Decarbonising Australian Road Freight Transport: Low & Zero Emission Trucks Discussion Paper

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Contents

EXECUTIVE SUMMARY

Low and zero emission technologies have been promoted as a panacea to the growing challenge of climate change, particularly in the transport sector. This paper provides a practical, evidence-based outlook on the potential of low and zero emissions trucks, based on the views and product plans of Australia's truck manufacturers and importers.

It is globally recognised that fossil fuels will eventually be greatly reduced in society and net zero carbon emission should be achieved not later than 2050. Transport is expected to become the largest emitter and probably the most stubborn sector to transition. Leading nations have focused policies, penalties, and incentives to provide clear market signals and accelerate the transition to renewable energy powered road transport.

The Australian political environment on emissions reduction has been volatile and disparate for more than a decade. International and electorate pressure has led the adoption of a national net zero by 2050 policy. The execution of this policy remains a matter of debate across the political spectrum.

Some parts of Australian industry have shifted its expectations of emissions reduction far faster than Government, with clear statements driven by the need to remain socially acceptable and the desire to show leadership. TIC has developed this paper as a statement of where Australian truck manufacturers and importers currently stand in the energy transition, and to articulate the realistic potential for rapid change.

Low & Zero Emission Vehicles (LZEVs) are just one part of an emissions reduction strategy, but a critical one. The different LZEV technologies have various strengths and weaknesses that may improve over time, but none currently provide a direct, simple, transition from diesel. Some offer more emissions reduction potential than others. Typically, the higher the emissions reduction potential, the more challenging the transition.

Key LZEV technology barriers can be summarised as follows:

- Technical – availability of a suitable technical transport solution (line haul, remote location trucks)
- Operational – where the operation of the vehicle is impeded (e.g. payload impact, operational range)
- Financial – where the total cost of ownership (including infrastructure) is prohibitive
- Market maturity – where despite the two above barriers being overcome fleets still do not adopt LZEV technology vehicles.

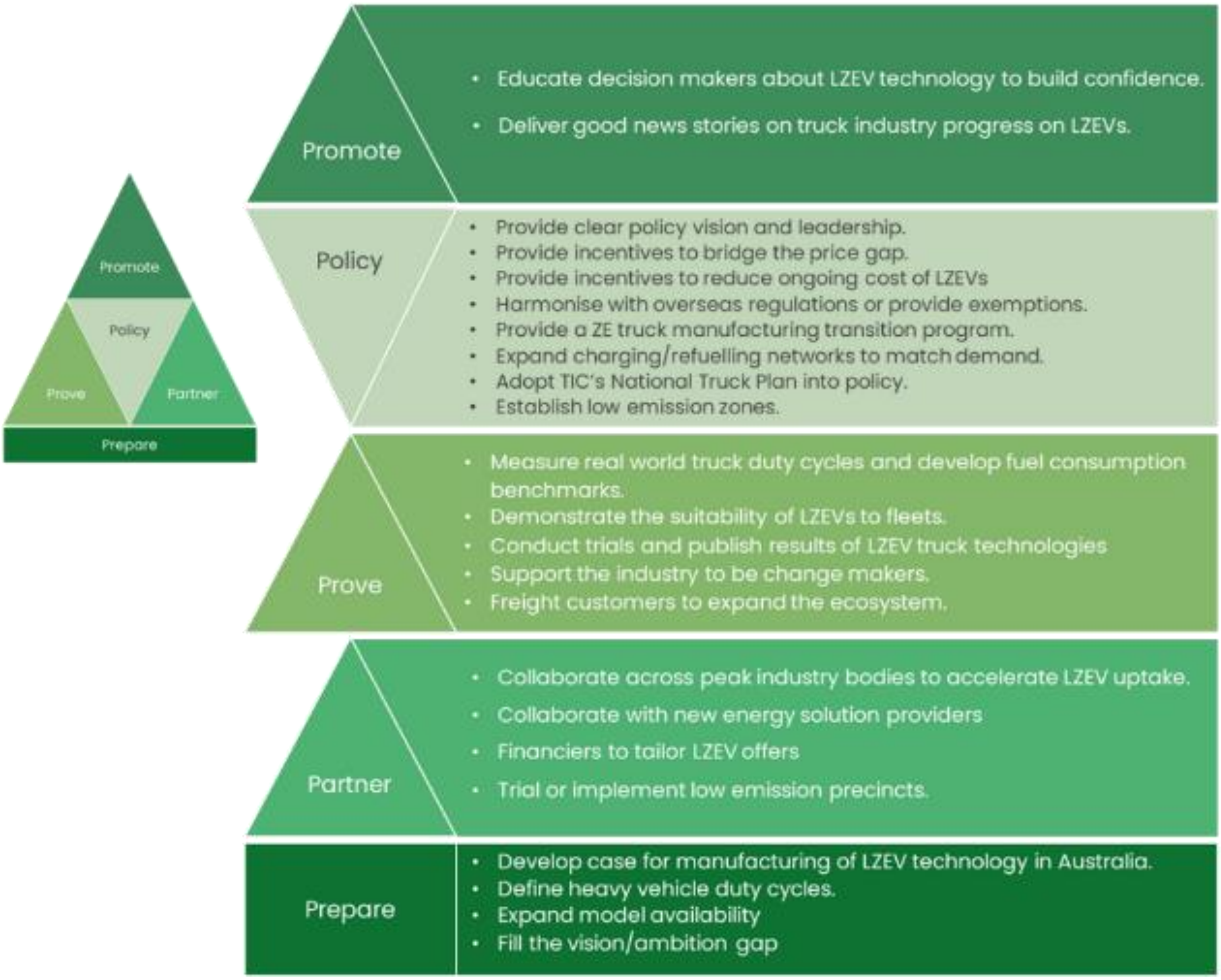
These barriers, the availability of suitable vehicles, and access to fuels all hinder the transition to LZEVs.

The paper includes results from a survey of Truck Industry Council (TIC) members about their LZEV product plans internationally and for Australia and their views on the barriers the LZEV market faces. TIC is forecasting that with favourable government policy/regulation, one in four (25%) new truck sales in 2030 will be a LZEV, with the majority of uptake in the Light and Medium Duty truck segments.

One implication of low LZEV uptake, in any specific sector, is the effect it has on the business case for introducing LZEVs into the market. Small volumes make it hard to justify the costs of engineering/adaptation for the Australian market, due to high costs and poor economies of scale.

A second implication is that the potential emissions reductions will be low. For trucks to achieve anywhere near the emissions reduction targets set for the economy as a whole, would require very ambitious, very targeted, and very supportive policies (as well as some disincentives); and a clear vision about how to get there. TICs projections are that only 2% of the Australian truck fleet will be LZEV by 2030 and that other technologies and CO_2 abatement strategies must be considered in combination with LZEV take-up to achieve government abatement targets.

The transition to LZEV technology trucks will require concerted effort from all stakeholders, new and established. Planning an orderly, sustained shift across the market will require coordinated effort and support across short and long timescales. The barriers explored in this paper can be overcome through actions and enablers grouped into a '5P' framework requiring preparation, partnerships, proving (demonstration), policies, and promotion. The framework and associated actions are summarised below.



1 Introduction

Climate change is the kind of challenge that rarely emerges, but which requires coordinated global action. Collectively, all countries agree something must be done. But without global regulation, the pathways and mechanisms vary greatly. Individually, governments must engage people and businesses to transform paradigms and practices entrenched over generations. Equally, companies and citizens must accept that change is required, and that it will come at some cost. This complexity and uncertainty must be navigated via imperfect political systems and an unstable global economy. Success is not guaranteed, but if COVID-19 has demonstrated anything, it is that such challenges can be measured, met, and managed.

The former federal Coalition government's response to the climate challenge was a commitment to 'net zero emissions' by 2050, with support for new technologies rather than punitive costs – "technology not taxes". The new Labor government hasn't significantly changed that approach, avoiding, punitive policies while also setting a more ambitious interim 2030 target of a 43% CO_2 reduction from a 2005 baseline. Australian government's generally have, at this point in time, avoided punitive measures, unlike many governments globally.

But neither side of politics has focussed sufficiently on transport, particularly freight transport. Movement of freight by trucks is critical to the efficient functioning of the economy and to maintaining Australia's high standard of living. It will continue to play a critical role in the economy regardless of action on climate change. In all countries, states, cities, and industries, trucks keep the economy functioning by placing people, materials, equipment, energy, and waste where they need to be. The key variable is how those trucks will be powered, and how soon those changes occur.

Members of the Truck Industry Council (TIC) supply nearly all new trucks entering the Australian market. They are the innovators and developers of low emission technologies that will transform the truck market and deliver future freight to increasingly demanding businesses and consumers. If technology is the saviour of future climate, then their voices must be heard to ensure policy is based on sound evidence and market realities, not hopes and dreams.

> ***The aim of this paper is to provide the clearest possible picture of current and emerging truck technologies and their potential to reduce greenhouse gas emissions in the freight sector. It provides policy and decision makers with a technology baseline and a roadmap for determining low and zero emission policy for trucks and freight.***

Transport also affects society in other ways – noise, noxious air pollution, road congestion, and safety. But these operate at local or regional scales, not globally. They are also common to all modes of transport including private car use, rail, and aviation. To some extent, they are accepted as the price of unconstrained mobility of both people and goods. Yet TIC is also working to minimise these impacts in several ways, including:

- Engaging and educating policy makers about the modern truck fleet and truck operations
- Engaging in regulatory reforms such as Heavy Vehicle National Law and Motor Vehicle Standards
- Articulating a coordinated fleet modernisation strategy, *The National Truck Plan*, which can
  - Accelerate adoption of advanced safety systems to avoid accidents and reduce road trauma
  - Accelerate retirement of the oldest, most-polluting trucks
  - Increase vehicle productivity to reduce the number of trucks on the road.

With those issues covered elsewhere, this paper looks at the role of trucks in the climate challenge.

2 What this paper covers

2.1 Trucks

There is some ambiguity about different classes and types of trucks. For simplicity, this paper uses the word ‘truck’ to describe large commercial vehicles primarily intended to carry goods or power equipment, which aligns with the common usage and perception of such vehicles.

In the technical language of the truck industry, this includes all “heavy vehicles” above 3.5 tonnes Gross Vehicle Mass (GVM) which are primarily intended to carry goods and also includes specialist non-freight trucks such as emergency service vehicles. It does not cover vehicles below 3.5 tonnes which are typically passenger cars and light commercial vehicles (vans and utilities). Nor does it cover buses above 3.5 tonnes which are represented by a different industry association.

TIC defines three sub-segments within the truck market:

Heavy Duty Trucks: a cab-chassis type vehicle with (a) three or more axles; or (b) two axles, a GVM greater than 8,000 kg, AND a Gross Combined Mass (GCM) of more than 39,000 kg.

Medium Duty Trucks: a cab-chassis type vehicle with GVM greater than 8,000 kg, but with a GCM less than or equal to 39,000 kg.

Light Duty Trucks are cab-chassis type vehicles with GVM of 3,501 kg to 8,000 kg inclusive.

These segments are relevant to the work that trucks perform (how much they can carry and tow), driver licence categories, as well as the suitability of technologies. However, all segments are grouped as ‘trucks’ in the paper for ease of reading.

2.2 Low & Zero Emission Vehicles (LZEV)

There isn’t a universally agreed definition of a zero emission or low emission vehicle. Interpretations draw their boundaries at different points in the life cycle (tailpipe, fuel-production, or vehicle manufacture and disposal); different impacts (pollution versus carbon); and how ‘low’ or zero are subjectively defined. Others have used technology as the criterion, defining LZEVs as electric or fuel cell vehicles. But this does not account for the emissions associated with the production or distribution of the fuel or energy, which in some cases can be higher than a conventional diesel engine.

TIC’s view is that neither it nor the government should ‘pick a winner’ in the technology race. This constrains research, stifles innovation, distorts the market, and favours some suppliers. The most effective policy approach is to set a performance objective (some quantum of reduced emissions) and then incentivise or enforce manufacturers and their customers (fleets) toward that outcome in the most cost-effective way.

> ***TIC defines an LZEV as one that can operate without producing tailpipe emissions, or that significantly reduces greenhouse gas emissions (more than 50% over a conventional diesel engine) via the fuel/energy source. Electric and fuel cell vehicles clearly fit in the first category, while renewable combustion fuels and hybrid technologies could fit in the second and regardless, these later technologies will contribute to lowering Australia’s road transport carbon emissions, though not specifically meeting this definition for a low emission vehicle.***

Truck greenhouse gas emissions today result from using fossil fuel energy to power the engine. TIC's definition establishes a level playing field for all alternative fuels that meet the intended objective. This currently includes battery electric, plug-in hybrid, hybrid, hydrogen fuel cell, biofuels, hydrogen ICE and renewable 'e-fuels' – but it doesn't preclude the emergence of other cleaner fuels and technologies

2.3 What does 'net zero' emissions mean?

There can be confusion on climate metrics terms and measures, such as Net Zero CO_2, Net Zero emissions, Net Zero CO_2-e, and carbon neutral, with many agencies and consultants providing their own interpretations. The IPPC definitions do not differentiate these terms, representing a state where human generated CO_2 emissions to the atmosphere are balanced by the removal of human generated emissions over a specified period. The definition provided for "net zero emissions" is when all human created GHG emissions to the atmosphere are balanced by human created removals (IPCC, 2018):

Emissions Produced - Emissions Removed = Net Zero

This aligns with the Australian government's explanation of its commitment to Net Zero by 2050, suggesting that emissions need not be eliminated entirely – "Zero is not zero", in the former Minister's words.[1]

Though not a strict difference, carbon neutral or climate neutral are often used to describe a product, service, or organisation; whereas Net Zero tends to describe an emissions reduction target.

IPCC Terms	Emissions included
Net Zero CO2 emissions & Carbon Neutral	CO2
Net Zero emissions (CO2e)	CO2, N2O CH4 SF6, HFC, PFC

Australia's accounting for Net Zero do not include emissions from international aviation and shipping, with the International Civil Aviation Organization responsible for setting and managing international aviation emissions targets; and both the International Shipping Industry Organisation and the International Maritime Organization responsible for international shipping emissions monitoring.

[1] https://www.canberratimes.com.au/story/7463893/net-zero-is-not-zero-emissions-taylor/
https://indaily.com.au/news/2021/10/11/zero-is-not-zero-energy-minister-qualifies-emissions-target/

PART A: WHY?

DEFINING THE PROBLEM

3 Trucks in Australia's carbon emissions

Transport is a significant contributor to greenhouse gas emissions globally, third highest behind Industry and buildings (IEA, 2021d). In Australia, transport is also the third largest source of emissions, at 19%. Road transport is by far the largest contributor of all transport modes (around three quarters), followed by aviation. Cars and light commercial vehicles contribute the largest share. Collectively, trucks represent a little over 4% of total national emissions (Australia's Emissions Projections 2022 - Department of Climate Change, Energy, the Environment and Water). So, even if all truck emissions could be eliminated tomorrow, it would barely make a dent in our national carbon footprint.

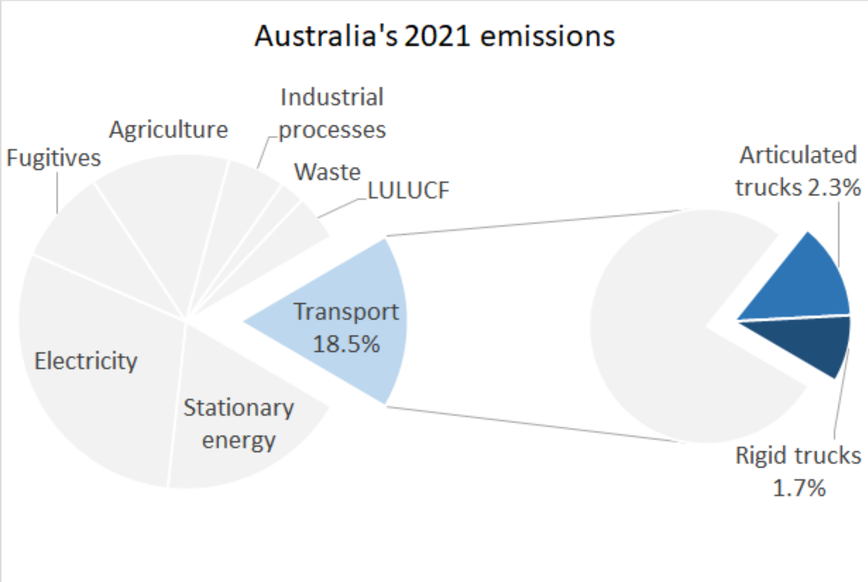


Figure 3.1: Transport share of national emissions; truck share of transport emissions

Projected emissions for road transport show strong growth for all commercial vehicle classes – particularly rigid and articulated trucks (Figure 3.2). This increase is due to the combination of four contributing factors: continued growth in the freight task, limited improvements in energy productivity in the freight sector, virtually no uptake of lower-carbon alternative fuels, and slow fleet turnover. These are explained in more detail in Section 5.

