships with local dealers.

The unique Queensland freight task

Queensland's unique geography and spread-out regional centres create unique challenges to the freight industry adopting ZE trucks in some applications. However, the proportion of urban kilometres in Queensland is like other large states: Around 70% of all rigid truck kilometres travelled in Queensland are in urban areas (Figure 8). This suggests an opportunity to transition at least some of those trucks to ZE technology.

Many articulated trucks typically operate outside urban areas, but around 30% of Queensland's articulated truck activity is also in urban environments. Some proportion of this may suit battery electric powertrains when they are offered, but activity away from the cities doesn't preclude their suitability either. Hydrogen FCEV trucks may also be technically capable on most operations that articulated trucks undertake, when costs fall within an acceptable range.

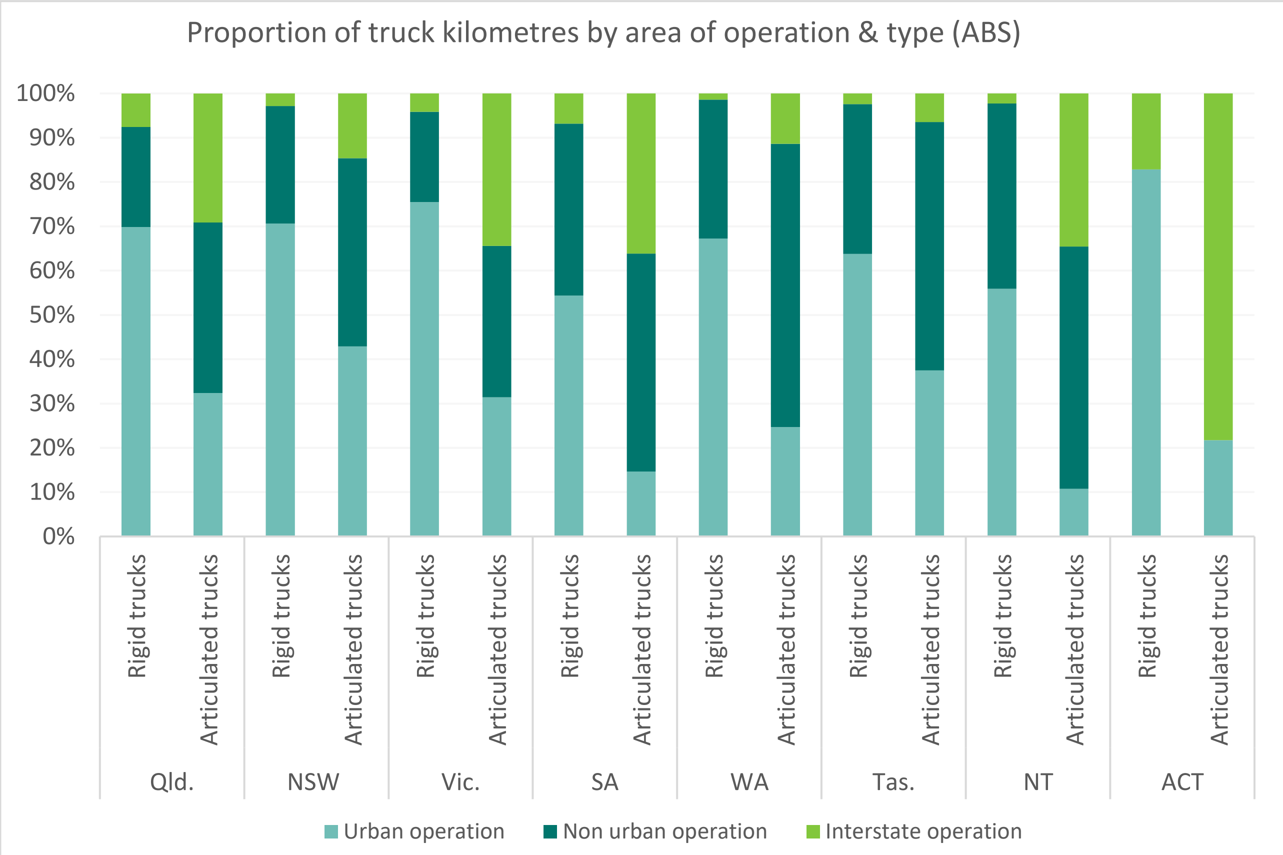
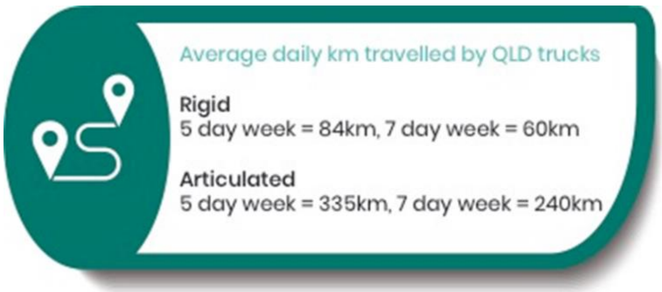


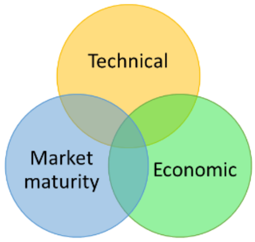
Figure 8 -Proportion of road freight kilometres by Urban and other operation (8)

Perhaps most importantly, the same ABS data (8) shows that the average daily kilometres travelled by a rigid truck in Queensland is 60–84 km per day, which is less than half the driving range of most battery electric truck models available today. In contrast, articulated trucks on average travel 240-336km per day, a more sizable task but not as high as may be perceived.



Ultimately, the compatibility of ZE technology is dependent on the individual truck's task, which may be suitable in either regional or metropolitan settings under the right circumstances and with the right infrastructure.

5. Mapping barriers



There are many barriers constraining the uptake of ZE trucks, both internal and external to organisations, and both perceived and real. They broadly fall into three groups – technical, economic, and market maturity barriers.

5.1. Technical barriers

The technical barriers are the objective limitations of the current technology. This encompasses both limitations of the vehicle itself (e.g. range, payload) and supporting infrastructure (e.g. charge speed). They can be further characterised as follows.

Payload impacts – All ZE truck options will have an impact on vehicle loads. Even when the diesel engine and transmission have been replaced with a smaller and lighter electric powertrain, a ZE truck requires additional space and weight to carry the required energy, in the form of batteries and hydrogen tanks.

In applications which have low energy demands and rarely run with maximum payload – such as urban delivery and site trucks – there will only be a small or no effect on operations. In other cases, such as line-haul, the size and mass of the required storage could have significant payload impacts.

Charging time – BEV trucks take longer to charge than simply refilling a diesel tank. The time taken depends on the vehicle, charger, and the amount of energy required. There is a potential for this to adversely affect operations. For example, an urban delivery vehicle working one eight-hour shift and parked overnight at its depot would more than likely be able to recharge with no operational impact. On the other hand, trucks travelling very long distances or working multiple shifts may struggle to recharge in the available time.

Hydrogen filling time – FCEV refilling generally takes a lot less time than BEV charging. Hydrogen filling on heavy vehicles is expected to be like that of diesel but can be delayed due to pre-fill refrigeration of the gas in the dispenser (9).

5.2. Economic barriers

Beyond the technical barriers, ZE trucks will never be adopted unless it is economically feasible to do so. Practically, this means that the total cost to a business of running ZE trucks must be at least similar to or lower than the total cost of running diesel trucks. The economic barriers can be characterised as follows.

Vehicle purchase cost – Both BEV and FCEV trucks are currently far more expensive to purchase (or lease) than the diesels they would replace. Future resale value of the truck is also a concern, because it is hard to estimate the future resale value of equipment that so far has only been sold in very limited numbers, and whose usability depends on refill infrastructure that is limited or non-existent in many areas. This uncertainty alone creates a risk that many fleets will not accept.

Vehicle running costs – Less obvious than purchase costs, running costs include not only direct costs like fuel (diesel, hydrogen, or electricity) but also insurance, maintenance, registration, and labour required to operate and maintain the new technologies. Unreliability may also be a major cost – expenses are incurred with unplanned downtime, roadside breakdowns and repairs.

Infrastructure cost – Diesel refuelling infrastructure is ubiquitous, relatively low cost, and amortised across many users. However, most ZE trucks (except some BEVs charged overnight) will require a business to have access to newly installed charging equipment or a hydrogen refuelling station.

Operational flexibility – Although most new trucks are purchased with a single purpose or application in mind, it is more common for a truck to be reassigned for some periods to other duties which can be very different in terms of locations, load, and trip distance. Diesel trucks have this flexibility. All current ZE trucks have limitations in terms of range and/or refuelling/recharging locations. A ZE truck that is purchased as ideal for a certain application within a business may not be so flexible to fill in other roles as needed.