Regardless of cause, the projected emissions increase is in stark contrast to the deep reduction required if the transport sector is to achieve Australia's 2030 emissions reduction target (BLACK dashed line in Figure 3.2).

Zero emission vehicles are touted as the most important technology to reduce transport emissions. However, these technologies depend on the sale of new trucks, and a long asset life means the truck fleet takes decades to be replaced with new trucks. Further, this will require a reversal of the market trend where sales of alternative fuel trucks have been declining in Australia for over a decade.

So, how achievable and realistic is a U-turn in emissions in the short-to-medium term?

What contribution could trucks make, what would it require, and what have other more-advanced markets done to reduce truck emissions?

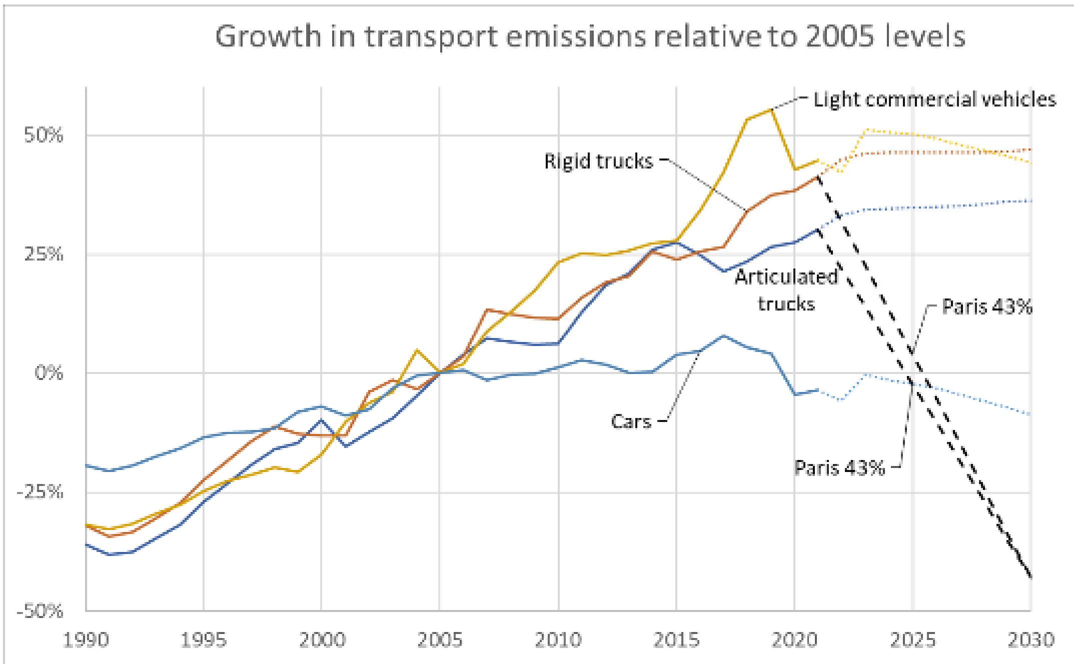


Figure 3.2: Emissions trajectory for various classis of road freight vehicles, Australia 1990 – 2030 (A2EP, 2021).

4 Why is action required?

The Intergovernmental Panel on Climate Change (IPCC) is a UN body with 195 member countries including Australia (IPCC, 2021) (DISER, 2020). The IPPC's 6th Physical Science Basis report provided an update on climate research, confirming that warming of the atmosphere, ocean, and land has been unequivocally influenced by human-induced emissions of greenhouse gases including carbon dioxide (Figure **4.1**). Ninety-seven percent of published climate research identifies human activity causing global warming since pre-industrial times (1850-1900) (NASA, 2021).

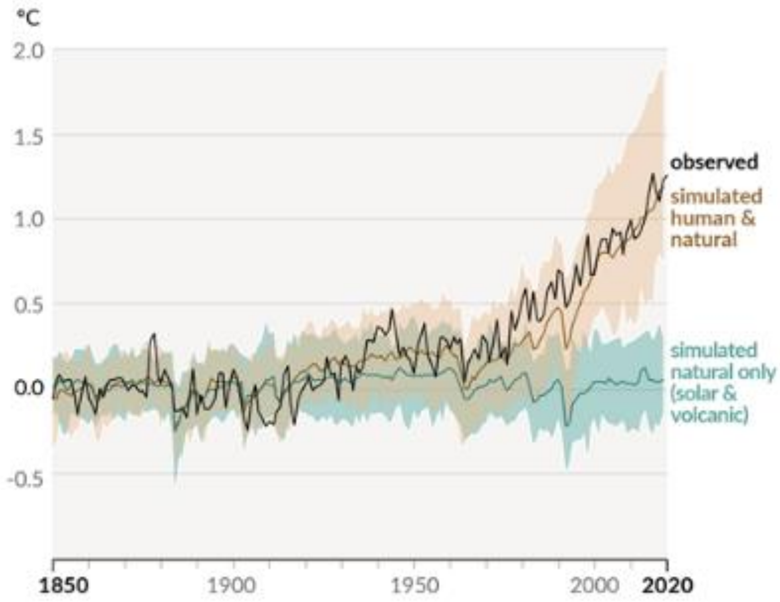


Figure 4.1 Change in global surface temp (annual average) – observed and simulated **(IPCC, 2021)**

Impacts on natural and human systems from global warming will be more severe if warming exceeds 1.5°C and then recedes by 2100, compared with gradually stabilising and not exceeding 1.5°C at all. If peak temperature rises to 2°C or higher, some impacts will be long-lasting or irreversible. Net negative anthropogenic CO_2 emissions may still be required to prevent further warming and to reverse ocean acidification and minimize the rise in sea level (IPCC, 2018).

The IPPC's recommendations include that:

- Net Zero emissions of carbon dioxide (CO_2) be reached by 2050; and
- Net Zero of all greenhouse gases (CO_2-e) be reached in the second half of the century.

For Australia, there is much economic imperative due to rising costs and the tightening of market access for countries that are seen as lagging on climate action. Countries without strong domestic policies or internal carbon pricing can face unilateral action by others, manifesting as:

- Tariffs and taxes on exported goods when they arrive at the importing country, to address carbon leakage and free-riding (countries and companies gaining a commercial advantage by not imposing carbon pricing within their own borders). Carbon border adjustment taxes are already proposed by major markets such as the US, EU and Japan.

- Restricted availability of imported goods and equipment, with cleaner technologies first going to markets that have strong regulatory or incentive regimes.
- Exclusion from new trade deals and bilateral agreements, particularly those with a cleantech focus or a shared aim of reducing emissions.
- Reputational risk and loss of 'trusted partner' status.

With Australia's recent commitments to global emission targets, the above actions would be unlikely, subject to Australia meeting our pledged obligations.

The reality is that climate action also brings opportunity. The OECD highlights Australia's abundance of green energy sources places it in a preeminent position to leverage economic benefits (OECD, 2021). These economic opportunities often come with environmental co-benefits, particularly with respect to urban freight transport. These can include reductions in traffic congestion and emissions, noise, and visual impact – leading to improved health and quality of life outcomes. (Nenni.M, Sforza.A, & Sterle.C, 2019)

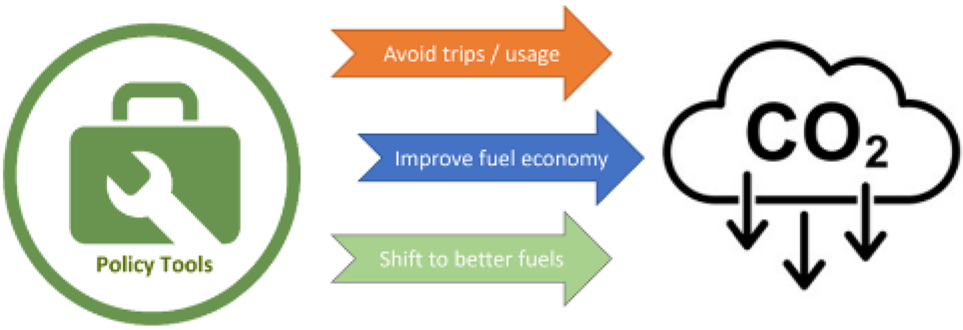
Clearly, there are compelling reasons to act, and there is general agreement that the distant future will be very different. However, the collective challenge for the truck industry lies in navigating a difficult transition to ensure that all customers can be supported (new technology and old technology), without destroying customer loyalty, industry capability, market confidence, and company value/profitability. It is no small task. While the challenge for government is to enable a transition that will not impact the economy by driving up freight costs (and hence fuel inflation), or disrupt, the essential role that road freight plays in the everyday life and prosperity of all Australians.

5 Why is LZEV technology necessary?

Several factors underpin the emissions challenge for road freight:

- the freight task (how many tonnes need to be moved and how far)
- the efficiency or productivity of the trucks moving the freight, and that of the overall network
- the type of energy or fuel used to power trucks

Conveniently, these factors point to the pathways that can reduce freight transport emissions. The International Transport Forum suggests that the best practice policy toolbox for efficiency and decarbonisation of road freight transport should include a strategic mix of "Avoid – Shift – Improve" measures (ITF, 2021b).



5.1 Avoid trips

Due to the critical role that road freight plays in the economy, the opportunities for "Avoid" actions to support emissions reductions are fairly limited, particularly in a country as vast as Australia. Even where these opportunities exist, they are insufficient to offset the expected growth in the road freight task over coming decades. As Figure 5.1 shows, the road freight task was expected to increase by at least 23% and up to 38% between 2018 and 2030, based on pre-COVID estimates.

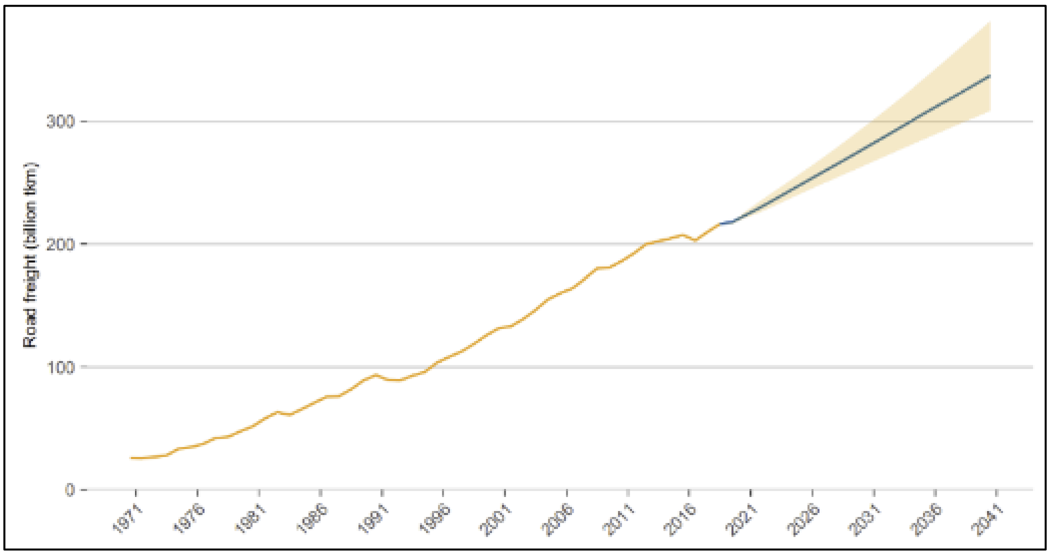


Figure 5.1 Road freight task projection from 2018 (BITRE, 2019)

Despite a temporary blip early in the pandemic, demand for goods is still strong and few would argue that the 50-year historical trend seen in the graph will plateau any time soon. Indeed, increases in e-commerce and home delivery spurred by the pandemic, will likely drive-up urban freight by more than the 60% already expected by 2040 (Freight Australia, 2019).

In other words, reductions in freight-related emissions are unlikely to come from a decreasing freight task over the medium-long term (limited ability to 'avoid' activity).

5.2 Improve efficiency / productivity

The International Energy Agency (IEA) and others have promoted the idea that energy efficiency is usually the cheapest emissions reduction and should be considered the 'first fuel' alternative. Many in industry are familiar with the mantra of 'doing more with less', and there are numerous fleet-scale operational and technology solutions to achieve this, which also result in emissions reductions.

However, despite increasing use of high productivity freight vehicles (HPFVs), the data show limited improvement in sector-scale energy intensity over time, resulting in the stagnant trend seen in Figure 5.2 Contributing factors may be an ageing fleet, a shifting freight task (to less efficient urban deliveries), and poor uptake of more efficient hybrid and electric vehicles. A dynamic step change is needed to shift this trend downward.

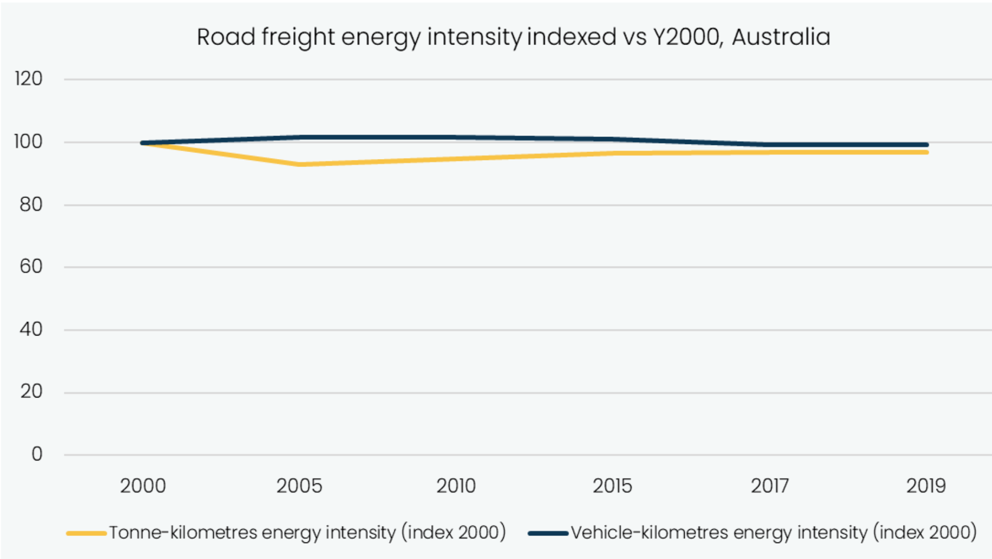


Figure 5.2 Australian road freight energy intensity, [data from (IEA, 2021b)**]**

Demand is not going to reduce (the Australian freight task will continue to grow). Equally, there will be no quantum improvements in road freight productivity, however modest gains in productivity will continue and more could be eked out with favourable government policy and reform of existing regulations (for example more equitable vehicle registration charges). These potential gains in freight efficiencies coupled with switching to cleaner fuels and powertrain technologies, will all be required measures to be used collectively, in an effort to achieve climate goals.

5.3 Shift to better fuels/technologies/modes

Fuel shift: Australia's transport sector is almost entirely reliant on oil, and the combustion of that oil (as petrol or diesel) produces emissions. Therefore, the more activity required by the freight task, the more oil gets consumed, and the more emissions increase. Figure 5.3 shows that only agriculture is as reliant on a single energy source, though that sector's demand is much smaller.

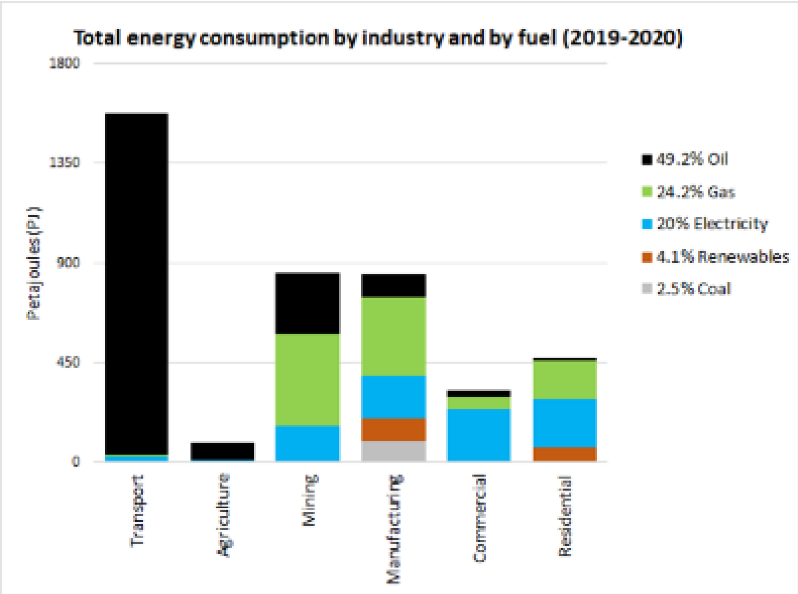


Figure 5.3 Fuel diversification by sector

Technology shift: While technically viable alternatives to diesel trucks are available, their uptake in Australia has been low due to various market barriers and limited policy support. Addressing the barriers would not only reduce emissions but also improve supply chain resilience through redundancy, diversification, and improved energy security (NREL, 2021) (DEE, 2019).

This reality is confirmed by the sale of new low and zero emission drivetrain trucks in Australia, that has been on a downward trajectory for over a decade (84 trucks in 2010 down to just 22 trucks in 2020), whilst over the same period, new diesel truck sales have shown strong growth (29,393 sales in 2010 through to 34,476 in 2020). In 2021 LZEV sales remained insignificant at less than 2 sales per month (0.1% of annual truck sales) despite near record sales of 41,404. Figure 5.4 shows this divergence, with the left axis and **BLACK LINE** tracking total truck sales, and the right axis and **GREEN LINE** tracking total LZEV sales.

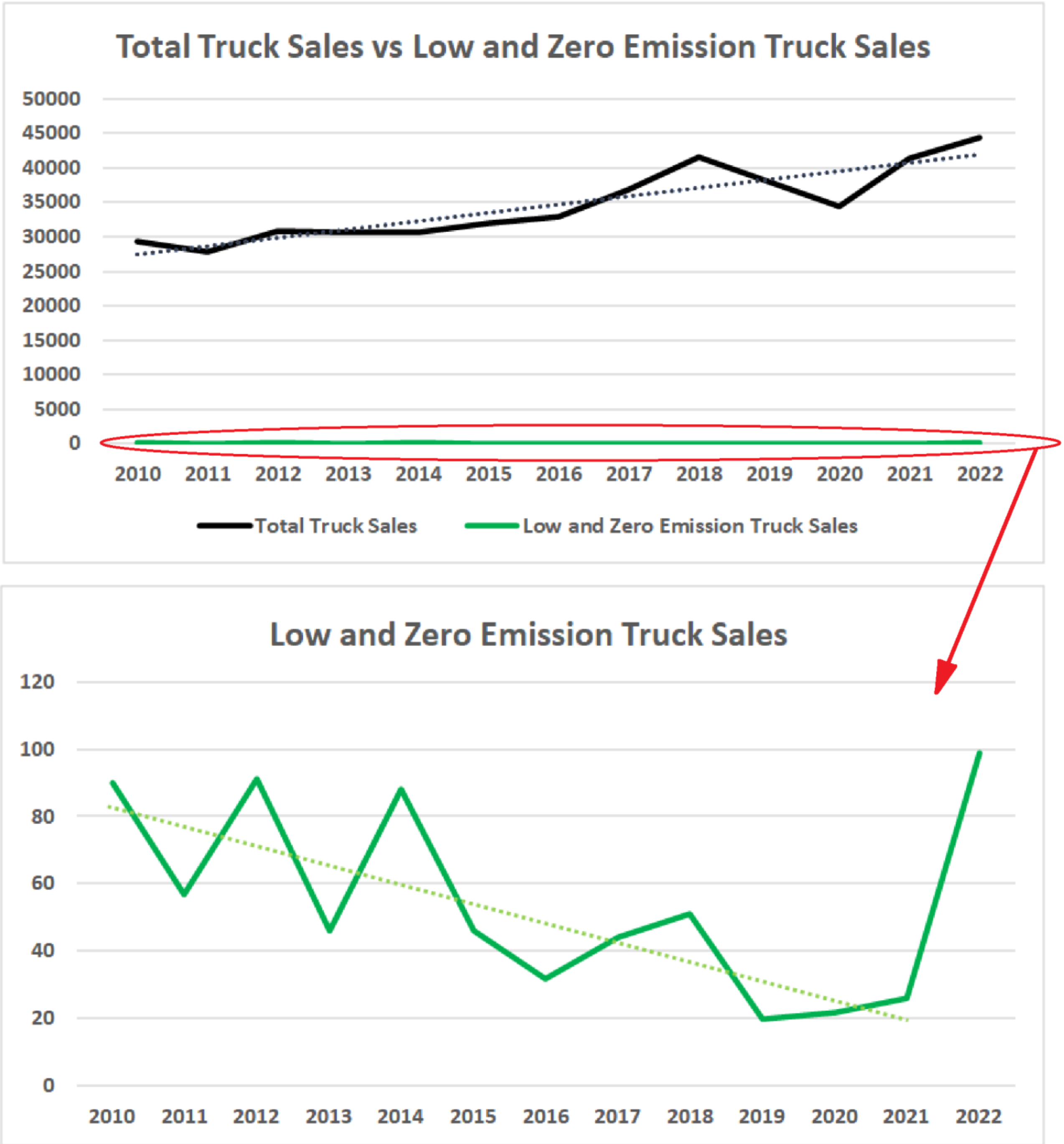


Figure 5.4 Total Australian Truck Sales (BLACK line) verses Low and Zero Emission Truck Sales (GREEN line)

Figure 5.4 details total Australian truck sales for the twelve year period 2010 to 2022 (the **BLACK** line) verses total low and zero emission truck sales (the **GREEN** line) over the same period. The breakout graph (RED circled) shows total low and zero emission truck sales on a more readable scale. On both graphs, the dotted lines represent the average sales trend line. While overall truck sales have steadily increased on average year-on-year, the opposite has been the case for total low and zero emission truck sales over the same period, steadily decreasing from a peak of 90 trucks when first introduced in 2010 to approximately

20 sales in 2020 and 2021. This represents a sales average for low and zero emission truck sales of just 0.31% in 2010 falling to 0.1% in 2020 and 2021 of total Australian truck sales.

However, 2022 saw a noticeable turnaround in this sales trend, with the sale of new LZEV increasing to levels previously seen a decade ago. Sales of LZEV doubled between 2021 and 2022. Of the record 44,379 new trucks sold in 2022, 99 were LZEV (0.22% of annual truck sales). Of these, 27 were zero emission vehicles (0.06%) and 72 were low emission hybrid trucks (0.16%).

The take-up rate of LZEV has increased over three fold year-to-date, October 2023. Of the 39,422 new trucks sold year-to-date in 2023, 287 were LZEV (0.73% of annual truck sales). Of these, 107 were zero emission vehicles (0.27%) a five-fold increase over 2022 ZEV sales and 180 were low emission hybrid trucks (0.46%) a three-fold increase in low emission truck sales over 2022.

TICs modelling indicates that the upward trend witnessed in 2022/2023 will continue, with sales growth expected to double year-on-year to 2030 and beyond. Resulting in a TIC forecast of one in four (25%) new truck sales in 2030 being a LZEV, leading to an expected total of approximately 18,000 ZEV trucks on Australian roads by the start of the next decade. Despite this optimistic sales projection, the result is that just 2% of the Australian truck fleet will comprise ZEV by 2030, when the Australian truck fleet size is expected to be approximately 850,000 vehicles, based on current growth trends. In addition, it is expected that 1% of the Australian truck fleet will be LEV trucks (hybrids) which will require some diesel fuel use. In total, TIC estimates that 98% of the Australian truck fleet will require diesel.

Despite this positive upward trend, it can be seen from the above that the LZEV sales forecast in Australia remains low and lags the uptake required for achieving Australia’s climate goals. The UN Zero Emission Vehicle Transition Council (ZEVTC) target is for ZEVs to reach 90% of global heavy truck sales by 2040 and 100% by 2045. To achieve this, the IEA highlights the need for early deployment of alternative fuel technologies for medium to heavy trucks this decade, for large scale adoption in the 2030’s (IEA, 2021c). Though recent changes by the UN to allow ICE trucks to be sold beyond 2035, provided that they can only operate on carbon neutral liquid fuels (such as renewable diesel and green hydrogen), is an acknowledgement that technologies other than battery electric and hydrogen can provide carbon abatement in the heavy vehicle road sector. TIC firmly believes that a mix of vehicle technologies (bio/renewable diesel, electric, hydrogen fuel cell and hydrogen ICE), in combination with other strategies (freight consolidation, High Productivity Vehicles and ADR80/04 truck uptake) will be essential to achieve Australia’s climate objectives.

Modal Shift – Road freight currently accounts for approximately 85% of all energy used to move freight (A2EP, 2021). Modal shift policies provide opportunities to avoid multiple smaller volume trips via truck over long distances by shifting the freight to rail or water. There is building momentum and investment across Europe and China in modal shift as part of the solution.

Australia is also looking at opportunities within the freight network, with modal shift seen as an option, particularly within long haul rail. However, Australia’s disparate rail and intermodal network would require significant investment to shift the rail focus from bulk freight, which represents 93% of its current freight task (BITRE, 2021). Only around 10% of the road freight task is contestable with rail, and modal shift is not a feasible option to address emissions associated with the significant growth predicted in the urban freight task.

Perhaps more importantly, unlike road trucks which are into their fifth generation of limiting air pollution emissions, locomotives in Australia do not have to meet any emissions standards at all. This means the noxious pollution emissions from rail might increase significantly if rail took a higher share of the freight task.

PART B: WHAT?

LZEV TECHNOLOGY CONSIDERATIONS

6 Overview of LZEV technology

The potential of LZEV technologies to decarbonise the truck fleet hinges on the relative strengths and weaknesses of the technologies. Not all alternatives are suitable for every vehicle type or task, as they do not result in consistent outcomes in every application (e.g. diesel hybrid powertrains in an urban delivery task achieve high fuel savings, but not in a line-haul application).

6.1 Low or zero technologies

"Zero emission" technologies can be somewhat ambiguous. Depending on the context, the term may refer to zero carbon emissions (greenhouse gases), zero pollutant (noxious) emissions (from fuel combustion), or zero tailpipe emissions (carbon and pollution). Only a battery-electric vehicle (BEV) truly has no tailpipe emissions of any kind. But the elimination of harmful combustion emissions by using a fuel cell (the only emission being harmless water) and of course elimination of greenhouse gases, also confers the zero emissions title on fuel cell vehicles.

Importantly, any vehicle powered by a 100 percent renewable fuel, regardless of technology, can be considered zero *carbon* emissions if it results in no increase in greenhouse emissions (net zero). Such vehicles will still emit harmful combustion emissions (PM and NOx) at levels equivalent to the noxious emission compliance of the engine (Euro O through to Euro VI, or the equivalent standard). In all cases above, the emissions *intensity* of fuel/energy production becomes important to ensure emissions are not simply transferred upstream (e.g. to the electricity grid, hydrogen plant, or farm for renewable/biofuels).

In contrast, a hybrid electric vehicle (HEV) is usually partially electrified, but still relies on fuel combustion during longer trips to either charge the battery or drive the vehicle wheels directly. HEVs could be considered low emission vehicles (under TIC's definition) if they reduce greenhouse emissions by more than 50% (over a conventional diesel engine). Typically, current diesel/electric hybrid trucks would not be considered low emission vehicles under TIC's definition, however these hybrid technologies will help lower Australia's road transport carbon emissions and must be considered as an effective carbon abatement measure in a difficult to abate sector such as heavy vehicle road transport. HEVs using renewable diesel blends could also achieve an abatement rate above 50% whilst providing operational advantages over current ZEV trucks (e.g. extended operational range, existing refuelling infrastructure).

Examples of LZEV fuels and technologies are shown in Figure 6.1 below, placed along a spectrum of carbon and pollutant emissions. It shows that developing a holistic solution to decarbonise transport does not rest in the operation of the vehicle technology alone, but in the supporting policies and programs to incentivise actions and engagement across the entire value chain, including use of renewable energy to create the fuel or electricity at each step.

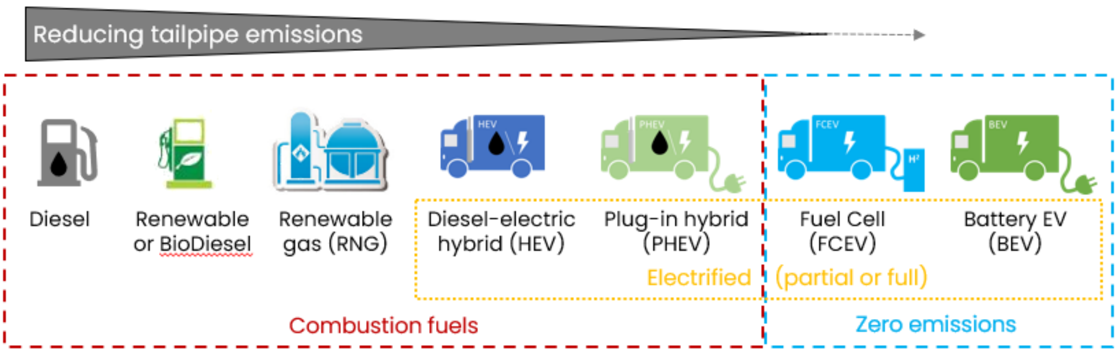


Figure 6.1 Different Types of vehicle technologies

6.1 Key characteristics of LZEV technologies and fuels

Table 6.1 provides a summary of the main characteristics of each fuel type and technology, with discussions included after the table.

Table 6.1 - Summary comparisons of technologies

	CO_2 Emissions	Indicative efficiency	Timing to scale	Total Cost of Ownership (TCO)	Refuelling time	Fuel infrastructure	Payload impact	Maintenance	Longevity
Diesel	**Baseline** -	**39%**	Phase out targets being introduced overseas	Lower purchase cost, but high running costs	~10 minutes	In place	–	–	–
BEV	✓✓✓	**>77%**	Currently available for LR/MR/HR	Higher purchase price, lower running cost; TCO can be less than diesel in the right application	Several hours (in dwell time, commonly overnight)	Often depot based; limited need for public charging early on; DC fast chargers being deployed for light vehicles; some grid issues at scale	High for both mass & volume	Much less than diesel Major savings on brakes, transmission, consumables	Batteries degrade over time, will likely need replacing later in life
FCEV	✓✓	**54%**	>2-5 years	Much higher purchase price; Hydrogen higher price than diesel. Running cost and TCO not likely to be less by 2025 or 2030	Slightly longer than diesel	No current infra-structure; high cost of development and production	High for volume; some mass	Much less than diesel; likely higher than BEV	Batteries and fuel cells degrade; Fuel cell life is not clear. Tank life typically 15-20 years before replacement
PHEV/HEV	✓	**44%**	HEV currently available as LR & MR; PHEV not expected	Higher purchase price than diesel, lower TCO. Higher operating costs than BEV	HEV - like diesel. PHEV: diesel fill time + hours charging	Diesel infrastructure already established; charging infrastructure as per BEV (depot charging likely)	Moderate for mass and volume	Similar or lower than diesel; higher than BEV; major savings on brakes	Batteries degrade and will require replacement or loss of efficiency
RNG	✓	**29%**	Gas trucks previously available in Aus	Higher purchase price than diesel; RNG higher price than fossil NG so TCO may struggle to compete with diesel	Depends on CNG or LNG (can be similar to diesel)	Limited for fossil gas (CNG & LNG); expensive	High for volume; some mass	Some increased maintenance due to more complex fuelling system	Tank life typically 15-20 years before replacement

Renewable /Biofuels	✓	**39%**	Currently available in limited volume; underutilised	Higher purchase price than diesel. Renewable Biofuels tend to be more expensive without incentives. Could be more cost effective if production volumes were to increase.	Same as diesel	Depends on product Renewable diesel can be used as a drop-in diesel substitute; biodiesel usually blended at 5% to 20%; supply constrained	None	Slightly more than diesel. Some increased requirements for fuel tank cleaning and for more frequent engine service intervals	Similar to diesel
Hydrogen ICE	✓	**39%**	1-3 years	Higher purchase price than diesel; Hydrogen higher price than diesel so TCO cannot currently compete with diesel	Slightly longer than diesel	No current infra-structure; high cost of development and production	High for volume; some mass	Some increased maintenance due to more complex fuelling system	Tank life typically 15-20 years before replacement

Energy efficiency: Measures the loss of energy by the powertrain during operation of the vehicle. Energy is lost to either noise or heat generated by operation of the powertrain. Zero emissions technology such as BEV and FCEV is far more energy efficient than ICE powertrains. This partially explains why they are so quiet and generate little heat compared to a diesel engine.