5.3. Market maturity

The ZE truck market is in its infancy worldwide, even more so in Australia. This situation presents barriers of its own, as well as exacerbating some technical and economic barriers. Even in the US, where the electric truck market is significantly more mature than in Australia, there are still many unknown factors (Figure 9).

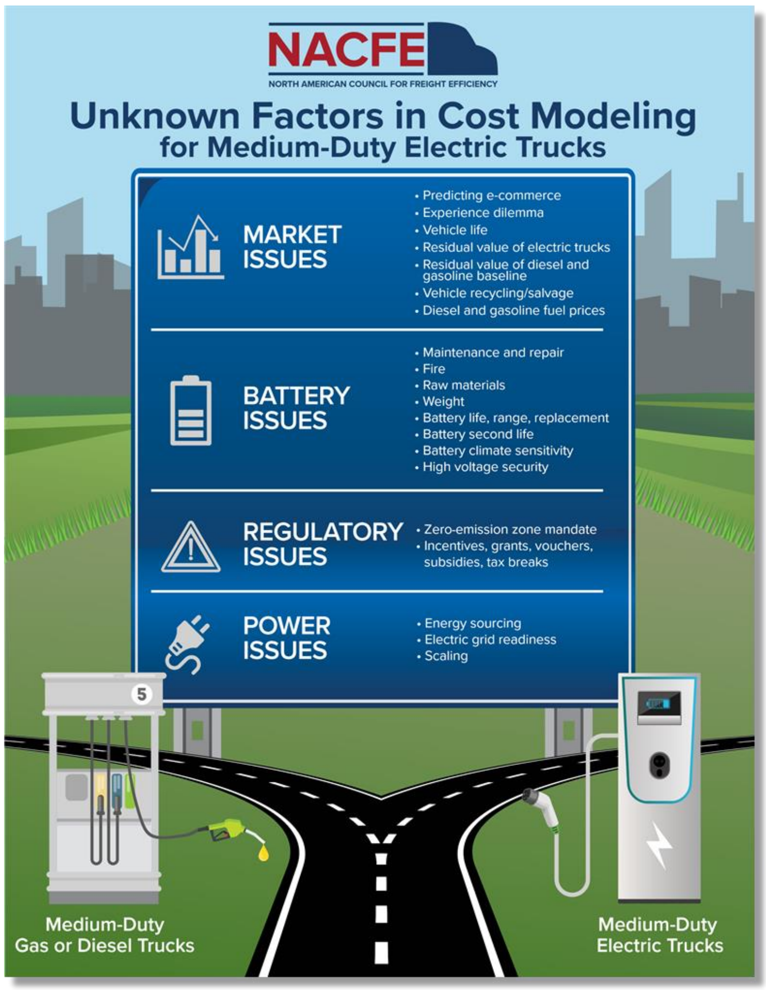


Figure 9 – Unknowns in the business case for medium duty electric trucks (10)

Whilst there are only a few suppliers of ZE trucks in Australia, and low numbers of fleets using them, the main barriers that this immature market presents can be summarised as follows.

Rapid pace of change – The ZE truck market and its supporting infrastructure is advancing rapidly, reducing the payload/range compromise, charging time, and costs. In this fast-changing market, the promise of radical improvements may in itself be a barrier to adoption as fleets hold off purchases with the expectation that the technology available 'next year' will be cheaper or better for their application.

Vehicle availability – Even if a fleet is very keen to transition to ZE trucks, they have a very limited choice of models to meet the operational needs of their specific applications.

Energy/fuel and infrastructure availability – Truck operations rely on supporting infrastructure to be successful. Inadequate access to energy (electricity, chargers, hydrogen gas, hydrogen fuelling stations) or maintenance and repair services (dealerships, training, tools, parts availability) could present an insurmountable barrier to ZE truck implementation.

Market demand – As with many nascent technologies, a lack of customer demand is seen as a barrier to OEMs bringing more ZE models on to the Australian market.

Culture – Trucking generally advances with slow evolutionary changes, based on extensive experience. ZE trucks represent a step-change in technology, which requires a different approach. A research-backed leap of faith is required to enter the ZE truck transition, which presents a barrier for many operators, dealers, and truck industry service providers alike.

Industry confidence – The nascent market in Australia presents many unknown factors which reduce confidence in a conservative, low-margin industry. The primary concern is that the truck is fit for purpose. Other confidence barriers are reliability of the new technology, resale values, future fuel/energy costs, knowledge and skills, and whether the ZE truck is actually better for the environment than diesel.

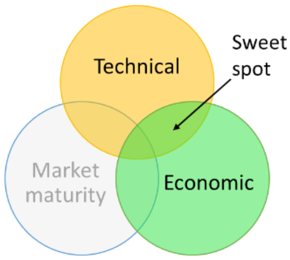
As with the electric car transition, there is a lot of information available, but much of it is conflicting, overly optimistic, or even intended to deter transition. This confusion reduces confidence to switch.

Capability/Capacity – Fleets have many competing priorities from normal fleet operations, customers, and staff. Use of a ZE truck presents many differences from business as usual, so it takes commitment and time (another cost) for a fleet to learn about ZE truck adoption, training, and implementation.

Regulation – There are no regulations that specifically prohibit ZE trucks, but Australia's unique vehicle regulations (such as width) increase the cost of adapting overseas designs to the Australian market. This hurdle will only be overcome if OEMs are confident of sufficient local sales.

Given the additional mass required for a ZE truck, there are calls for regulations to allow mass concessions and axle limit relaxations (as implemented in other countries), as well as driving licence concessions, to accelerate ZE truck uptake in Australia.

6. Defining the sweet spots for ZE trucks



Around 35,000 new trucks are sold every year in Australia. Each of these is purchased for a particular application, or to cover multiple applications. As noted in section 2, only a portion of these applications are technically and economically suitable for switching to a ZE truck.

The technical suitability of a ZE truck depends greatly on its configuration (size, weight and layout) and its duty cycle (Table 1). These factors determine its overall energy requirement and the opportunities to replenish that energy (to refuel or recharge). Each of the nine applications was assessed for its technical and financial suitability for transitioning to ZE trucks. This was done separately for the two technologies (BEV and FCEV), assuming the state of technology that is expected in 2025. Only slight improvements are expected over the technology and vehicle designs available in Australia today. Improvements will reduce the impacts on payload and charging for most applications. Results are described in 6.1 and 6.2.

As part of the industry consultation for this project, workshop participants considered which segments of the market they felt would be first to adopt ZE trucks at scale. Respondents resoundingly voted for first- and last-mile delivery in urban areas, as well as trucks that have high engine hour/low kilometre travel, such as some waste operations. They also identified noise-sensitive operations and the enabling of night operations where that may be currently restricted.

In contrast, when asked about sectors unlikely to adopt ZE trucks in the short term, long distance and highway articulated trucks were put forward, as were heavier domestic waste collection trucks.

6.1. BEV trucks

Figure 10 shows applications that are expected to be technically and economically viable for a BEV truck between now and 2025. Applications in **bold** indicate higher confidence in suitability across a range of users.

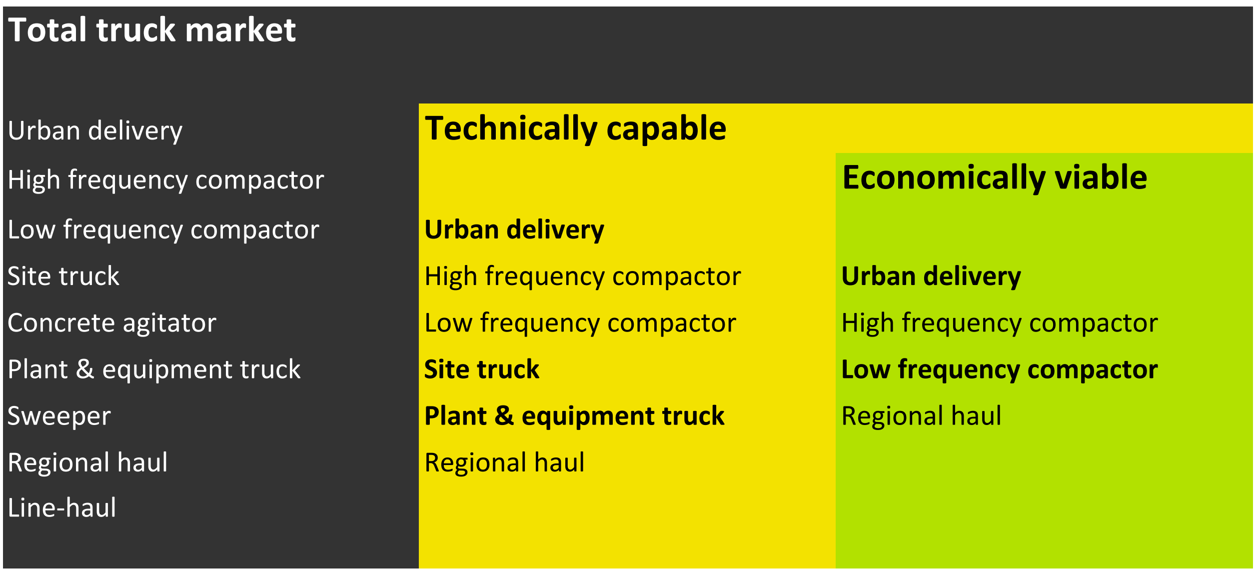


Figure 10 – Battery electric truck sweet spots

Winners

Urban delivery trucks and low frequency compactors are the most likely to be economically viable as BEVs. These correlate with the first applications in which BEVs have been used in Australia already. A smaller proportion of regional haul and high frequency compactor operations are also likely to be viable.

Although there are exceptions, many urban delivery trucks can avoid the mass, volume, charging drawbacks of BEVs. This is because they generally have low energy requirements, are not fully loaded in mass or volume, and can be back at the depot overnight for a single long charge. Some exceptions would include tippers carrying bulk materials that could be regularly limited by mass, and trucks working multiple shifts that will not have sufficient time to charge.

High frequency compactors require repeated heavy acceleration and braking, which wastes a lot of diesel energy and causes very high brake wear. Not only do electric motors excel at low-speed operation, but regenerative braking can reduce brake wear by two to six times in these applications, as well as reducing the size of battery required. High frequency compactors can suffer from some payload impacts, and they are only expected to be viable where there is a short distance between the depot/transfer station and pickup area.

Regional haul BEV trucks are already in use in the US, and it is expected that at least one OEM will introduce a suitable prime mover to Australia by 2025. There are examples of large rigid trucks available in Australia that are already performing regional haul in New Zealand. BloombergNEF notes in its latest EV outlook report:

> *Electrification is also making inroads into heavier vehicles. In urban duty cycles, battery electric trucks of any size become the cheapest option for several use cases in the 2020s.* (12)

Technical losers

Line-haul, concrete agitators, and sweepers are the only BEV trucks that are not expected to be technically capable in the near term. Although there are manufacturers working on BEV prime movers in the US and Europe (Tesla, Freightliner, and DAF, for example), Australian line-haul trucks are amongst the longest and heaviest in the world, meaning they must carry more energy or stop more frequently to charge. Given the mass, volume, and charging limitations, BEV trucks are not expected in line-haul in Queensland by 2025.

Concrete agitators and sweepers do not travel long distances, but they require significant energy for the barrel rotation and sweeping equipment, on top of that required for driving. This high energy requirement can severely impact on these applications that generally operate at the maximum allowed payload and have very limited available space for locating batteries.

Economic losers

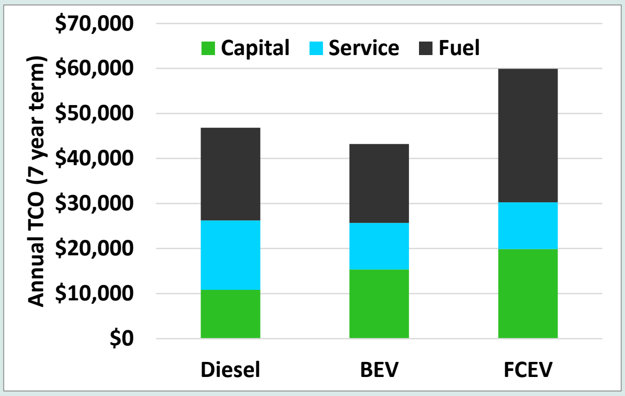
Economic viability is largely driven by how much energy a truck uses. The capital cost of BEV trucks is much higher than diesel, only offset by a lower cost of energy and maintenance which depend on the application and electricity price. Figure 11 details two examples.

Vehicles that currently do not use a lot of diesel cannot offset their increased capital cost via fuel savings. These include site trucks and most plant and equipment trucks, which spend large parts of the day sitting on a work site, such as the Energex plant and equipment truck in Figure 7. As discussed in Section 0, leadership and knowledge development are the likely motivations for this implementation, not economic viability.

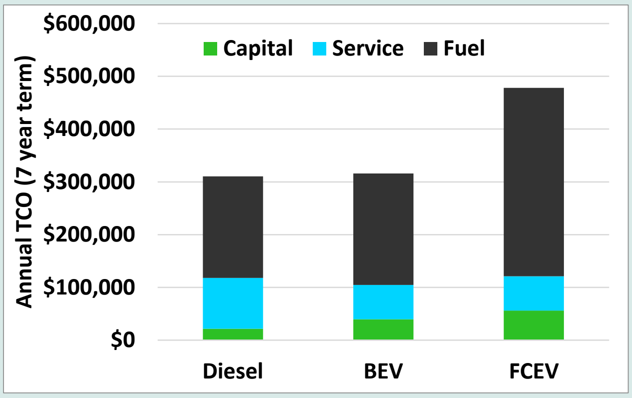
ZE Truck Total Cost of Ownership comparison

Most fleets are commercial operations and cost – usually total cost of ownership (TCO) – is an essential consideration. Assuming appropriate vehicles are available in Australia by 2025, Figure 11 provides an indicative TCO analysis using the assumptions in Table 3. The two applications represent opposite ends of economic viability, but they come to the same conclusion:

> *Over seven years, the TCO for a BEV is expected to be similar to a diesel, but a FCEV would cost significantly more to do the same job without significant subsidy.*



Heavy rigid urban delivery



Articulated line-haul

Figure 11 – Expected total cost of ownership in 2025

	Heavy rigid urban delivery			Articulated line-haul		
Annual	40,000 km			250,000 km		
	Diesel	**BEV**	**FCEV**	**Diesel**	**BEV**	**FCEV**
Price	$200,000	$320,000	$420,000	$400,000	$800,000	$1,200,000
Service	40 c/km	26 c/km	26 c/km	40 c/km	26 c/km	26 c/km
Energy use	37 L/100km	900 Wh/km	7.4 kg/100km	55 L/100km	1,700 Wh/km	14.3 kg/100km
Fuel cost	$1.40 /L	18 c/kWh	10 $/kg	$1.40 /L	18 c/kWh	10 $/kg

Table 3 – Main estimates for 2025 costs (4), (3), (11).

- BEV: Includes the costs for sufficient in-house charging infrastructure to support each operation.
- FCEV: Assumes hydrogen from public refuelling stations.
- All technologies assumed to have typical diesel-like depreciation over the first 7 years.

6.2. FCEV trucks

Figure 12 shows which applications are expected to be technically and economically viable for a hydrogen fuel cell truck between now and 2025. The applications in **bold** indicate a higher confidence that they will be suitable across a range of users.

Total truck market	Technically capable	Economically viable
Urban delivery		
High frequency compactor	**Urban delivery**	
Low frequency compactor	High frequency compactor	None
Site truck	Low frequency compactor	
Concrete agitator	**Site truck**	
Plant & equipment truck	Concrete agitator	
Sweeper	**Plant & equipment truck**	
Regional haul	Sweeper	
Line-haul	**Regional haul**	
	Line-haul	

Figure 12 – Hydrogen fuel cell truck sweet spots by 2025

Technical suitability

Like a BEV, FCEVs require new systems that add weight and take up space, which can affect payload in some applications. Up to 90L of space and 36kg of tank structure are needed to store 1kg of hydrogen (roughly equivalent in energy terms to 10L of diesel) (13). In the US, Class 8 prime mover chassis using hydrogen fuel cells are expected to be one metre longer to accommodate hydrogen tanks. This approach would result in a payload penalty in some long-distance line-haul operations in Australia due to our different regulatory dimension limits, which would then constrain adoption in that market segment. However, for all applications a proportion would be technically capable of switching to FCEV by 2025.

Economic losers

None of the on-road applications are expected to be economically viable by 2025 on a pure commercial basis (that is, without government grants, subsidies, or co-investment). As with BEV trucks, economic viability is largely driven by the substitution of diesel with lower-cost energy. The high capital cost of FCEV trucks and associated fuelling infrastructure can only be offset by a much lower cost of energy and maintenance which is not expected to be the case by 2025 (14).

The most likely applications to see FCEVs are those where BEVs may not be technically capable, such as line-haul, some regional haul, concrete agitators, and sweeper trucks, but this will come at a significant price. Hydrogen fleet projects will still emerge, relying on government funding to cover the financial gap by 2025.

Based on more extensive experience in the US, the North American Council on Freight Efficiency (NACFE) suggests that FCEVs are best suited to niches that involve specific conditions, which include government financial incentives (Figure 13).