Timing: Most technologies are either currently available or were available but are no longer widely offered due to lack of uptake (i.e. LNG/CNG powertrains). The most notable exception is FCEV powered vehicles which are not expected to operate in Australia in high numbers until beyond 2030, this is due to the commercial availability of competitively priced "green" hydrogen and the deployment of mainstream distribution, storage and refuelling infrastructure. Further detail on global market availability of ZEV powertrains is provided in section 10.

Total Cost of Ownership (TCO): TCO typically combines the capital costs (purchase price minus resale value; stamp duty; finance; etc) plus the operating costs (fuel, maintenance, registration, insurance). Results vary depending on operating conditions that favour one technology over another. Example: despite a much higher capital cost, lower energy and maintenance costs for BEVs can equalise TCO in some cases.

Refuelling time: The downtime required to replenish a vehicle's on-board energy storage (fuel or electricity). BEVs are most affected by this factor; however, in many cases it can be effectively managed within the vehicle's normal dwell times, either overnight or rest/loading stops. Variation in fill time for BEV is greater than other powertrains due to the possibility of DC fast charging vs AC charging (i.e. 250kW vs 22kW). This needs to be considered when assessing operational suitability.

Infrastructure requirements: All fuels other than diesel (mineral and renewable) require a new supply and delivery network to make them accessible by the truck. In all cases, this network doesn't currently exist, or only exists in part.

- Dilute or low-blend renewable biofuels up to B5 don't require specialised infrastructure as they are drop-in fuel
- Higher blend ratios require separate tanks to preserve consistency of fuel quality (i.e. B20 cannot be stored in the same tank as B50). Further, the number of existing diesel trucks that can operate on biodiesel blends above B5 is extremely limited.
- Except in a few cases (ACT), CNG infrastructure is not available via an open-access service station model; it is also unlikely to become so considering the low demand for vehicles and past failures.
- BEV powertrains require a charging unit that matches the vehicle's energy and power needs – from slow overnight AC charging at the depot (little investment) to ultra-fast DC public charging on motorways (expensive and may trigger additional grid upgrades).
- FCEV uses an electrified powertrain, but the energy storage mechanism is either gaseous or liquid hydrogen, not electric charging. Hydrogen refuelling is virtually non-existent, so it will need to develop via a combination of depot-based and open access refuelling sites (e.g. service stations).
- Hydrogen ICE powertrains share the same infrastructure and refuelling issues that FCEVs have.

Payload impact: Most alternatives have much lower energy density than diesel, which even their higher efficiency may not make up for. This means additional space and mass dedicated to on-board energy storage, resulting in higher unladed weight (tare) and/or lost space to tanks/equipment on the chassis.

The result is less mass and/or volume available for payload before the truck's maximum weight/length is reached, for an operator, this results in less revenue per trip. These impacts vary by technology group. For example, BEV trucks typically have the greatest tare mass disadvantage of all technologies. FCEV trucks need up to 90L of space and 36kg of tank and structure to store 1kg of hydrogen (approximately 10L of diesel equivalence) (NACFE, 2020). The US has seen Class 8 prime movers need to extend the chassis by up to a meter to accommodate H2 tanks. Similarly, compressed natural gas tanks need up to 13 times the volume of diesel tanks to store the same energy (with liquefied gas needing 1.7 times the diesel volume).

Maintenance: Maintenance of BEV, FCEV and HEV trucks can be lower than diesel trucks, with BEVs having the lowest maintenance cost of the alternative technologies due to:

- Few moving parts and simplicity of powertrain.
- Very few consumables (e.g. filters, oil, coolant); and
- Regenerative braking saving brakes & capturing energy when slowing down.

Whilst hybrids and FCEVs also enjoy the above benefits to a lesser degree, HEV and PHEV also contain ICE motors, and FCEVs entail complex fuelling systems and tanks.

Natural gas-powered vehicles are expected to have similar maintenance costs to diesel however have additional complications regarding fuelling equipment and tanks onboard the vehicle. This is especially true in the case of CNG and LNG, using high pressure and cryogenic tanks respectively.

Hydrogen gas-powered internal combustion engine (ICE) vehicles will have similar engine maintenance costs to diesel however have additional complications regarding fuelling equipment and tanks onboard the vehicle. This is especially true for hydrogen storage at current vehicle storage pressures of 350 bar to 700 bar (5,000 psi to 10,000 psi).

Biofueled vehicles typically require more frequent engine service intervals than mineral diesel once biodiesel blends exceed B5, or B7. Onboard and storage tanks require additional cleaning/maintenance.

Longevity: Longevity is somewhat uncertain for nearly all the alternatives. A battery system is a significant component for BEV, FCEV and HEV/PHEV powertrains. Batteries degrade depending on their chemistry, usage, temperature management, as well as charge cycles and speed of charge, rather than any particular age effect. Generally, once a battery has degraded to 70% of original capacity, it is considered to have reached the end of its useful life in a vehicle. Early indications are this may represent around 10 years of operation in key use cases – similar to the frequency of diesel engine rebuilds. Fuel cell life is still an unknown due to lack of experience. Natural gas powertrains requiring replacement of high-pressure tanks at 15-20 years in line with local safety regulations.

Range: Because LZEV fuels are energy constrained, the payload penalty to carry additional fuel needs to be balanced against required driving range (distance between refills). Renewable diesel is the only option without a significant compromise in this area. At the other end of the spectrum, BEVs are highly constrained. The other options sit between these extremes. Hydrogen is touted as a likely solution for long haul operations due to a lower mass penalty than BEVs, as well as a faster refuelling time. However, FCEVs still suffer a similar volumetric payload penalty (tanks take up space); and as battery technology develops, the driving range and charge times may improve to approach the expected range of hydrogen FCEVs.

Examples of ZEV truck models launched around the world plotted against their stated driving range are shown in the graph below, with FCEV trucks to date clearly at the higher end of driving range than BEVs.

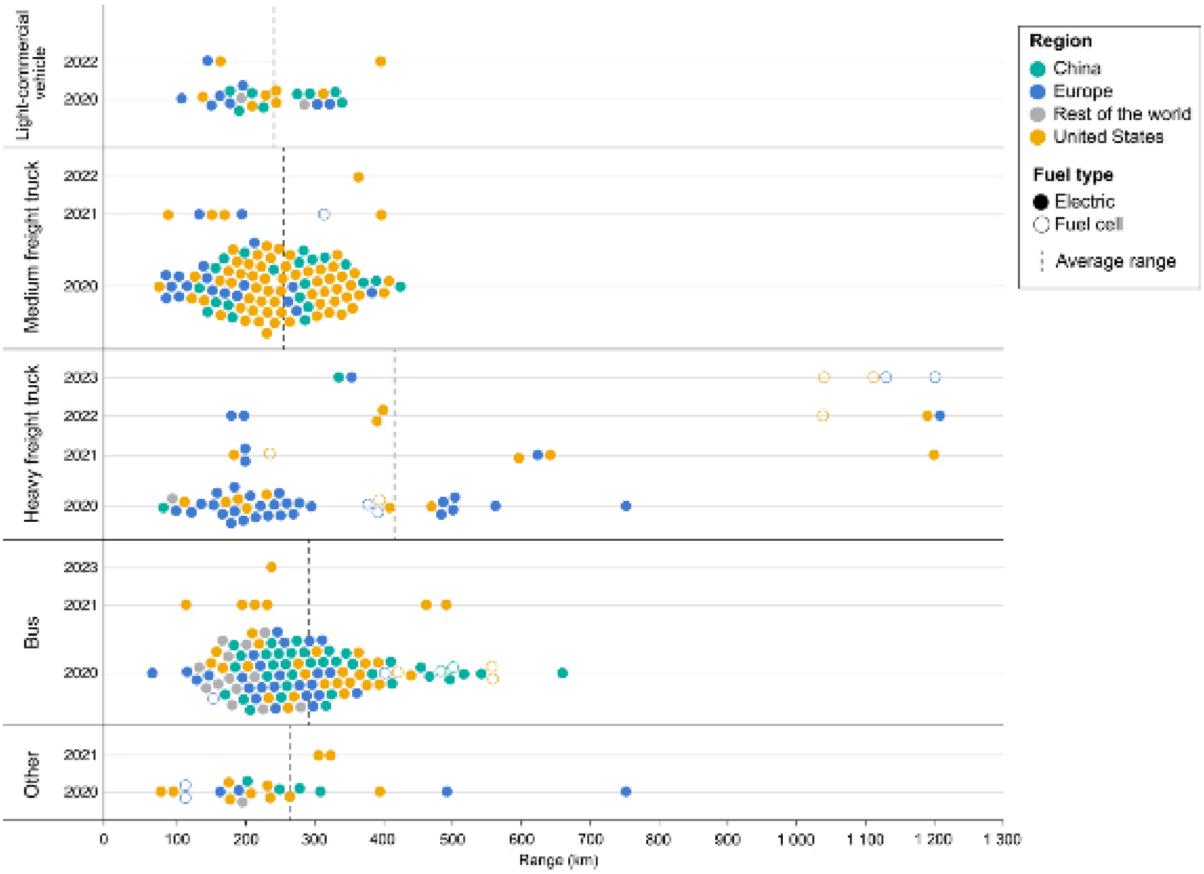


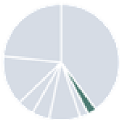
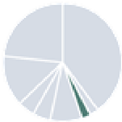
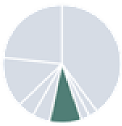
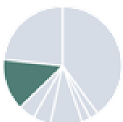
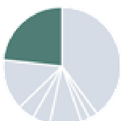
Figure 6.2 Emerging BEV and FCEV technology by range (IEA, 2021)

6.2 Segmentation explains LZEV suitability

As noted in a recent report for the Queensland Transport and Logistics Council (MOV3MENT, 2022) classification or segmentation is critical because trucks do many different tasks, these tasks consume energy at significantly different rates, and nearly all ZEV technologies are energy limited. This means different ZEV technologies are suited to some tasks but not others. Understanding which segments are likely to transition first will help both manufacturers and customers prioritise the most commercially viable operations sooner.

The QTLC report classified these tasks into the applications shown in Table 6.2, in no particular order.

Table 6.2 – Task-based or duty cycle classifications can be used for technology suitability

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

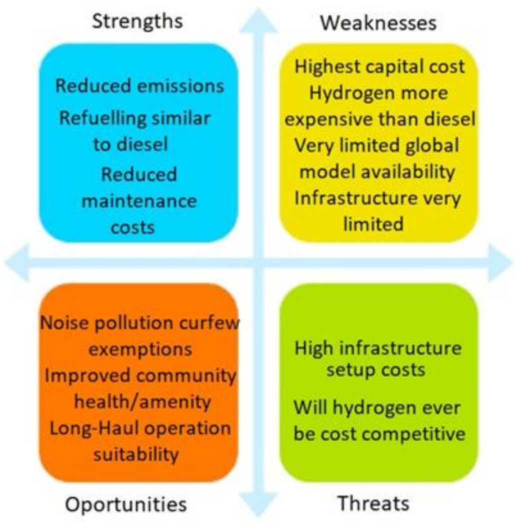
7 Technology state of play

Hybrid Electric Vehicles (HEV) - powered by a diesel engine with an auxiliary battery system that captures reclaimed energy through regenerative braking. This auxiliary system supports the diesel engine utilising the high torque benefits of an electric motor to increase power and reduce the fuel combustion and associated emissions.

Despite some penetration into the Australian bus and truck market, the take-up in the truck market remains relatively low. There are approximately 660 HEV trucks operating in Australia, all in the Light Duty segment. This represents approximately 0.1% of the Australian Light Duty truck fleet. selection.

Battery Electric Vehicles (BEV) derive energy from onboard batteries which power an electric motor and all ancillary systems (e.g. pneumatics, hydraulics, HVAC). Like a HEV, BEVs also use regenerative braking to recharge the battery while driving, thereby reducing brake wear and energy. Electric motors are far more efficient than ICE and have fewer moving parts, reducing maintenance costs.

There are currently 6 brands supplying the Australian market with more brands are expected.



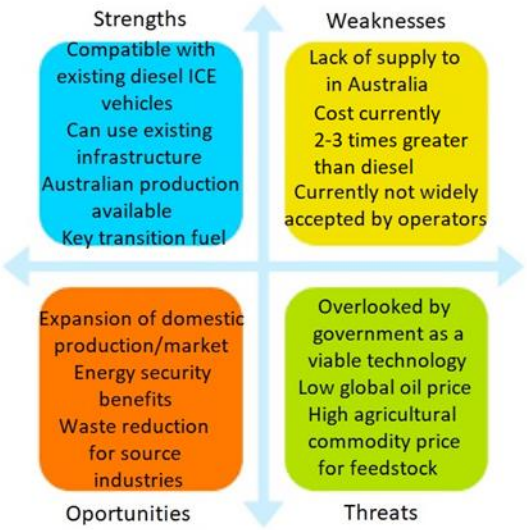
Fuel Cell Electric Vehicles (FCEV) – Nearly all classes of vehicle will see increasing levels of electrification into the future. FCEVs use an electric motor and (smaller) battery like a BEV. However, most of the energy is stored onboard as compressed or liquefied hydrogen which is converted to electricity in an on-board fuel cell and used to both charge the battery and power the fuel cell. In theory, this makes FCEVs more suitable for long distance and regional transport, provided that refuelling is available.

Hydrogen may become Australia's fourth super resource export (with coal, LNG, iron ore) as well as a domestic fuel, with significant funding going into rapid development of this technology.

Hydrogen Internal Combustion Engine (H-ICE) – Alternative gaseous fuel replacement for conventional mineral diesel in modified internal combustion engines (ICE). The hydrogen internal combustion engine is typically a modified version of a traditional diesel or petrol powered internal combustion engine. The absence of carbon means that no CO_2 is produced, which eliminates the main greenhouse gas emission of a conventional hydrocarbon fuelled engine.

As pure hydrogen does not contain carbon, there are no carbon-based pollutants, such as carbon monoxide (CO) or hydrocarbons (HC), nor is there any carbon dioxide (CO_2) in the exhaust. However, as hydrogen combustion occurs in an atmosphere containing nitrogen and oxygen, it can produce oxides of nitrogen known as NOx. In this way, the combustion process is much like a diesel or petrol engine. A hydrogen ICE engine is less energy efficient than a hydrogen FCEV.

Renewable and Biodiesel diesel – Alternative fuel replacement for conventional mineral diesel. These fuels are also referred to as Low, or Zero, Carbon fuels. Biodiesel is produced from agricultural inputs or wastes (canola, tallow) or waste oils like used cooking oil (USDA, 2020). It can be produced locally and is typically blended with diesel rather than used alone. In Australia it was widely used in the early 2000's but many facilities have closed, and remaining plants are underutilised. All trucks can use up to B5 without modification. Many older trucks can use up to B20, however few new trucks (ADR80/04 – Euro VI) can use B20 and none without modification.



Renewable diesel is also made from biomass feedstocks or chemically formulated with inputs such as hydrogen. It is chemically/physically identical to diesel so can be used as a direct 'drop-in' replacement up to 100% without engine modification (or can be blended with diesel). Burning biofuels results in emissions of carbon dioxide (CO_2). However, according to international convention, CO_2 emissions from biofuel combustion are excluded from national greenhouse gas emissions inventories because growing the biomass feedstocks used for biofuel production is considered to offset the CO_2 produced when biofuels are burned (U.S. Energy Information Administration, 2022). Note: there is continuing discussion and differing views, regarding the carbon intensity of Biodiesel produced from animal fats, as some consider these feedstocks have not captured CO_2 during their life cycle.

Renewable natural gas (RNG or Biomethane) – Methane is a *cleaner* burning fossil fuel than diesel and is abundantly available in Australia. Biogas is sourced from biomass or as a biproduct of waste feedstocks, stored as a compressed gas (CNG) or cryogenic liquid (LNG). It requires a dedicated spark-ignited engine, or a dual-fuel system with diesel.

The bus industry was once heavily reliant on CNG, but past enthusiasm for gas fuelled trucks over a decade ago did not lead to widespread uptake in trucks faltered due to cost fluctuations in diesel and gas (driven by the export market). Refuelling locations for trucks are now rare.