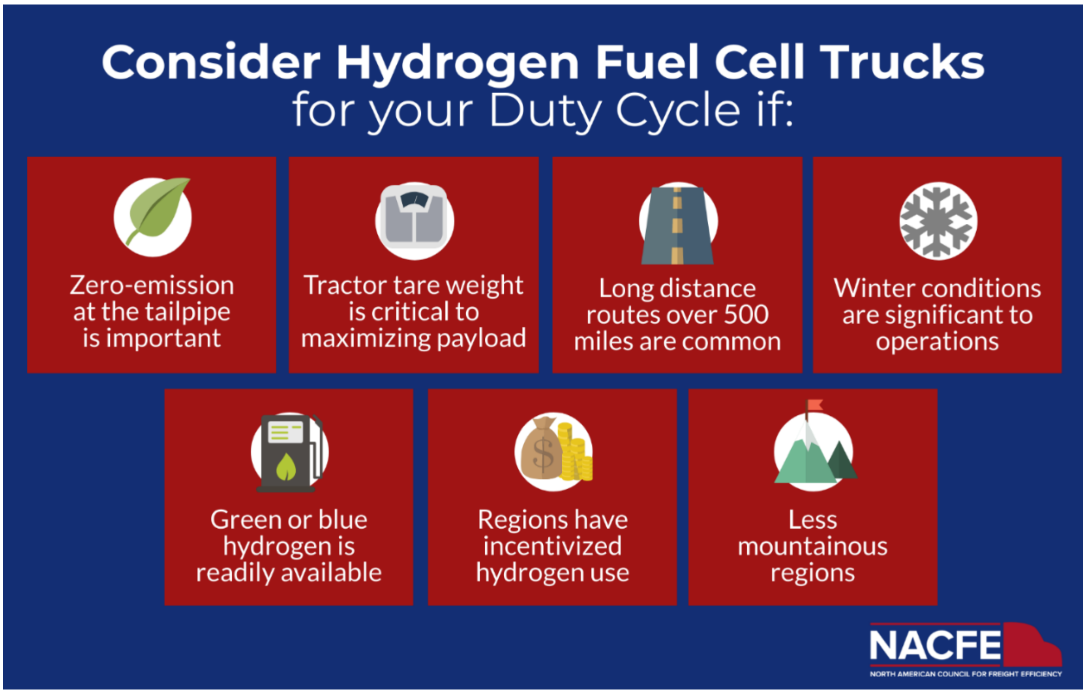


Figure 13 Potential FCEV niches (15)

6.3. Changes over time

Technology continues to improve for both BEVs and FCEVs. New materials, chemistries (batteries and fuel cells), and storage technology are in development to solve the technical barriers. It is highly likely that the impact on payload and the cost of both technologies will decrease long term, but not significantly by 2025.

These changes mean that both locally and overseas, the costs and suitable applications for ZE trucks will change as the improving technology is better understood, and as production volumes and competition increase. These changes will likely develop more slowly in Australia, where governments are reluctant to develop and implement the kind of supporting policies seen overseas, such as low emissions zones, diesel bans, carbon taxes, grants, and ZEV targets.

7. Understanding the uptake gap

The following sections explore the main issues related to market maturity for ZE trucks. Some are less rational than technical or economic suitability, and often steeped in beliefs or perceptions that can be overcome with experience, familiarity, and the right information. However, whether real or perceived, these will need to be addressed to achieve greater uptake of ZEVs.

Participants in the consultation workshops described their main barriers as model availability and purchase cost (Figure 14). Grouping their other responses into the three barrier types in Section 5 shows that issues related to market maturity (blue) were the most common. Confidence and knowledge were major issues, with poor understanding of ZE truck requirements still a challenge for most fleets. Participants recognised that confidence issues could be overcome with the right trusted information.

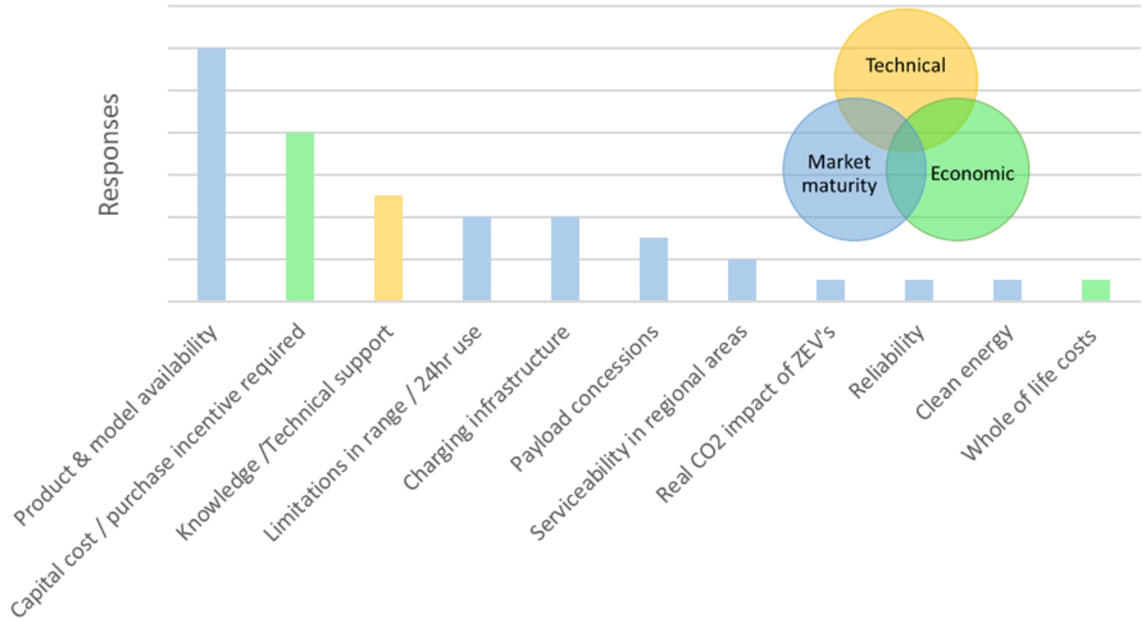


Figure 14 – Industry-reported barriers to ZEV uptake

Some of the key issues identified by workshop participants are explored in more detail below.

7.1. Vehicle Availability

BEV and FCEV heavy vehicle technology is in its infancy. While there is increasing interest from established and emerging OEMs, few models are available commercially and almost all models are in early production phases. To date, only three manufacturers supply BEVs in Australia, two of which released their first model in 2021. At least two groups have ordered FCEV trucks, but none have been commercially delivered to date.

Fleets can't buy what manufacturers don't make or supply.

Availability is a major barrier to adoption, and the first hurdle the market needs to overcome. It has two dimensions: availability of models for the right applications; and the volume of units required to satisfy demand. On the first issue, ZE trucks need to be the in right size, class, and configuration that their applications demand. For example, there are urban delivery applications where electric prime movers would be highly suitable but there are no models yet available to purchase locally. McKinsey (16) cites a lack of electric truck models as a key restriction to uptake in the light and medium duty segments even beyond 2025.

While many more models are available in Europe, China, and the US, there will be significant delays between availability there and in Australia. These delays are caused by a perceived lack of market demand as well as local engineering and compliance requirements. Those OEMs who address these challenges and offer vehicles in the most viable niches will likely gain early market share and position.

Participants in the industry consultation recognised these factors. Discussion on product availability often focussed on the heaviest articulated vehicles in the Queensland fleet and the reality that ZE models to support those tasks may be a long way off. However, participants also recognised that models for some niche applications, like moving containers around the port, may be well suited to articulated ZE trucks with around 30t GCM available overseas now. The role of regulations restricting or damping model availability was also a commonly held view and discussed at length.

Model variety coupled with global demand for not only whole trucks but also batteries, sub-systems, and other components, will leave the market supply-constrained for at least the short term (e.g. the current global shortage of semiconductors). The consultation workshops heard from leading ZE truck manufacturers Volvo Trucks, Scania, SEA Electric, and Hyzon. All provided valuable insights into their individual journey to expand model availability and developing models for more customer segments. The common message was that the industry is at the beginning of a global wave of change; that Australia could capitalise on early learnings in other markets; and balancing supply and demand will impact the rate of uptake.

More ZE models in more operational segments are expected to be available in the next few years. These models will mostly be rigid trucks. Prime movers should follow the rigid models and be available closer to 2025. Manufacturers are keen to engage with operators and government alike to meet the needs of the industry, address the barriers, and accelerate the uptake of ZE trucks.

Impact – The Australian market competes with overseas markets for volume, and it has some unique regulations that constrain the number of vehicles that can be imported without changes. With relatively small total sales volume and few supportive policies to make the business case compelling, manufacturers have not prioritised supply to Australia. Yet without a supply of both models and volume, organic uptake of ZE trucks will be constrained and slow.

7.2. Energy & fuelling infrastructure

The infrastructure required to support ZE trucks includes both the energy itself (electricity and hydrogen), as well as charging and refuelling facilities. These two ZE technologies have very different requirements for replenishing energy, but both suffer from similar perceived and real barriers. Some of these can be overcome with knowledge, but others involve significant cost.

Access to suitable charging is seen as a barrier for BEVs. However, the reality is that the initial deployments of BEV trucks will likely be charged at their depots and/or distribution centres, in a self-contained environment. Obtaining suitable charging equipment is not a constraint but understanding what is required and planning the required solutions is a knowledge gap. Contrary to some beliefs, any BEV trucks currently offered in Australia can be charged with a common 32A, 3 phase connection. Very few depots would have to upgrade current energy supplies to operate one or two BEV trucks.

In contrast, larger fleet deployments may place high demands on site electricity systems if large numbers of vehicles or multiple fast chargers operate simultaneously. Negotiation with connection providers (Distributed

Network Service Provider, DNSP) will likely be needed for larger fleets to secure megawatt-scale site supplies. Connection applications and upgrades are not fleet core business, can take many months, and costs are unpredictable. Engagement with the relevant DNSP is best done as early as possible in the procurement process. In some cases, fleets are aware of their truck replacement cycle many years in advance so they could be planning site energy upgrades well before they are required.

Electric trucks travelling longer distances will require enroute charging, with both availability and speed being potential barriers. The charging network in Queensland and across Australia is growing, driven by electric car needs. These chargers can often deliver more power than current electric trucks can use[2]. No current truck can manage an 80% charge within an hour. Improvements in electric truck charge speeds are expected to catch up with or exceed models of electric bus and car already on Queensland's roads.

Similarly, the availability of hydrogen refuelling stations is a barrier to FCEVs. The first three public hydrogen fuelling stations in Australia were only opened in 2021. They are also costly, representing up to 70% of the hydrogen retail cost [(14)]. These stations are small, only capable of displacing an estimated 200-750L of diesel per day[3]. Given the specialisation and scarcity of both fuelling stations and FCEVs, any new deployments will require considerable coordination between fleets, OEMs, fuel suppliers, and retailers.

Hydrogen fuel can be produced on-site or pumped or trucked to a filling station from a centralised production site. Of the demonstration sized plants planned for green/renewable hydrogen in Australia so far, most are to supply hydrogen to other industries such as ammonia production, refining, natural gas blending, and export. In the early years at least, competition from these sectors may reduce hydrogen availability as a transport fuel. Unlike electricity, which is effectively confined in a domestic energy market, large-scale hydrogen exports will also create a new international fuel market that could see costs increase significantly, as it did for east coast natural gas when it went from a mostly domestic fuel to a globally traded commodity.

7.3. Market demand

Low ZEV sales are often attributed to low demand. This was also the case in the light vehicle market, despite many surveys showing customers intended their next purchase to be an EV.

Consultation participants in this project were asked how advanced their plans were in considering a switch to ZE trucks. Almost all operators and supporting organisations have taken their first steps or developed business cases for initial vehicles. Four organisations had placed orders for or received their first vehicle. This shows not just interest, but a preparedness to put money down to at least assess vehicle suitability.

If OEMs were confident of consistent high demand, Australia would likely have more access to the many ZE truck models currently available worldwide. Higher demand for ZE trucks overseas has been achieved via a combination of targeted long-term policies including low emission zones, investment support for manufacturers and fleets, impending diesel vehicle bans, and organisations willing to lead the transition.

[2] Trucks include Fuso eCanter = max 50 kW; SEA electric = max 100 kW; Volvo FE = max 150kW. Charging includes Queensland electric superhighway 33-100 kW; RACQ/Chargefox and Evie networks Ultra-rapid chargers 350 kW.

[3] 22-80kg of Hydrogen a day (23), with estimates for efficiencies and regeneration.

7.4. Culture and change

For a conservative, high-capital industry like truck manufacturing, responding to rapid changes and disruption can be difficult. After a century of development and entrenched culture supporting diesel, this change will be hard for some industry actors, but it is a journey that must be navigated to achieve societal goals.

Fleet management and procurement

A road freight fleet manager’s role is one of risk avoidance and mitigation based largely on experience, either personal or collective. *What works for me? What have others used? What didn’t work?* These are common questions that shape decisions and result in a bounded rationality (rules of thumb). This approach works well for vehicles and technologies that have had years or decades to prove their worth, but not as effectively for nascent ZE technologies.

As outlined in Sections 0 and 4, larger private and government fleets have been first movers in adopting zero emissions trucks, driven by:

- customer requirements (typically a large multinational or government contract),
- a sustainability initiative or commitment, or
- wanting to lead or differentiate themselves (competitive advantage).

These initial deployments will help build confidence in the industry but are yet to result in any company switching its whole fleet or broader uptake across the sector. There is still scepticism in parts of the workforce and support for cultural evolution will be required to build confidence in even the most proactive fleets. New and additional responsibilities for fleet managers (charging, EV training) may also be resisted by some.

Dealer staff

Selling ZE trucks which have complex energy requirements is a new challenge for dealerships. While dealer sales staff are accustomed to learning about new models and even new technologies, this shift has been shown to be more challenging in the light vehicle sector where dealers have actively avoided selling ZEVs. (17)

Sales teams’ attitudes and beliefs directly influence the adoption of ZE vehicles (both positively and negatively), as do their KPIs. If the effort and time of selling a ZE truck affects achievement of sales targets, they may avoid doing so. OEMs and dealers will need to navigate these pressures in the early part of the transition where much of the sales process is spent providing education to fleet and procurement managers. Some truck manufacturers have embraced the change, developing tools and training for sales staff and customers to assess the suitability of ZE trucks in their operation.

7.5. Confidence

Switching to a ZE truck is at least partly a leap of faith, with fleets relying largely on OEM and dealer claims. Before switching, managers want confidence that examples are relevant to their business and their operation will continue unimpeded. But even diligent research will likely only provide limited relevant information, possibly about other applications, or even other countries. Below are the many elements that workshop participants said needed to be clear in their minds.

More accurate information was identified as critical to building a business case to support decision-making. While the operating cost of battery electric trucks are known to be significantly lower than diesel trucks in some applications, these savings can only be realised if the initial barrier of capital expenditure and longer-term depreciation can be overcome. Uncertainty about the future resale value of ZE trucks is a primary concern, with depreciation often the biggest component of whole of life costs or TCO.

Fleets purchase vehicles to fulfil contract requirements and to ensure stable revenue. Reliability and uptime are often as important, or more important, than the direct cost of maintenance. This includes access to appropriate parts and services. The word of the dealer or OEM that backup service will be available for a new technology is sometimes not enough to satisfy concerns.

For electric truck deployments, grid connections and upgrades are significant blind spots for fleet managers. Fleet operators at the consultation workshops mentioned that the process for grid connection upgrades is complex and uncertain. Trial case studies with clear, independent data would help build confidence, and cost information could help with business case development. Data sourced from manufacturers or suppliers is less trusted and often discounted by fleet managers when estimating savings.

Some of the uncertainty is due to inconsistent or incorrect information. Workshop participants were not sure about the true environmental impact of ZE trucks, noting concerns about the embedded emissions within batteries. While some studies have explored this issue for light vehicles in Europe [18], there is not much relevant data for trucks in Australia.

7.6. Organisational capacity & capability

Fleets are so stretched with operational challenges, where will learning about new tech fit?

Fleets often don't know what information they need about ZE trucks and are not sure where to get it. They also have many competing priorities from operations (compliance, breakdowns, scheduling), customers, and staff – with limited spare capacity to learn about and plan complex changes. Typically, the smaller the fleet the greater the capacity constraint. Making it easier for fleet managers and procurement staff to build confidence is the key to overcoming this barrier at the purchasing stage.

In terms of capabilities, fleets need to shift their operational view from one that is not usually energy constrained (diesel) to one that will likely be limited by the onboard energy (or time and payload impacts). Having the ability to assess energy requirements of their current fleet and then model changes with ZE technology is not a core business skill. This is where OEMs offering ZE trucks may need to step in with support.

When a ZE truck is added to a fleet there are many new things the entire team needs to learn, which is a further capacity drain. Training for drivers, depot staff, technicians and schedulers may be required. Traditional training sources such as TAFE have been slow to meet these needs, so more support may be required from OEMs or the function removed from the depot, going back to the dealer.

7.7. Regulation

While there are no inherent restrictions to ZE trucks in Australia, some regulations affect their potential competitiveness. Were these to be overcome, the uptake of ZE trucks might greatly improve. The issues below were mentioned by workshop participants.

Mass and dimension limits

The maximum permissible width of heavy vehicles in Australia is narrower than in Europe and the USA, both major sources for emerging ZE truck models. This results in re-engineering or different components for models to be imported to Australia. This engineering spread over a relatively small sales volume increases costs and restricts model availability. While there are many historical reasons for the dimensions prescribed in Australian Design Rules (ADRs), a shift in technology could be the catalyst to harmonise regulations.

BEV trucks are heavier than diesel trucks due to the additional weight of battery packs and motors versus engines and fuel. This can be as much as a 30% tare weight increase, with the most impact on the front axle. If a diesel truck is already at or close to its maximum weight, attempting to do the same task with a BEV may require an operational change (less payload, smaller body, or increased vehicle movements) or a switch to a larger vehicle class (higher GVM or axle capacity). This may also increase costs, dimensions, and licence requirements. The EU has introduced concessions allowing ZEV trucks to operate above the maximum limit to offset the payload impact of the heavier powertrain (19).