Plug-in Hybrid Electric Vehicles (PHEV) – Like a HEV, but with a larger battery that can be charged from an off-board electricity source. Can be used in pure electric mode for short trips making them suitable for use in low emission zones.

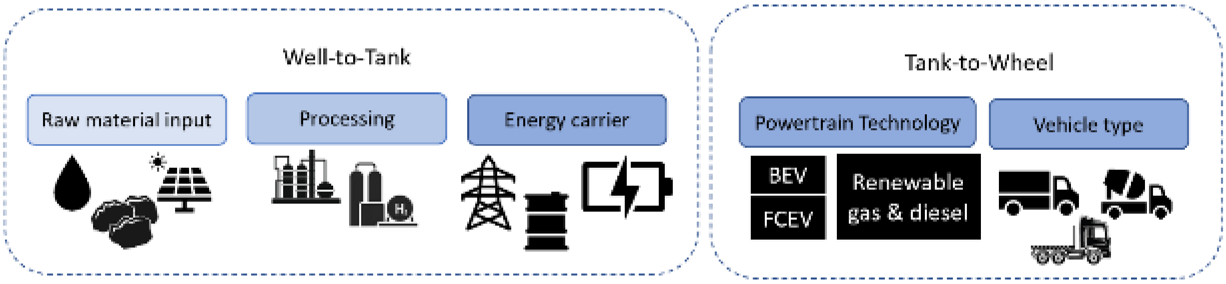
The mix of independent electric and diesel power provides flexibility across long haul and urban delivery, however the emissions reductions are limited.

There are no PHEV trucks currently in Australia, and few models overseas. Pure BEV may be preferable for urban applications due to the limited electric range of most PHEVs.

8 LZEV energy and emissions

LZEV technologies are usually classified based on tailpipe emissions, often described as a 'tank-to-wheel' analysis. This can assist in determining the best LZEV technology in relation to reporting requirements (Scope 1 emissions) as well as direct environment impacts where trucks are used. However, it doesn't include impacts associated with production of the fuel or energy, known as a 'well-to-tank'. Combined, these two phases provide a well-to-wheel analysis, with different outcomes depending on the feedstocks and processes used (Figure 8.1).

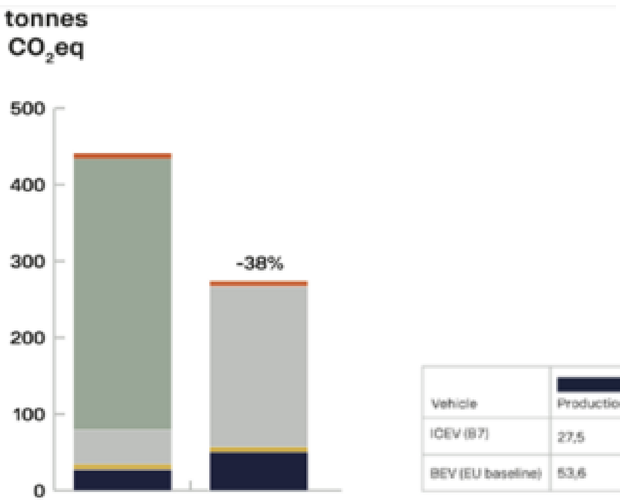
Figure 8.1 Well-to-Wheel example inputs



Neither of these include the environmental impacts of making the vehicle itself, which combines with the fuel-related emissions into a full life-cycle impact. This is important as the market moves to ZEVs whose energy storage and transfer systems can also have significant environmental impacts (batteries, fuel cells).

Figure 8.2 shows the results of an analysis by Scania assessing the lifecycle emissions of a diesel truck (left) and a BEV truck (right). It includes the production phase, well-to-tank and tank-to-wheel emissions, maintenance, and recycling. Three things stand out:

(i) Production of the BEV results in more emissions than for the diesel truck (likely battery-related)
(ii) Across the lifecycle, the use phase produces 5-10 times more emission than the production phase
(iii) The tailpipe emissions phase (tank-to-wheel) associated with a diesel engine is transferred upstream into the well-to-tank phase (at the power station) for a BEV, albeit a much lower level.



Vehicle	Production	Maintenance	Use WtT	Use TtW	Recovery
ICEV (B7)	27,5	2,4	44,9	354,3	2,1
BEV (EU baseline)	53,6	2,4	209,5	0,0	2,1

Figure 8.2 Lifecycle emissions profile ICE vs BEV (adapted from Scania)

Some car and truck OEMs contend that only a lifecycle assessment provides meaningful perspective on the total environmental impact of future fuel choices. TIC believes that this is a valid judgement, however, TIC also believes that global carbon accounting methods allocate emissions associated with resource extraction, manufacturing, energy production, and supply chain activities, to the footprint of those sectors in the country/countries where the carbon emissions are generated.

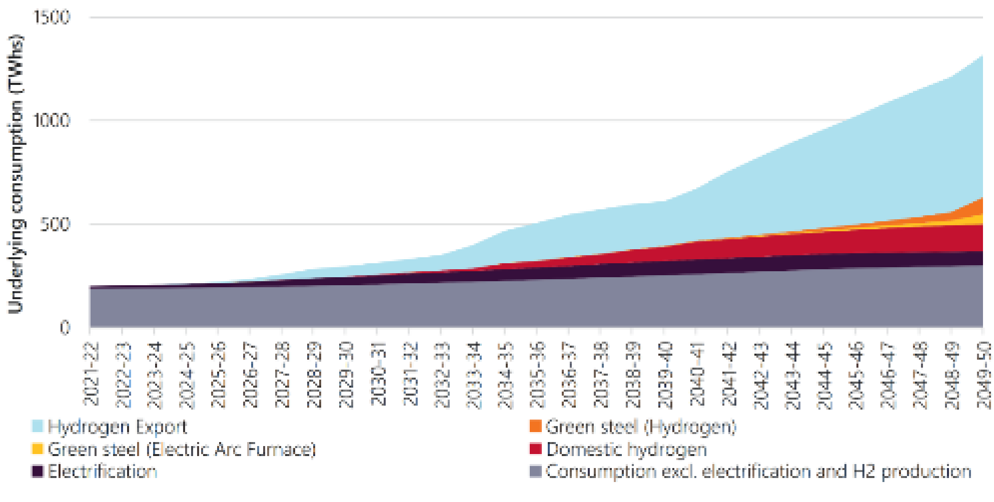
As the graph above showed, electrification will be a key tool to transition multiple sectors, so there has been a focus on solutions to grow grid capacity with clean ("green") energy. As the transport sector transitions towards a net zero future, IEA modelling indicates that approximately US$1 trillion worth of investments will be required globally in supporting infrastructure by 2050. The primary focus areas will be:

- New electricity generation from renewables to increase demand from electric and hydrogen vehicles
- Augmenting and shifting grid demand to reliably meet higher peak demands as well as increasing reverse flow from solar and vehicles back to the grid
- New tariffs and demand controls to shift charging away from peak periods

Electrification of transport and other sectors is a concern for many who see the necessary expansion of the electrical grid as a barrier due to the sheer scale of the task. To that issue, Figure 8.3 shows AEMO's projected increase in demand for both electrification and hydrogen under the most ambitious "hydrogen superpower" scenario. The black wedge represents additional electricity demand from increased electrification of industry including EVs, which does not represent a significant impost on grid capacity. The much larger red wedge represents additional electricity demand for hydrogen consumption within Australia, and the blue wedge for production of export hydrogen.

Even when combined, additional electricity demand for EVs and domestic hydrogen do not represent the kind of 'doubling of the grid' many fear, at least not until sometime after 2050. So, it is not ZEVs that will overwhelm the electricity grid even with a rapid expansion. However, it does show that hydrogen exports at super-scale would need a massive expansion of clean electricity generation if it is to reach the level many governments hope (tripling today's total electricity generation by 2050).

Figure 8.3 Projected electricity demand by end use in H2 Superpower scenario, 2021 to 2050 (AEMO, 2021)



8.1 Environmental winners (the OEM perspective)

TIC members were asked to rank what they thought were the most promising LZEV fuels and technologies to reduce emissions over a 2030 and 2050 timeframe.

Figure 8.4 shows the average rating provided by the manufacturers. BEVs are seen as the most promising technology in 2030 and close to best in 2050. Hybrids, plug-in hybrids, and hydrogen scored similarly for 2030 (with HEVs slightly ahead). But by 2050 hydrogen jumps just above BEVs and the hybrid technologies fall in significance to about the same level as renewable/biofuels and methane (natural gas). These latter two fuel were not considered to change in significance much over the entire 2030-2050 timeframe.

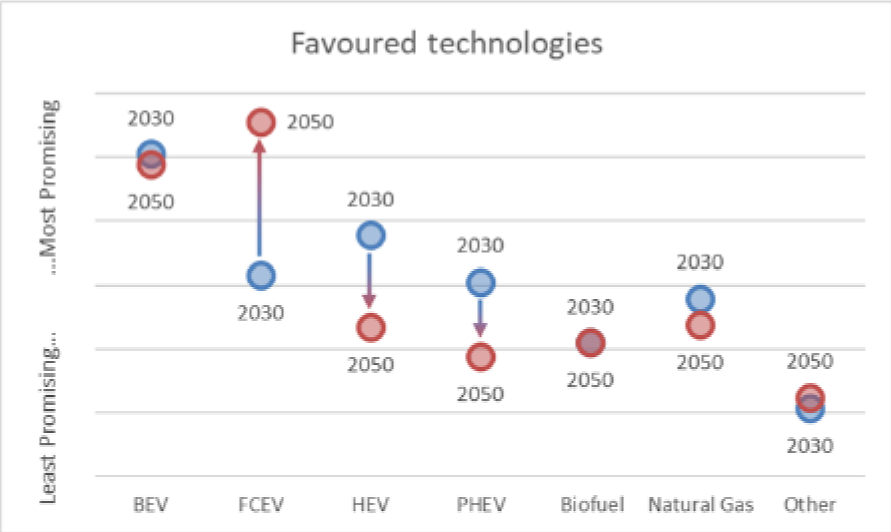


Figure 8.4 Technologies favoured by OEMs to reduce emissions in 2030 and 2050

The averages shown in the graph above mask significant differences in how manufacturers ranked the various technologies. Figure 8.5 illustrates this variation. The red and blue boxes represent the range covering 50% of responses; the whiskers show the full range of responses (min and max rating for each technology) excluding any outliers. Finally, any dots show responses that were considered outliers.

In some cases, the range of scores were spread across the entire spectrum from top to bottom. However, looking at the middle 50% of scores (the coloured boxes):

- BEVs had the smallest differences of opinion in 2030, and second smallest in 2050.
- Hydrogen had the most variation for 2030 but the least in 2050.

In other words, even among truck manufacturers, there is still some disagreement about the best solutions to reduce emissions as nascent technologies evolve and develop.

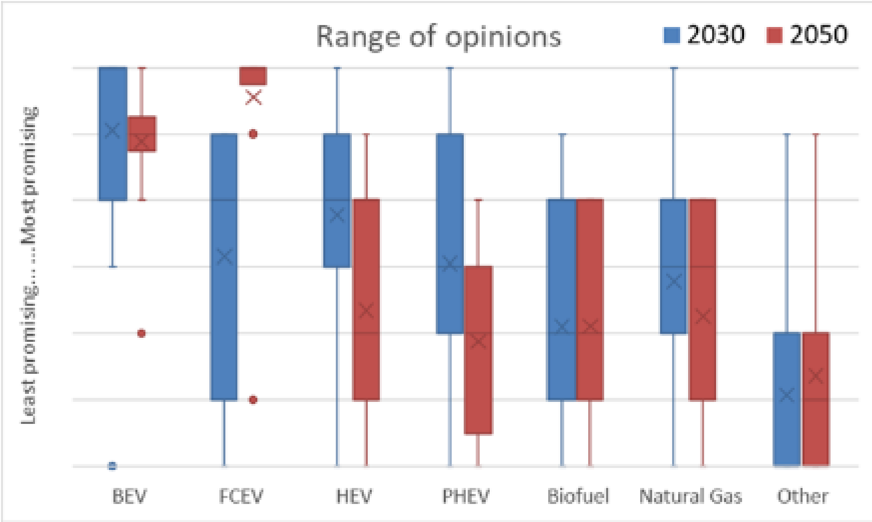


Figure 8.5 Variation in OEM responses for preferred technologies to reduce emissions.

8.2 Emissions variability

A significant factor contributing to the wide range of views above, is the continued reliance in Australia on energy sources with a high emissions intensity (e.g. a coal-powered grid in some states), with renewable energy sources not currently incentivised or regulated for transport. Uncertainty in the cleanliness of the different fuels/technologies applies equally to electricity as it does to hydrogen.

8.2.1 Electricity

Emissions related to (mineral) diesel combustion are consistent, irrespective of where that fuel is sourced or consumed. The same applies for renewable diesel, though the emissions advantage over diesel is significant. However, the emissions advantage of BEVs over diesel trucks varies significantly depending on where and how the BEV is charged. For example, the Tasmanian grid has the lowest emissions intensity due to the high prevalence of hydro and wind power, with 0.16kg CO2-e/kWh of electricity consumed. On the other hand, Victoria has one of the most fossil fuel reliant grids, producing 0.96kg CO2-e/kWh (DISER, 2021) – six times more (see Table 8.1).

Table 8.1 Emissions Calculations BEV in Multiple Australia Grids vs ICE Light Rigid

	Diesel (Euro IV+)	Renewable diesel (R100)	BEV (Tasmania)	BEV (Victoria)	BEV (Average)
Energy Consumption (L/100km OR kWh/100km)	21	21	52	52	52
Daily km	235	235	235	235	235
Daily Energy Consumed (L OR kWh)	49	49	124	124	124
Emissions factor per unit of energy	70/GJ	10.5/GJ	0.16/kWh	0.96/kWh	0.6/kWh
Annual Emissions (t CO2-e)	34	5.1	5.2	30.9	19.5
Difference from Diesel ICE (%)	-	-85%	-85%	-11%	-44%

Currently across Australia there is an average 65% emissions improvement in switching from diesel ICE to BEV. As the Australian grid decarbonises with a predicted 50% improvement by 2030, BEV emissions will continue to drop significantly throughout the life of the vehicle. The use of renewable diesel could also provide significant emission improvements directly proportional to the blend ratio of renewable to mineral diesel.

8.2.2 Hydrogen

The emissions profile of hydrogen depends on the feedstock used (water, gas, etc) and the source of energy used in its production. The combination of these factors produces a kaleidoscope of different grades of hydrogen (Figure 8.6). Green hydrogen is the only grade that generates no emissions in its production, with other grades relying on various means to offset or sequester the carbon produced. With blue and particularly grey hydrogen cheaper to produce, and no mandated use of green hydrogen or other support mechanisms, there is a risk that hydrogen will continue to come from the dirtier sources like more than 99% of hydrogen production today.

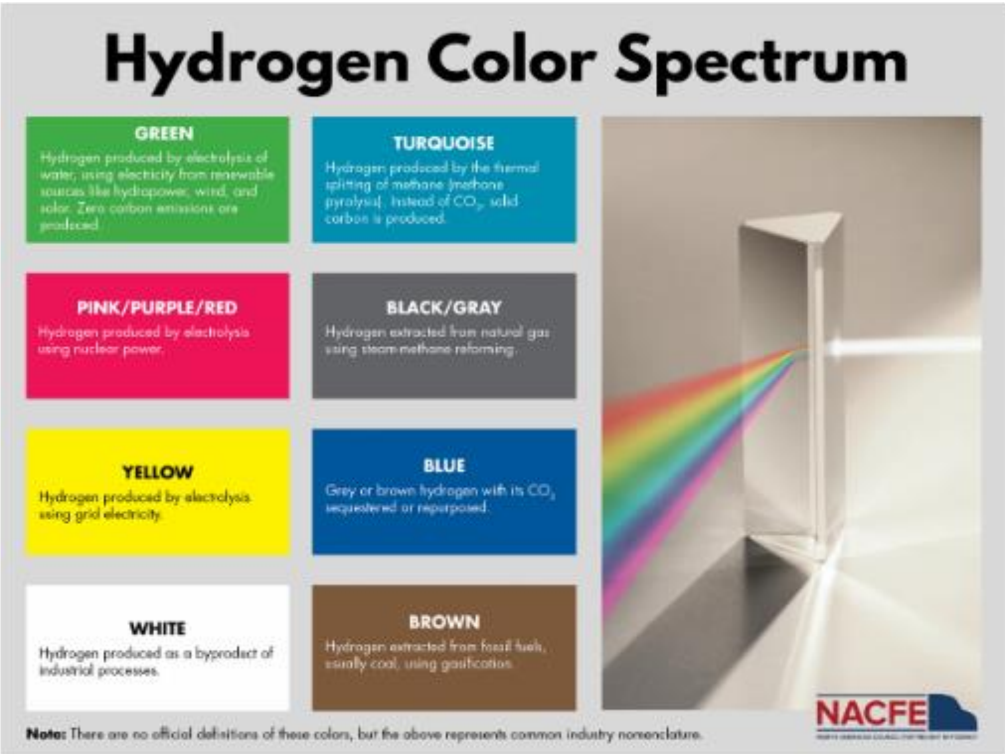


Figure 8.6 Explanation of Hydrogen Colours (NACFE, 2020)

Compared to a diesel vehicle, green hydrogen used in an FCEV has the potential to reduce emissions by between 30% (brown) and 90% (green) (NACFE, 2020).