Licencing limitations

Some fleets prefer trucks that can be driven with a car license because drivers are easier to recruit. This is especially important in last-mile delivery and tool of trade vehicles. In New Zealand, BEV trucks receive a concession for license class (6.5t vs 4.5t in Australia) to reduce the payload impact of the tare mass increase.

8. Insights and Recommendations

The actions below could help overcome the barriers and issues raised by industry and discussed in this paper. They have been assigned to different stakeholder groups and classed as either:

Foundational – required to achieve baseline organic uptake beyond a few ZE truck trials.
Supporting policy – provides a clear intention or path to overcome barriers and provide an environment supporting ZE truck uptake.
Accelerative – boosting effect on the organic baseline ZE truck uptake.

No single stakeholder group can transform the market. While most actions can be implemented individually, they often have a greater impact when coordinated and combined, so collaboration is required across all stakeholder groups in Queensland.

8.1. For all stakeholders

Recommendation	Action	Action type
Define heavy vehicle duty cycles: There are no duty cycle definitions in Australia that fleets can use to compare performance or assess a ZE truck suitability. This action could be for government, OEMs, researchers, or NGOs.	Define and develop duty cycle profiles Operational and energy profiles of each duty cycle are required to provide a baseline for ZE truck compatibility. This includes measurement of real-world operations and how they differ to one another.	Foundational
	Support fleets to assess ZEV readiness. Fleets assess real-world activity against defined duty cycles to gain confidence that the diesel truck tasks can be met by capabilities of ZEVs. Various stakeholders have a role to play.	Accelerative
	Collate vehicle population data by duty cycle. Vehicle sales are not currently tracked by the duty cycles used in this paper. Segmenting the fleet in this way would help quantify the size of the potential market for ZE trucks and would benefit policy actions.	Foundational
Collaborate. The ZE truck transition is complex and has many stakeholders. Ensuring all parties are focussed and building on the work of others will accelerate transition. QTLC can take a leading role in this process.	Work across sectors to showcase and enable change. Developing hubs, precincts and ecosystems of ZE trucks with collaboration between all stakeholders can reduce costs, increase reach, and build confidence quickly.	Accelerative
	Share the wins and lessons. Confidence is key to the transition and early lessons can provide this to fleets close to a decision. Share information via a central source (e.g. NGO) and active learning events rather than passive.	Accelerative

8.2. For Governments

There are many policy levers available to all levels of governments to support clean technology transition within the transport and logistics sector. These ensure Queensland will meet its increasing freight task, while achieving energy productivity gains and emissions reductions to support its net zero target.

Recommendation	Action	Action type
Review and integrate policy: Address policy distortions which constrain adoption of innovative technology.	**Harmonise regulations to increase technology availability.** Australian design rules and standards currently preclude overseas ZE trucks from being directly compatible, reducing model availability. Standards should be aligned to allow ZE truck models from compatible markets to be imported.	Supporting Policy
	National collaboration on emissions targets. A lack of clarity on how to reduce transport emissions reduces confidence in those who need to act. Take a clear stance on heavy vehicle emission standards to provide industry confidence.	
	A clean energy plan for transport. The energy sector has seen significant decarbonisation focus, with plans and strong targets in place. Transport remains disconnected from these plans, but its impact in terms of energy and emissions is growing. A clean energy plan is needed for transport.	
Develop and implement effective policies and incentives. Incentivise action towards goals and/or disincentivise practices with negative impacts.	**Policies to renew an ageing fleet.** The community bears the cost of an ageing truck fleet through illness and health costs. Internalising those costs via fees & charges could support ZE technology.	Supporting Policy
	Differentiated access for ZE trucks. Access concession such as night-time delivery, special use lanes, and low emission zones, would all recognise the benefits of ZE trucks. NHVR and states could provide concessions for mass and licencing to offset the loss of payload in ZE trucks.	
	Incentives to reduce operating costs: Industry confidence could be improved by sending a policy signal through fee exemptions or discount periods on registration, stamp duty, and tolls.	
	Incentives to reduce capital costs: Capital cost is regularly noted as a barrier to ZEV uptake. Providing tax offsets, grants, rebates, or co-investment initiatives will increase ZE truck uptake.	

Recommendation	Action	Action type
Transport industry funding: Allocate budget for transport efficiency to support improvements across the broader economy, including new local businesses and manufacturing.	**Recovery/stimulus packages.** Economic stimulus, such as Covid-19 or natural disaster recovery, should include environmental conditions or incentives. Requirements such as setting and reporting on emissions goals, or building back better, with funding for ZEVs and infrastructure as part of the package.	Accelerative
	Infrastructure project planning. Targets to improve transport energy productivity and reduce emissions should be included as criteria in government projects. This would signal to all stakeholders the need to shift to ZE trucks over time.	Foundational
	Support cost-effective recharging/refuelling infrastructure. Significant public funds have been put to fast-charging networks for light vehicles. Future public funding should go to the most cost-effective approach (not just fast-charging); target sites likely to see high utilisation; and be tied to data sharing requirements to inform future investment.	Accelerative
	Research, Development & Demonstration funding. Resolve knowledge and confidence barriers by funding research and development projects that support ZEVs in Queensland settings. This should include support for the local truck industry to bring and develop products locally.	Accelerative
	Develop a contestable fund for ZE trucks. Upfront costs for ZE trucks will continue to be a barrier for some time. A contestable fund for competitive grants (like NZ) could support new ZE rollouts.	Accelerative
Lead with government fleet and contracts: Governments can play a key role in setting an example and leading innovation through their contracting arrangements.	**Government fleet policy and targets.** Include requirements and metrics to drive ZEV transition in government fleet (e.g. NSW and Tasmania), expanding from light vehicles to light commercial vehicles and trucks where relevant.	Supporting policy
	Insert criteria for suppliers into government contracts. Government tenders billions of dollars in contracts each year. Contracts supporting major infrastructure projects could favour suppliers who use ZE trucks in at least part of their fleet or include ESG assessment criteria. NSW previously used a program called SPECTS to support higher productivity vehicles while also reducing community impacts in major urban projects.	Supporting policy

8.3. Suppliers and service providers

Truck operators rely on an ecosystem of suppliers and service providers like fuel stations, workshops, training organisations and the finance sector. This ecosystem needs to expand and adapt to support ZE trucks. Hydrogen needs to be produced, distributed, and dispensed. BEV trucks will need support from grid operators and energy retailers. Each part of the ecosystem can act to support & accelerate ZEV adoption.

Recommendation	Action	Action type
Energy and charging providers need to engage with truck fleets: BEV trucks will first emerge in back-to-base operations (waste, council works, urban distribution), and will need support from the electricity industry.	**Electricity connection providers to assist fleets.** Electricity connections for larger and centralised fleets pose a significant challenge to transitioning to BEV trucks. DNSP's should streamline the process for connection assessments and upgrades to remove this barrier to large fleet transition. Early engagement with fleets who plan to transition is required.	Foundational
	Charging providers to engage and educate fleets. Fleets need to accurately understand their vehicle charging requirements and the interaction with the grid. Charging equipment suppliers should engage with truck fleets, provide lessons and insights, and assist transition planning.	Accelerative
Financiers and Fleet Management Organisations (FMOs) to tailor ZEV offers: Due to the higher upfront purchase price of ZEVs, FMOs can play a strong role enabling their adoption.	**Financiers and FMOs to lead and enable fleets.** Even with a better TCO, upfront capital cost of ZEVs can still be a barrier due to financial access. FMOs can provide easier access to capital for ZEV buyers, accept greater uncertainty during early transition, and enable rather than constrain uptake.	Accelerative
	Provide preferential finance packages for ZE trucks. There is a requirement for… • **Better finance rates for ZE trucks** • **Improved residual values for ZE trucks** Some finance providers offer preferential rates for ZEV personal vehicles which could be extended to ZE trucks. Residual values for ZE trucks could be less conservative to support a better business case.	
Provide heavy vehicle refuelling / recharging: Despite limited current demand, all public DC fast charging and hydrogen refuelling sites should consider heavy vehicles access.	**Provision of public heavy vehicle charging infrastructure.** DC fast chargers currently being installed in areas frequented or nearby truck routes or depots should include access considerations for trucks.	Accelerative
	Upgrade current DC fast chargers to be suitable for trucks. Many current DC charging stations could be suitable for smaller trucks (Fuso eCanter, SEA 300). However, the size of the truck may make other charge bays inaccessible. Longer charge cables or access to DC ports for trucks to use their own longer cable would alleviate this problem and build confidence for fleets operators.	