Hydrogen itself is a greenhouse gas, and therefore hydrogen leakage during storage and delivery needs to be factored into net zero equations.

Due to the potential of hydrogen as an export commodity, governments at all levels are investing in rapid development and expansion of hydrogen production, and several truck trials have been announced to take place across Australia. However, the costs associated with both the technology and fuel may limit its uptake in the short-medium term beyond demonstration projects, as other alternative LZEV technologies provide more cost-effective solutions.

8.3 Environmental health impacts

In addition to CO_2, diesel trucks emit other pollution and noise. A new truck complying with current Australian emissions standards, ADR80/03, is already a very clean truck in terms of noxious exhaust emissions, and many TIC members offer trucks at the even cleaner Euro VI, or equivalent, standard which is not yet required in Australia). It is the older fleet, particularly those introduced prior to 2003 and still operating on urban roads, that are responsible for a disproportionate share of the pollution-related health burden – around $400 million p.a. or half the total truck health burden, despite representing only 35% of the fleet and carrying a much lower share of the freight task (Austroads, 2021).

This is particularly an issue within built up, high traffic urban areas where LZEV technologies such as BEVs will be best suited – meaning that LZEVs can address multiple issues while continuing to meet the growing urban freight task.

In regional and remote areas where traffic density is lighter and residents are more dispersed, health costs are not as high. However, this is also the area that zero emission technologies like BEV and FCEV cannot yet compete or are yet to be developed. This technology gap opens the opportunity for low emission alternatives such as renewable diesel. While still burning fuel and emitting some level of noxious emissions, these renewable fuels can significantly reduce CO_2 emissions – by up to 85% in some cases - while maintaining current refuelling infrastructure, current refuelling times and vehicle range.

8.4 Energy availability and infrastructure

The fuel supply chain for LZEVs is a limiting factor globally and a substantial issue in Australia with our relatively sparce population, yet expansive road network, with significant investment needed to realise transport decarbonisation. The main considerations include suppliers, supply chain, production capacity, location, and refuelling infrastructure.

8.4.1 Renewable/Biofuel liquids

There are a small number of renewable/bio fuel producers across the eastern states (Figure 8.7). Collectively, they have capacity to manufacture 100 ML of biodiesel per year (CEFC and ARENA, 2019). However, only around 40% of this is utilised, with more than one third of production going to export markets. The remaining infrastructure is either highly under-utilised, under repair, or mothballed.

Clearly, there is a lower commercial incentive to use the fuel produced domestically than there is to send it overseas, if exports attract greater profit. Put another way, under the right policy settings, there is enough production capacity to more than double the market share of renewable/bio fuels in the Australian fuel mix, even without additional investment in expanded production capacity. This would result in a corresponding additional reduction in CO_2 emissions proportional to the increased production/use.

Investing in additional capacity would take time and capital, but so too does building out charging infrastructure, hydrogen production, hydrogen storage and refuelling stations. Meanwhile, increased renewable/bio diesel production could use existing infrastructure until such time as it reaches a maximum blend wall acceptable to the fuel industry and vehicle manufacturers.

A renewable/bio diesel fuel standard would need to be created by government. However, renewable/bio diesel could use existing distribution and storage infrastructure, and could be used in all current (old) and new diesel vehicles – both of which are major advantages of this fuel to achieve quick CO_2 emission reductions.

Figure 8.7 Domestic commercial-scale bio-fuel plants (CEFC, 2019)

Looking beyond bio diesel, other forms of renewable diesel offer even greater flexibility, as they are chemically identical drop-in substitutes not needing to be blended with (mineral) diesel. In the US, there are already tens of thousands of vehicles, ferries, emergency generators, and other equipment operating on 100% renewable diesel, resulting in up to 80% lower greenhouse emissions than if they were on diesel. This includes all the Port of San Diego truck fleet and all of New York City truck fleet.

Opportunities for expanding renewable diesel production in Australia are significant, as it doesn't rely exclusively on the same feedstocks as biodiesel, and demand can be considered the same as for conventional (fossil) diesel – not just for trucks, but also rail, shipping, light vehicles, mining, and other off-road sectors.

8.4.2 Biomethane or renewable natural gas (RNG)

Unlike Australia's burgeoning fossil gas industry, production of biomethane, or renewable, gas in Australia is scarce, with only a few projects under initial deployment or at demonstration stage (Figure 8.8).

As with renewable diesel, renewable gas could use any existing infrastructure from earlier times when CNG and LNG were considered viable transport fuels. Even then, the open-access infrastructure was quite limited and constrained to geographic pockets – Tasmania, regional Victoria, ACT. In 2013 there were 47 private CNG stations and only 5 public. Currently, either none or very little of that infrastructure appears to still be operational.

In 2015, a CNG refuelling station was opened in Tullamarine (Victoria) in a partnership between Caltex and AGL Energy. The station was to supply local truck fleets and cars. AMPOL lists CNG as currently available at the Tullamarine station. However, the majority of gas-powered heavy vehicles in Australia were transit buses that refuelled at private depots not available to the public or to freight operators. Many vehicles in these fleets have transitioned away from CNG or are in the process of doing so.

The production of biomethane, or renewable, gas in Australia would most likely be best used as a short to mid-term mechanism to reduce the CO_2 intensity of the domestic natural gas supply, or to fuel agricultural equipment and not as a road transport fuel.

Figure 8.8 Domestic biomethane or renewable gas (RNG) production

8.4.3 Electricity

Replenishment of electricity via recharging is critical to an EV's successful operation. Unlike other liquid and gaseous fuels, electricity is ubiquitous and can be accessed just about everywhere. However, the rate of energy flow (the current, in Amps) at any given outlet varies considerably, and may not support the relatively large energy requirements of EV fast charging for trucks. These constraints may be due to the electrical system on the site (depot wiring, switchboard capacity, etc), or by the electricity distribution network infrastructure outside the site (more likely an issue when many vehicles need to be charged).

Charging equipment is generally required to take electricity from the grid connection to the vehicle, which requires investment and civil works where it is installed. Chargers vary in physical size, speed of charge, and cost; so each operation requires a tailored charging assessment to minimise costs.

There are different charging strategies that can be used for commercial EVs, including:

- Depot based chargers supporting back to base operations.
- Depot and destination chargers supporting opportunity charging when loading.
- On-route public or privately accessible charging such as highways, roadside and service stations.
- A mix of the above.

Charging equipment is widely available in Australia from many vendors. Some provide hardware only, while others offer turnkey solutions. Not all hardware providers can supply the required software to manage the speed and timing of chargers, which is often overlooked as a part of minimising costs.

Civil and electrical works are in addition to these costs and can often add 100% or more to the charger cost depending on the site and existing infrastructure. Grid connection upgrade costs also vary greatly depending on site and grid capacity, and the network provider dictates the costs.

8.4.4 Hydrogen

As with other liquid and gaseous fuels, hydrogen must be produced, distributed, and stored for dispensing into the vehicle. There are currently no commercial-scale plants producing renewable hydrogen for transport applications. Hydrogen refuelling stations are also scarce in Australia with only three active stations for cars (and only one of these is a fixed/stationary dispenser):

- Hyundai Motor Company Australia stationary station in Sydney, NSW
- Toyota Motor Corporation portable station on back of truck in Sydney, NSW
- Toyota Motor Corporation portable station in Melbourne, Victoria
- ActewAGL refuelling station in ACT.

There are plans to upgrade these stations. Hyundai is working with Jemena and Coregas to supply green hydrogen (Western Sydney Green Gas Project) to an onsite station. Toyota and the Victorian Government are planning to make Toyota's portable station in Melbourne into a stationary public station with a capacity of 60 kg per day, part of the "Hydrogen Centre". Other proposals are shown in the table.

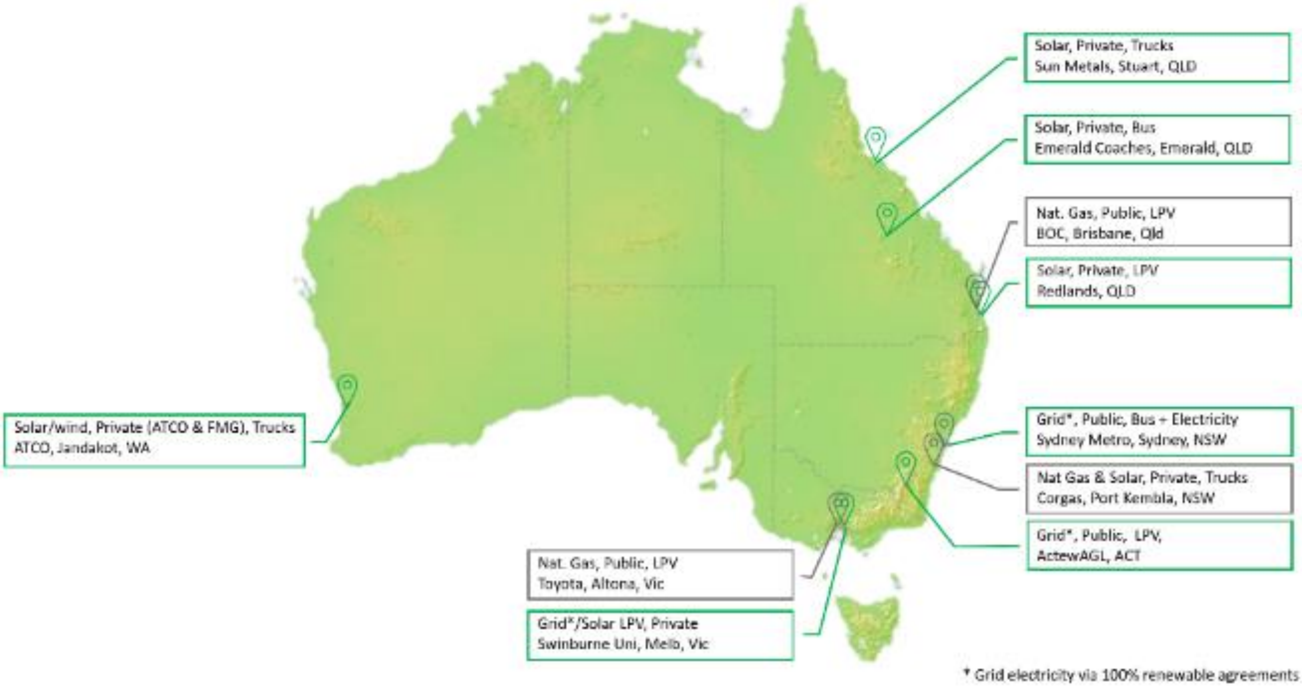


Figure 8.9 Domestic hydrogen production and refuelling stations

In March 2022 the New South Wales, Victorian, and Queensland Governments announced a joint project to collaborate on a renewable hydrogen refuelling network for heavy transport. The first stage of the initiative is the Hume Hydrogen Highway, to be completed by 2026 and including four refuelling stations between Sydney and Melbourne with each state government contributing $10m towards the stations and grants for long-haul FCEV purchase. Ultimately, the whole network will traverse the east coast to include the Hume, Pacific and Newell Highways. With the memorandum of understanding only just agreed, there is limited details in relation to the specifics of where, when and how much (DPE, 2022).

Importantly, the creation of an export market for hydrogen as an energy commodity will increase its trade potential but also its vulnerability to price increases. An example of a similar situation was when domestic prices for natural gas more than doubled and then tripled as east coast LNG export plants came online and could secure higher export prices. Without reservation policies or other market controls, suppliers send the fuel to its highest price market. In other words, there is a real risk that prices for hydrogen as a future energy carrier, rather than an industrial gas (today), could be quite different.

Emerald Coaches (QLD) – Green H2
Transitioning 120 coaches from diesel to H2 by 2040. The depot will producing its own green H2 via solar, feeding an electrolyser with rainwater, 60 busses can be charged at one time.
Company see diesel as becoming obsolete technology - "We already find it difficult to attract mechanics and people…. I'm just not sure how many skilled tradesmen we're going to have to be servicing diesel vehicles in 15 years' time".
Project cost - $100M, while the QLD government is supporting the project it is not clear if this includes funding.

Ark Energy (QLD) – Green H2
Leasing 5 Hyzon trucks, configured in a triple road train operating on a 30km loop from Townsville to Sun Metals refinery. The trucks will be fueled at the refinery.
Green H2 will be produced by a co-located solar farm. $15.5m is being funded by the Federal government for the H2 production infrastructure.

Port Kembla Hydrogen Hub (NSW) - Black/Grey H2
2 Hyzon trucks to be supplied in mid-2022 for stage 1 Heavy truck trial with H2 provided by Corgas at their Port Kembla site.

9 Barriers and market failures

There are many real and perceived obstacles constraining the wider use of LZE trucks. These barriers are quite different from a manufacturer versus an operator perspective, but they generally fall into one of three categories: operational, financial, and market maturity.

9.1 Technical/operational barriers

Productivity/Payload – The purpose of most trucks is to carry payload. However, with a lower energy density than diesel, most alternatives have heavy or bulky energy storage on-board, increasing their unladed weight and reducing available payload capacity up to maximum weight (GVM) or volume. This includes batteries, fuel cells, and other equipment which can weigh up to 2,400kg more than the diesel drivetrain (Bloomberg Law, 2021). The higher the energy requirement (e.g. critical applications such as line-haul), the larger the likely impact on payloads.

Australian trucks are already more limited in axle capacity than their overseas counterparts as Australia's National Heavy Vehicle Law is not aligned to the mass and dimension limits of global markets. This either limits availability of models in Australia, requires them to be significantly modified or redesigned, and reduces payload (i.e. increasing cost and/or reducing revenue).

BEV charging time –The time needed to charge a battery depends on the vehicle, type of charger, and the amount of charge required. The potential time off road to recharge for long distance or consecutive shifts could have an operational impact. This is less likely to be an issue within urban delivery applications where the vehicle works a day shift and is parked at the depot and charged overnight.

Hydrogen filling time – FCEV refilling is likely to be comparable to diesel refuelling time, but requirements for pre-fill refrigeration of the gas in the dispenser may result in delays (Danebergs, 2019).

Operational flexibility – Although most trucks are purchased with a single purpose or application in mind, the flexibility to reassign to different tasks is highly valued. This flexibility saves costs by allowing operators to meet a variety of needs without over-investing in many different sizes of truck for different freight types or destinations. This may be a challenge for ZE trucks as the vehicle purchased is ideal for a particular application but may not have the flexibility to be switched to other routes or tasks to undertake ad-hoc work like the rest of the diesel fleet. These limitations will also affect a trucks resale value.

9.2 Financial barriers

Capex and Opex - The commercial case for LZEVs can be difficult to make due to the upfront purchase price (up to 2-3 times higher than diesel), and uncertainty in TCO factors (resale values, the biggest cost element; and fuel price, the second largest). The break-out box below shows FCEV total cost may be much higher than a diesel truck, but this changes significantly at fuel prices seen through early 2022. As a truck will be kept in the fleet for years to come, should a truck buyer roll the dice and assume high fuel prices will remain longer-term; or that fuel prices will return to the long-term average seen since around 2011.

Trucks in Australia often live a second, third, fourth or even fifth life with different owners, but concerns about battery replacement or being restricted to a specific task or operational domain and availability of suitable fuels, particularly in regional Australia, are major concerns.

Additional infrastructure cost – Diesel refuelling is established and easily accessed with minimal disruption to operations. Apart from opportunities to charge overnight (slow charging over many hours, using current infrastructure), the introduction of ZE trucks will require an operator to have access to newly installed charging equipment or a hydrogen refuelling station to suit the number and operational demand of the new trucks.

Total cost of ownership (TCO) analysis – Figure 9.1 below provides an indcative TCO comparison of three popular truck segments, using cost estimates in 2030 to show the relative commercial viability of operating a ZEV truck up to an including that future date. It assumes suitable models of each technology will be available in the segments, and applies a modest improvement in efficency for ZEV and FCEV technologies compared with today's performance (2022).

In each case, under a 7-year ownership period hydrogen remains the most expensive option in each segment. BEV models offer the best option in both rigid truck segments, while diesel remains the most cost effective for line-haul.

The data in Table 9.1 summarises the main assumptions for the assessment. It includes best estimates for vehicle and fuel costs while benchmarking operating costs on real world 2022 data. The following specific assumptions are included in the assessment:

- Diesel: Fuel cost is long term average retail less typical fuel tax credit.
- BEV: TCO includes charging equipment amortised over vehicle life.
- FCEV: assumes refuelling from public hydrogen stations.
- A diesel-equivalent road user charge is included for both BEV and FCEV in 2030 to recover road damage costs no longer being captured via fuel excise.
- All technologies assumed have typical diesel depreciation over the first 7 years

The key findings from this analysis are that BEV trucks will be the most commercially viable in the rigid trucks in urban operations (as has been found in other analyses, even at today's 2022 prices); but that hydrogen is unlikely to be commercialy viable (unsubsidised) even by 2030 in any of these segments. This result will be surprising for some given the generally optimistic literature in its favour, However, the analysis below uses

- unsubsidised costs (no government grant funding)
- Australian prices and conditions (European analyses of FCEV trucks have a lower commercial hurdle because of the much higher diesel price in that market)
- No carbon pricing, consistent with current policies by both major political parties (some Australian studies have used a very high carbon price to make hydrogen appear commercially appealing, as high as \$230/t CO_2).

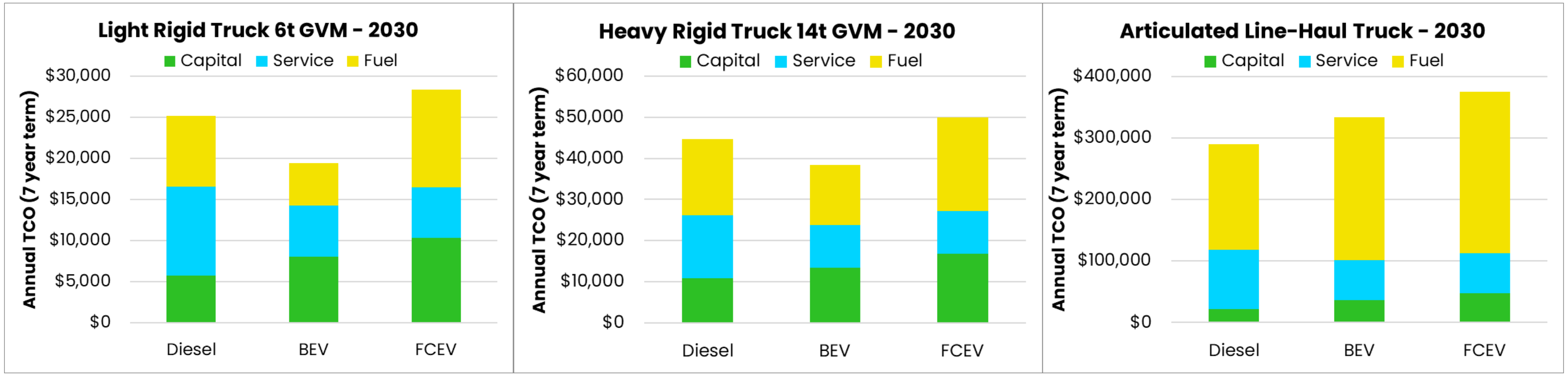


Figure 9.1 Expected TCO of truck segments in 2030

Table 9.1 Main estimates for 2030 TCO assessment

	Light Rigid 6t local delivery			Heavy Rigid 14t urban distribution			B-Double line-haul		
Utilisation	40,000km p.a.			40,000km p.a.			250,000km p.a.		
Technology	Diesel	BEV	FCEV	Diesel	BEV	FCEV	Diesel	BEV	FCEV
Price	$105,000	$147,000	$189,000	$200,000	$250,000	$310,000	$400,000	$670,000	$875,000
Maintenance	27c/km	16c/km	16c/km	39c/km	26c/km	26c/km	39c/km	26c/km	26c/km
Energy use	17.3L/100km	302Wh/km	3.1kg/100km	36.8L/km	695Wh/km	5.86kg/100km	55L/100km	1350Wh/km	11.3kg/100km
Fuel cost	$1.25/l	18c/kWh	$8/kg	$1.25/l	18c/kWh	$8/kg	$1.25/l	18c/kWh	$8/kg

9.3 Market maturity

Perhaps the most influential barriers relate to an underdeveloped or immature energy market in freight. An obvious indicator of this is the lack of LZEV truck models currently available, and lack of availability of future fuels like hydrogen. Another example is the industry's low use of energy experts or advisors to find fuel cost efficiencies in fleet operations. Both indicate a reluctance to explore energy opportunities.

Vehicle availability – Availability is the primary barrier: fleet operators can't buy what isn't on the market. Australian truck operators are very limited for LZEV model choice, with no models for many applications; and where there are, the choice is limited (not everyone buys the same brand or model). This is not an Australian unique issue, though our unique and restrictive dimension and mass regulations, limit the number of vehicles available in Australia. Globally, LZEV trucks are in their relative infancy and for many applications, for example, long distance, remote area operation, there is no LZEV solution available yet.

Availability of energy infrastructure – The location and type of charging infrastructure is essential to uptake of ZE trucks, particularly for long distance and large capacity requirements. Limited availability of recharging can lead to range anxiety due to both real and perceived risks, such as fear of running a battery flat and associated downtime or recovery costs. The speed of charging may also have an operational impact on schedules. Millions of dollars in public funding have recently been invested in fast public EV charging predominantly for light vehicles, few of these sites can be accessed by trucks, so will need to be adapted or duplicated.

Rapid pace of change – the ZE truck market and its supporting infrastructure is advancing rapidly, reducing many of the technical and cost barriers. This may create a hesitancy to buy now with operators preferring to hold off until a better/cheaper/more suitable technology comes along. This is exacerbated by the long service life of trucks in Australia, with a fear, for an operator, of being locked into an inferior technical solution.

Culture – The truck industry is conservative and can be hesitant to change, preferring tried and true technologies to minimise risks or service interruptions. This approach has resulted in evolutionary change within the industry, based on extensive real-world experience. Pivoting to new technology such as LZEV trucks requires a different approach. All market players – operators, dealers, service providers – are being asked to take a research-based leap of faith, despite the commercial and operational risks.

Large Fleets vs Small and Owner Operators – A large proportion of trucking businesses are owner operators, or small fleets, with approximately 80% of trucking organisations in Australia having five trucks or less. As such, these businesses, require trucks that have a diverse operational capability (a significant limitation for many LZEVs). LZEV take up will typically be much slower with these smaller organisations who representing the majority of the Australian truck fleet.

Operating margins – The Australian road freight industry is intensely competitive and businesses typically operate on very low profit margins. This is a significant factor in an operator's decision to "experiment" with new technology.

Industry confidence – The emerging LZEV market in Australia presents many unknowns which reduces confidence in decision making. There is a reluctance (and potential significant financial risk) among many fleets to be the subject of experimentation, research, or testing, the "guinea pig" as such. Available information is often overly optimistic or conflicting, leading to concern about vehicles being (a) fit for purpose, and (b) flexible enough to substitute for diesel trucks (interoperability). Operators would rather wait for real-world data and experience. Other unknowns include reliability, resale values, future energy costs, and whether the new technology delivers on the environmental benefits it claims.

Capability/Capacity – Fleets are resource constrained and have many competing priorities. The introduction of LZEV trucks and associated equipment requires commitment across the business. There is a sizeable investment of time and resources needed to learn about transitioning to these technologies, as well as training, implementation planning, execution, and operation. At the same time, there are few suitably qualified support staff (mechanics, electricians, other technicians, system operators, trainers, etc) to enable dealers to support these vehicles.

Road User Charging (RUC) – Following fuel/energy costs and driver's wages, the RUC is the single biggest expense for an operator. The current RUC is fundamentally flawed for use with anything but a diesel powered truck. The RUC must be reviewed and revised. This must be a priority for government, because an operator cannot make a long term commitment to a LZEV unless they have a clear understanding of the future RUC costing model and the impacts that will have on their existing diesel trucks and potential new LZEV purchases.

TIC members have identified what they see as the most significant barriers from their perspective, in terms of bringing vehicles to market to support fleets that want to transition. These barriers will therefore affect model availability (the business case for manufacturers to bring and sell vehicles in Australia). Results are shown in the graphs below. The wider the bar, the more respondents supported that as a barrier.

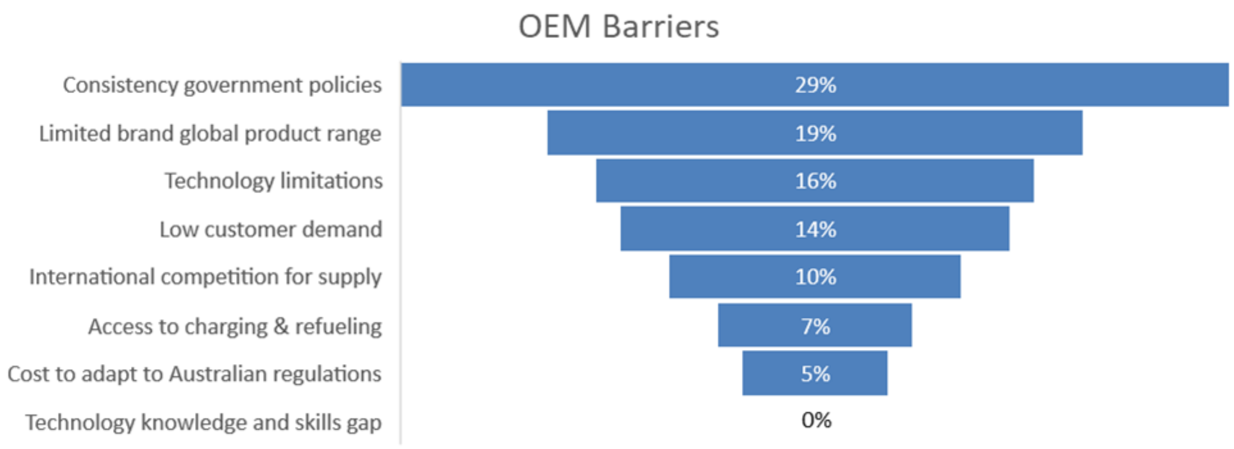


Figure 9.2 Manufacturer-nominated barriers to LZEV uptake

Given the long planning horizon in the truck industry, it is not surprising that consistency of government policy would be the top issue for truck and powertrain manufacturers. The main concerns relate to adapting vehicle designs and features for local regulatory compliance (due to inconsistency with overseas regulations in areas such as vehicle width and front axle limits), as well as the application of differing state-based instruments on a national (not state-based) transport industry.

An alternative, action-oriented perspective is shown below. The graph identifies factors that truck manufacturers thought most conducive to future LZEV uptake. Government grants and incentives to offset the purchase price premium was ranked highest and second highest, while regulatory concessions to offset the higher mass and consequent payload penalty was next most important. Low emissions zones or precincts, R&D / engineering subsidies to adapt overseas vehicles, and some form of carbon pricing or other punitive financial measures were all seen as roughly similar in importance.

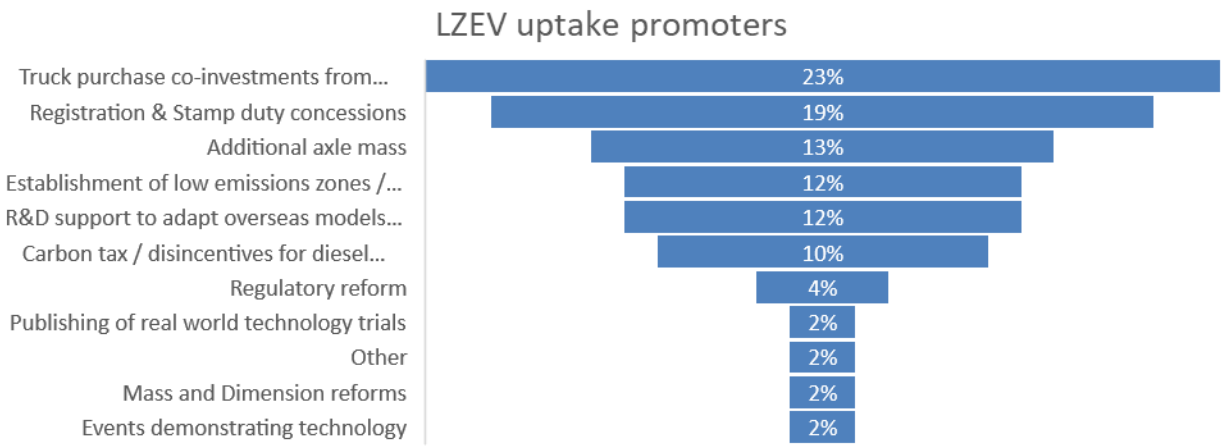


Figure 9.3 Manufacturer-nominated enablers of LZEV uptake

10 The speed of transition will be slow

A key objective of this paper was to understand how quickly the truck market can shift to new and cleaner technologies within the real-world constraints of the truck and freight sectors. A follow-on question was to what extent that might translate to CO_2 emissions reductions based on new technologies.

TIC members were surveyed about future model plans, and the impact of these on fleet emissions were modelled. The survey asked when manufacturers will offer LZEV technology and into which segments. Their responses provide the most reliable and most comprehensive picture of technology change yet published for the Australian market, as they are the authoritative source of information about how quickly they can source LZEV trucks from their parent companies or manufacture them locally.

10.1 Model availability over the coming decade

Figure 10.1, Figure 10.2, and Figure 10.3 show the results of planned technology introductions in the light-duty, medium-duty, and heavy-duty truck segments, respectively. Introduction timing is split into time intervals of near-term (0-2 years); medium-term (2-5 years), and longer term (5-10, and 10+ years).

Looking at the graphs by vehicle size, light duty trucks will see the highest number of technology introductions in the short-term, but it is heavy-duty trucks that will see the greatest number in the medium-long term.

Comparing technologies:

- BEVs that will have the highest number of introductions over the coming decade, with 31 identified across all segments in the next 10 years. BEV models are evenly spread across segments with 10 models per segment for light and medium-duty and 11 for heavy-duty.
- Companies planned about one-third as many FCEV introduction (11), closely followed by HEVs (8). All FCEV models were listed in the heavy-duty segment.
- Remaining technologies will see 12 introductions in total, with two-thirds of these for heavy-duty.