8.4. For the freight supply chain

Upstream actors in the freight supply chain include freight forwarders and logistics coordinators who engage the services of fleets. Downstream actors include large goods manufacturers and retailers (shippers). These parties influence fleet vehicle choices through contracts, setting targets, and collaboration partnerships.

Recommendation	Actions	Action type
Provide favourable conditions for fleets that operate ZE trucks: Use contract terms and conditions and other incentives to encourage fleets to try or switch to ZE trucks.	**Incentivise fleet innovation.** Shippers can support the transition to ZE trucks using a range of different options – from enforced requirements to subtle encouragement. A leading retailer has committed to all deliveries globally being made with ZEVs by 2025, motivating carriers who want that contract to shift to BEVs. Other incentives include preferential rates, longer contracts to amortise the higher truck cost, alternative financing, pooling buying power, and promotion and marketing. **Freight customers to expand the ecosystem.** ZE trucks require a fresh approach, and shippers and freight customers can support fleets by making their facilities part of the ecosystem. One example is providing suitable charging at the delivery site (e.g. retail store) to charge while unloading, reducing the size of the battery required for a BEV. **Support fleets with knowledge and insight.** Shippers are often large, well-connected organisations with influence. They can work with carriers by bringing experts in to help assess viable opportunities to switch. They may also have experience they can share from ZEV projects in other cities, regions, or countries.	Accelerative
Develop zones and precincts as catalysts for change. Freight movements are often concentrated in precincts and industrial zones, which can be used to support early adoption collaborations to build industry confidence.	**Develop zero emission hubs and precincts.** Freight hubs such as ports, industrial parks, rail heads, and intermodal terminals are areas that can support higher numbers of ZE trucks. This aggregates demand for fuel/energy (improving the business case). It also demonstrates viability and offers opportunities for ecosystem users to collaborate. **Incentivise ZE fleets.** Precincts can preference ZE trucks in term of access, queuing, or differential fees, recognising their environmental and other benefits. Diesel trucks could be levied to offset the impact they have and fund ZE truck incentives. Low emission zones could also be formalised in future as is done overseas (e.g. Port of LA). **Leverage off-road applications.** Payload constraints due to regulatory barriers (axle loads, mass/dimensions) do not apply on private roads. These private areas allow ZEVs to be used unconstrained, demonstrating technology readiness, and providing more options for models that can't be used on-road (e.g. left-hand drive).	Accelerative

8.5. For fleets

Fleet operators are the ultimate decision maker in the transition to ZE trucks, faced with balancing the benefits and challenges. They are unlikely to switch unless they have suitable models available to suit their application, the business case is favourable, the solution does not impact normal operations, and they are confident it will work. They also need to consider whether they will lead, follow, or lag the rest of the industry.

Recommendation	Action	Action type
Make a strategic choice to lead or follow. There are benefits in each approach. Not everyone can or should lead the charge, but those that want to need to act.	**Decide the triggers for a switch.** Some companies want to lead to differentiate themselves, others will learn and follow, while some will only switch when it is much cheaper to do so. Each company should decide what its strategic drivers are and what conditions need to be met to shift to ZEVs. Those conditions then inform and drive decisions.	Foundational
	Monitor the market. Suitable models, suppliers, charging/fuelling locations, and costs change quickly in a new technology market. Monitor these to inform the triggers above.	
	Plan and commit resources. Leader fleets should formalise the switch in their strategy, operations, and fleet purchasing policies. This could start with trials and data gathering.	
Understand the current diesel fleet and its potential to switch. Many fleets track diesel fuel use but will need a more detailed understanding of energy consumption to make the switch to ZE trucks.	**Assess fleet data to find suitable ZE opportunities:** Analyse current fleet data to ensure it is accurate before making any ZE assessments. Then assess ZE suitability using energy data on different tasks, routes, and duty cycles. Use OEMs, dealers & experts to build capacity.	Foundational
	Engage with ZE truck manufacturers on availability & capability: Begin the process early to better understand ZE truck considerations and to match vehicles and tasks using data.	
	Develop a business case: Detailed analysis to understand the breakeven point/payback. It should include an operational impact assessment, capital/operating costs, and co-benefits.	
	Prepare a fleet transition plan: Prioritise vehicles and tasks in the fleet to support a staged rollout. Adjust assumptions, trigger points, and resources with any learnings.	
	Seek out expertise: Recognise your company's limits in knowledge and resources. Use advisors with expert knowledge and experience – be they fleets, suppliers, or engineers/consultants. Engage early to ensure accuracy and relevance of results and plans.	
Take the first step. When all triggers are met, the fleet should buy its first ZE truck and monitor suitability.	**Procure wisely:** Ensure that the model and any supporting equipment and infrastructure is well understood before the contract is signed, including warranty and future upgradeability.	Accelerative
	Capture data and establish monitoring/feedback: Make the effort to track performance, energy use, costs, battery degradation, aftermarket support, etc to inform future decisions. Share with others.	
Establish partnerships.	**Collaborate and nurture partnerships.** Collaborations can often achieve more than an individual company, and some decisions are easier with broader cross-sector knowledge.	Accelerative

8.6. For vehicle manufacturers

Vehicle manufacturers and their dealers are the source of trucks, trust, and much knowledge for fleets. As such, they are critical to the transition.

Recommendation	Detail	Action type
Provide leadership and differentiation. The industry looks to OEMs for direction on truck technology. By controlling what models are available, they shape purchasing decisions and can provide a clear message to industry.	**Actively engage fleets in ZE truck planning.** Consultation shows a clear customer appetite for ZE trucks. Combining pockets of strong interest with the most suitable applications should inform ZE truck model introductions. **Expand model availability.** Offering ZE trucks in the most viable niches for Australia will help OEMs establish early market share and first movers with broad fleet coverage will be seen as leaders. Overly pessimistic/optimistic promises will delay the shift as customers wait for next year's model. **Share success stories to build market confidence.** Include specific details about the application and implementation requirements to help others understand what is required. **Expand to new niches:** As technology develops, energy infrastructure expands, and more customers become interested, models can be offered into new niches. **Support and educate the market:** Consultation showed a clear customer appetite for ZE trucks. Addressing the knowledge gaps and perceived and real barriers will grow the market size.	Accelerative
Help customers assess suitability. Operators are still early in their knowledge journey. They need support to understand differences and best applications.	**Provide assessment tools or rules of thumb.** Clearly establish which customer applications would be well suited for current ZE truck offerings (sweet spots) and communicate it widely. **Educate and upskill dealers** about ZE truck suitability in terms of (a) duty cycles; (b) driving range (supporting the required charging time); and (c) total cost of ownership. **Educate service providers.** First responders (emergency personnel), second responders (tow truck operators & mechanics) and vehicle inspectors all need to understand ZEV special requirements.	Foundational
Develop Partnerships. The diesel paradigm of simply selling trucks and leaving everything else to fleets / the market will not work with ZE trucks.	**Assist transition planning.** Customers' vehicle replacement schedules can be used to plan large spikes in demand, including effects on infrastructure and depots over several years. **Engage with coordinating bodies** including industry associations, consultants, government, NGOs. **BEVs: Actively engage electrical contractors, DNSPs and charging providers,** to understand compatible products and the depot planning process for ZE truck rollouts. **FCEVs: Actively engage fuel, fuelling station providers, and fleets.** Simultaneous rollout of hydrogen fuel supply, refuellers, and vehicles needs to be coordinated (or risk failure like LNG/CNG).	Foundational

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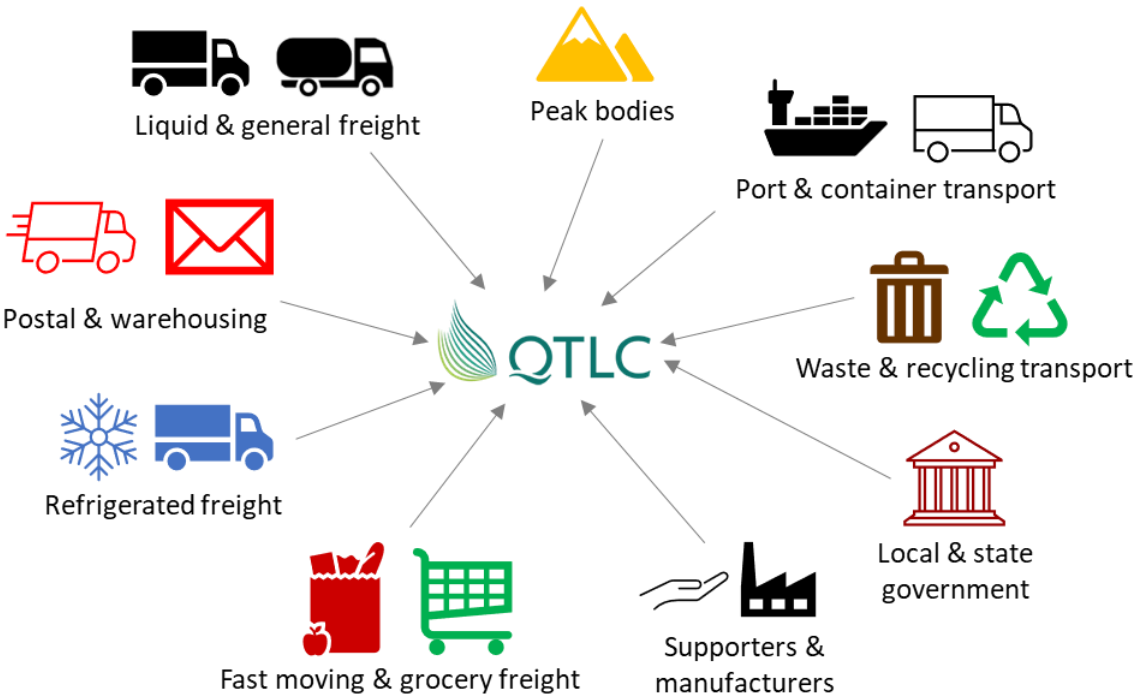
Appendix A Industry consultation findings

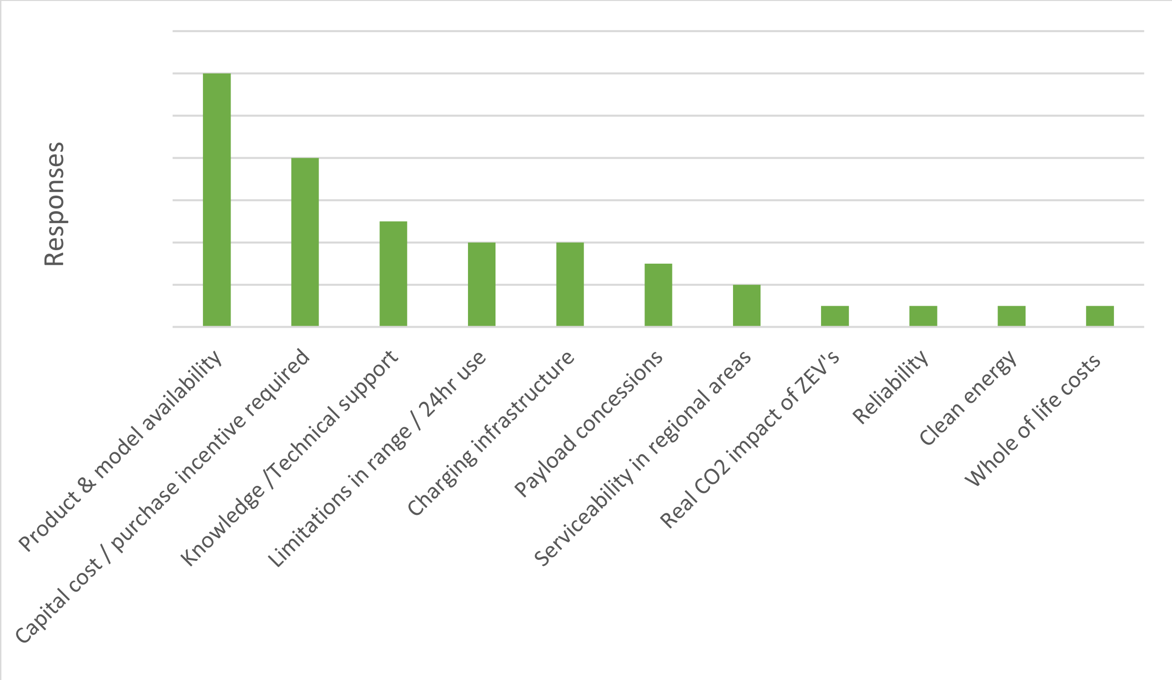
QTLC feels the industry view is paramount to the development of any policies and programs for ZEVs. Organisations are at different stages of their sustainability and technology journey, so meeting them where they are at is important to achieving progress. The project team conducted industry consultation workshops with fleets from across Queensland, spanning many freight types, to understand the challenges they face in transitioning to ZE trucks. The three consultation workshops included 14 fleets, 4 peak bodies, and 8 associated organisations covering the groups outlined below. Their broad and eclectic views on the present and future of zero emission trucks explained what they think they need to shift to ZE fleets.



We asked fleet operators questions about their ZE truck journey, the issues they perceive or have experienced, and what would be required for them to transition to ZE trucks in the coming years.

When asked how advanced they were in considering a transition to ZE trucks, almost all operators and supporting organisations had taken first steps or developed business cases for initial vehicles. Four organisations had placed orders for or received their first vehicle to trial and operate. This shows there is strong interest and appetite for ZE trucks across the industry.

The workshop participants described the barriers as they saw them. Product and model availability was the dominant hurdle, followed by initial cost to purchase. Education was also clearly an opportunity, as knowledge around every aspect is still low in most fleets, and it was recognised that many issues could be overcome with the right, trustworthy information.



Discussion on product availability often turned to the heaviest articulated vehicles in the state's fleet, recognising that ZE models to support those tasks was a long way off. However, some niche applications like those at the port moving containers may be well suited to articulated ZE trucks with around 30t GCM now.

The industry recognises that ZE trucks offer several benefits to themselves and society at large. Of those benefits the workshops identified it was the leadership and branding benefits that stood out strongest. Operators and their customers could benefit from the messaging and signal that ZE trucks send. Participants also recognised the potential emissions reductions, operating cost savings and simplification that ZE trucks can unlock.

The groups considered the segments of the industry where they felt ZE trucks were likely to work well and the responses were resounding for first-mile and last-mile delivery in urban areas, and trucks that have high engine hours/low kilometre travel like some waste operations. They identified noise sensitive operations and the enabling of night deliveries that may be restricted now. In contrast, when asked about the sectors where ZE trucks are not likely to be adopted in the short term, long distance and highway articulated trucks were nominated, as were heavier domestic waste collection trucks.

The drivers for change to ZE trucks were identified by the groups as (in order of popularity):

1. **Incentives –** Funding to support trials and purchases of vehicles would remove a key barrier. Other ongoing support such as registration concessions could support a better business case.
2. **Policy** –
    a. The need for Government and/or organisational targets on emissions or technology uptake. This sends the greatest signal that change is required and is here to stay.
    b. Payload concessions for heavier ZE trucks stood out for enabling various segments of the industry where a tonne could make all the difference to switch in some cases.
    c. Low emissions zones or curfews which favour ZE trucks could be a catalyst to uptake, either in areas of cities or in specific precincts.

3. **Technology** – development of and access to more ZE truck models; overcoming the refuelling infrastructure challenges, from grid connections to hydrogen refuelling access.
4. **Knowledge** – not just for fleets to overcome concerns about fit for purpose and resilience, but for the supporting industry and customers. Helping the finance industry to understand the cost of ZE trucks and their operating model could see better aligned loan structures.
5. **Motivation** – for organisations to be leaders.
6. **Investment** – in refuelling and recharging by the private sector.

Detailed and accurate information was identified as key to the decision-making process for fleets to build business cases for ZE trucks. A major concern was resale values uncertainty for ZE trucks, which is often the biggest element of whole-of-life costs. Uncertainty can stop a business case in its tracks.

For large deployments of electric trucks, grid connections and upgrades are significant blind spots for fleet managers. They mentioned the process and uncertainty around grid connection upgrades, which is obviously not an issue for diesel. Trial case studies with clear, independent measurement would be helpful to build confidence and develop business cases. Manufacturer-sourced data is treated with caution and often the claimed benefits are discounted by fleet managers in their assessments (a factor also seen overseas).

Workshop participants recognised that the long-term success of the trucking industry was dependent on a transition to ZE trucks. However, they felt that emissions reduction was not as front of mind in fleet purchase decisions within their organisations as it could be.

On balance, fleets and other organisations that joined the workshops were keen to engage in the transition to ZE trucks where fit for purpose models are available and if it makes financial and organisational sense.

A.1 Manufacturer's view

To support the industry consultations, participants heard from leading ZE truck manufacturers Hyzon, SEA Electric, Scania, and Volvo Trucks. These manufacturers shared their approach to developing and offering models to the market and their individual journey in expanding model availability. The consensus was that we are at the beginning of a global wave of change, that Australia could capitalise on early learnings in other markets, and balancing supply and demand will impact the rate of uptake we see.

More ZE models in more operational segments are expected to be available to the Queensland market in the next few years. These models will mostly be small, medium, and large rigid trucks in the early part of the decade. Prime movers are expected to follow the rigid models closer to 2025. The manufacturers were keen to engage with operators and government alike to meet the needs of the industry, address barriers, and accelerate the uptake of ZE trucks.

The Queensland Transport and Logistics Council (QTLC) is the respected agent of the Queensland Freight Industry. We aim to drive continual performance improvements in Queensland's freight and logistics sector, delivering improved productivity, safety and environmental benefits for all Queenslanders. We strive to change the way Government & Industry connect and work together to deliver Sector based improvements.

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