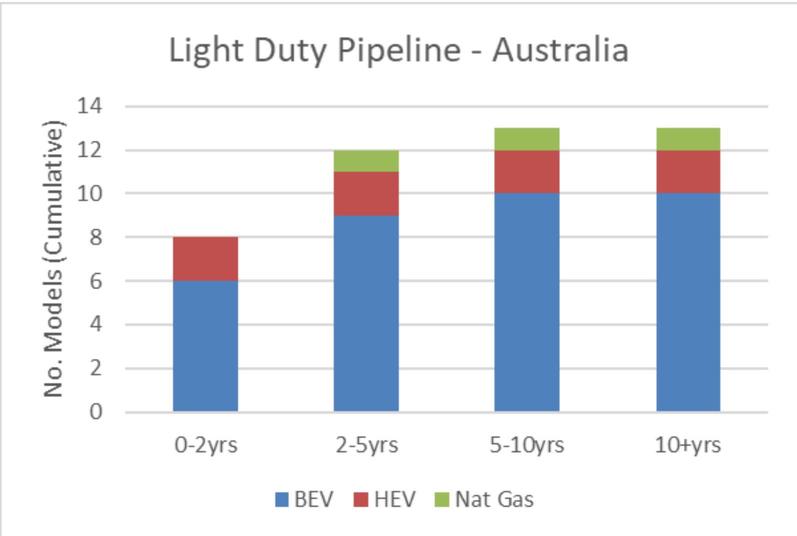


Figure 10.1 Expected availability of LZEV models by technology in the Light Duty segment

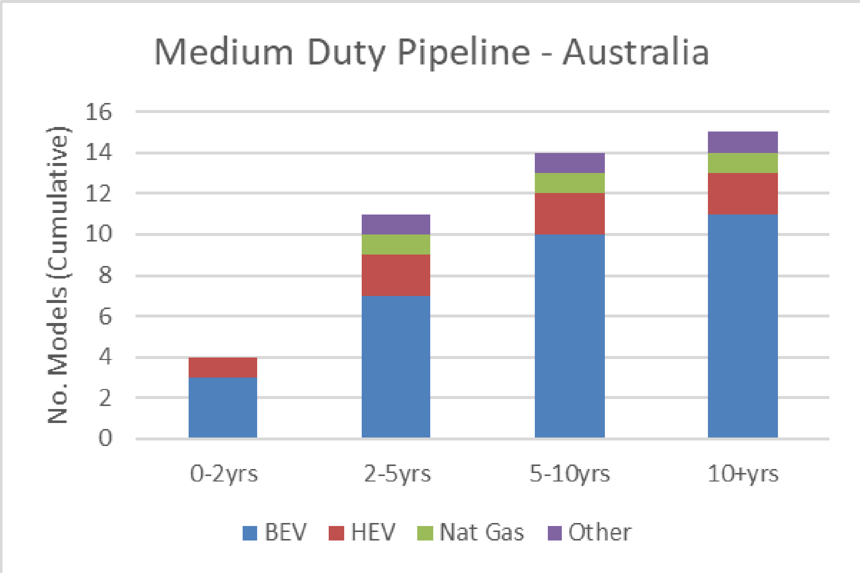


Figure 10.2 Expected availability of LZEV models by technology in the Medium Duty segment

While BEVs dominate other LZEV technologies in the light and medium-duty segments, there is a roughly even split in the heavy-duty segment between BEV, FCEV, and other technologies (one third each). If this translates to sales, a nuanced approach to energy and fuel infrastructure will be required, potentially catering to specific fleet, location and/or application. It also supports TIC's principal of not picking winners.

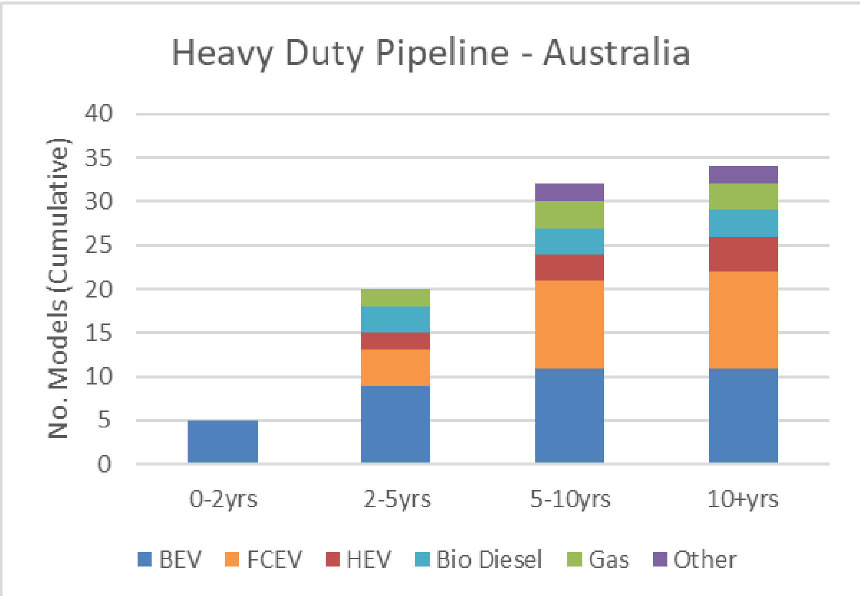


Figure 10.3 Expected availability of LZEV models by technology in the Heavy Duty segment

Comparing Australian introduction of models to overseas, almost half of the BEV models nominated will be launched in Australia at a similar time to their overseas launch. For FCEVs, just over a third will be released in Australia on a similar timeframe.

On average, there is a 2 ½ year delay between overseas release and launch in Australia.

10.2 2030 market share of LZEVs

Different manufacturers have very different views about the likely sales share of new LZEVs in 2030 in each of the three market segments (light/medium/heavy duty). Participants were asked to nominate an expected sales share in ranges 0-5%, 5-10%, 10-20%, 20-40%, and above 40%. Figure 10.4 shows the results, with darker shading indicating a higher number of responses.

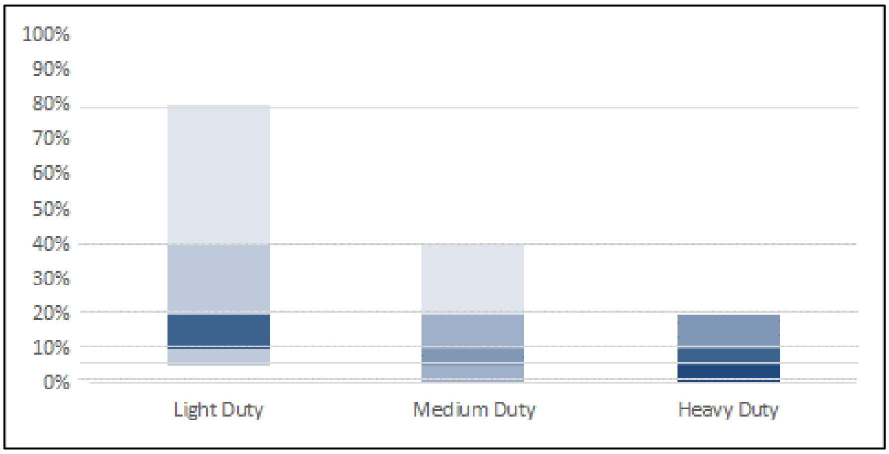


Figure 10.4 Expected sales share of LZEV vehicles in 2030 by segment

The light-duty segment had the highest expected average LZEV market share (mode 10-20%). Heavy-duty trucks were expected to see lower market share (mode 0-5%). Medium-duty trucks received a more even spread of responses across the three categories from 0-20%, indicating either less certainty or differing focus within this segment.

10.3 Implications for LZEV sales and investment

The segmentation of the truck market, combined with varying suitability of LZEV technologies and low model availability (globally and in Australia) and operator bottom line profitability, means that sales volumes will likely be relatively low in the period up to 2030.

The heavy-duty segment had the most diverse mix of technology options, with a roughly one third split between BEV, FCEV, and other fuels. Suppliers within the heavy-duty segment indicated offerings of 1 to 5 technologies while light and medium-duty suppliers indicated 1 or 2 options each per segment.

Taking the nominal average estimates for market share from the graph above (20%, 10%, and 10% for light, medium and heavy duty respectively), and applying to the quantum of annual sales in these market segments, provides a guide to how many LZEV unit sales might be expected (see tables below). An additional optimistic scenario can also be considered by using the upper limit of the average sales share estimates (40%, 20%, 20% for light, medium and heavy duty, respectively).

Approaching the segmentation in this way shows the overall sales potential of LZEVs in Australia. Assuming a simple equal share for each truck manufacturer shows that even in 2030, sales volumes of LZEV in the light duty segment will be relatively small: 127 vehicles p.a. for each manufacturer (spread across all LZEV technology platforms), compared with 1146 diesel per manufacturer. Even taking the optimistic estimates of 20% only increases the number to 254 LZEVs per truck OEM. The collective total estimated sales for each of the segments, Light, Medium and Heavy, is shown in the tables below.

Taking the same approach for the other segments shows that only the heavy duty segment will see LZEV volume approaching diesel levels – 662 vs 993 – albeit only in the most optimistic scenario, and still a third lower than diesel.

Clearly, LZEV volumes will remain constrained for some time to come. The case for OEMs to invest significantly in adaptation and engineering of overseas vehicles, based on these low volumes, looks poor at face value.

Picking one technology winner over others undermines the case for significant investment in different fuels and their related refuelling infrastructure. Figure 13.3 shows that all solutions may be required and are certainly being considered by truck manufacturers and importers operating in Australia.

Table 10.1 Expected heavy-duty LZEV market potential

Annual truck sales	Heavy-duty share[2]	Est. sales share	LZEV per OEM	Diesel per OEM
Total Au (2021)	40%	10%	13 OEMs	13 OEMs
41,404 →	16,561 →	1,656 →	127	1146
		20%	13 OEMs	13 OEMs
		3,312	254	1019

Table 10.2 Expected medium-duty LZEV market potential

Annual truck sales	Medium-duty share[1]	Est. sales share	LZEV per OEM	Diesel per OEM
Total Au (2021)	20%	10%	10 OEMs	10 OEMs
41,404 →	8,280 →	828 →	82	745
		20%	10 OEMs	10 OEMs
		1656	166	662

Table 10.3 Expected light-duty LZEV market potential

Annual truck sales	Light-duty share[1]	Est. sales share	LZEV per OEM	Diesel per OEM
Total Au (2021)	40%	20%	10 OEMs	10 OEMs
41,404 →	16,561 →	3312 →	331	1425
		40%	10 OEMs	10 OEMs
		6624	662	993

[2] Based on trucksales.com data, recent TIC data suggested a move in market share away from heavy-duty to light and medium-duty vehicles. Actual splits and whether this will remain a long-term trend was not included in this survey.

11 Implications for emissions

The OEM expectations for LZEV sales share were modelled to assess their impact on truck emissions out to 2030. The main assumptions in terms of fleet turnover, fuel/energy consumption, emissions intensity of fuels, and vehicle utilisation are included in Appendix A.

The graph shows that business-as-usual (BAU) growth in the freight task would see emissions increase by 19% from today without any improvement in efficiency or uptake of LZEVs, the black line in Figure 11.1. But even when including the emissions benefit of LZEVs at the rate the OEM's expect to see them sold, won't be enough to arrest emissions increasing from today's levels. By 2030, LZEVs could moderate emissions growth to 13.5%, but not create a reduction from today's level – see blue line, Figure 11.1.

To illustrate the size of the challenge, an extreme scenario was modelled involving a hypothetical mandate introduced from 1 January 2023 requiring ALL new truck sales to be ZEV (electric or hydrogen). TIC is not advocating for such an approach, or that it would even be possible, but for illustrative purposes even that extreme measure would only reduce truck emissions by 43% by 2030 (green line in Figure 11.1 below).

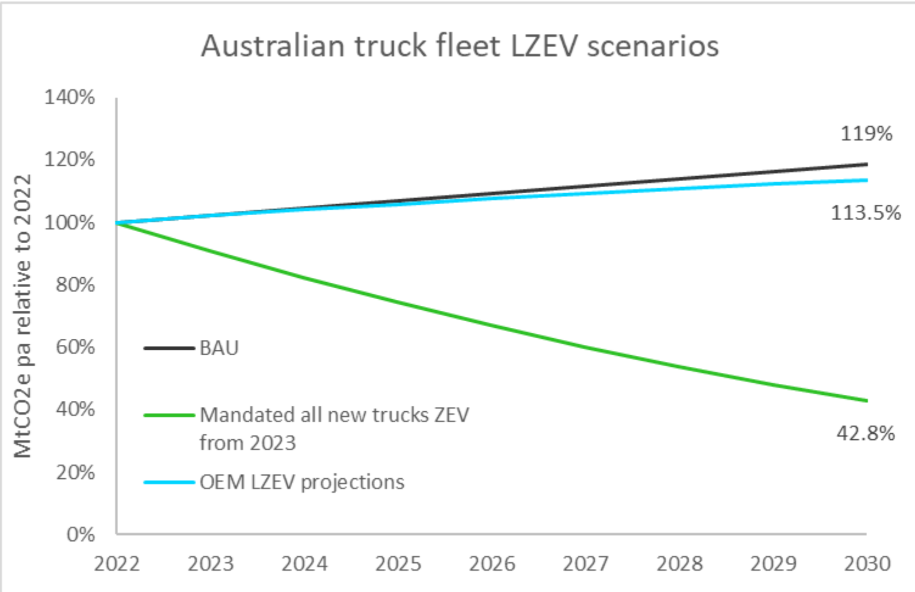


Figure 11.1 Expected sales share of LZEV vehicles in 2030 by segment

Extending the trajectory to 2050 shows that the hypothetical 1 January 2023 ZEV mandate would only just achieve zero emissions from the truck fleet by 2050. A more lenient approach requiring ALL new truck sales from 1 January 2023 being an equal split of Low (a minimum 50% emissions reduction for new trucks), or Zero (100% CO2 reduction for new trucks) would only see a reduction of 25%. Again, TIC is not recommending this approach, however this modelling highlights the limited CO_2 abatement effects that even the most extreme measures would achieve.

For comparison purposes, additional scenarios were modelled (Figure 11.2) to show the effect of different policy approaches. Compared with the original (above) hypothetical 1 January 2023 ZEV mandate (illustrated by the shaded green area in Figure 11.2 below):

- The blue line shows emissions increasing with freight task even with planned LZEV introductions
- The dashed green line shows the effect of delaying the ZEV mandate from 1 January 2023 to 1 January 2030
- The dashed red line shows emissions resulting from an LEV mandate in 2030 (minimum 50% emissions reduction for all new trucks), with emissions only falling around 15% from today's level

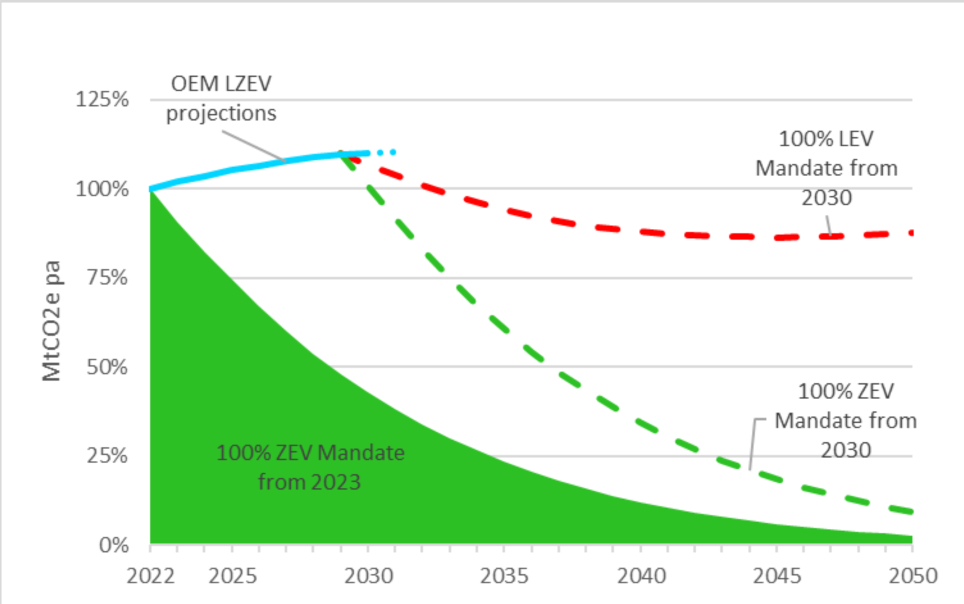


Figure 11.2 Expected sales share of LZEV vehicles in 2030 by segment

The two main scenarios (RED and GREEN lines in Figure 11.2) illustrate the difference between what everyone wants to achieve in terms of zero emissions, and what should be practically possible using technologies available today.

The GREEN line scenario would require ALL new trucks sold from mid 2022 to be ZEV. This is not realistic given the unsuitability of current ZEV technology in many applications, their high cost, limited supply, and the unlikelihood that governments would impose such an obligation on the market or that industry would accept it.

The RED line scenario (all LEVs from 1 January 2030) shows what might be considered the practical limit under a still highly ambitious approach. It builds off the current planned technology introductions of OEMs (blue line), which are effectively factored into the truck OEMs short to mid-term Australian business plans already. However, it allows the use of LEVs in segments where ZEV will not be suitable, and it includes time to build up domestic production capacity for renewable fuels for the modelled (LEV) case up to 2030. It is still a highly ambitious plan as it would require all new trucks to comply by 1 January 2030, which would most likely impose additional costs to the road transport industry, increasing freight costs and would be challenging from a truck supply perspective.

Again, TIC is NOT recommending either of these simplistic approaches. The scenarios are intended to show the potential (and highlight the difficulties) in reducing heavy vehicle emissions given the realities of the Australian truck market.

PART C: HOW?

TAKING THE RIGHT ACTION

12 The global policy response

UN participating governments have largely accepted the Intergovernmental Panel on Climate Change (IPPC) findings and committed to reduce emissions using a combination of measures under the Paris Climate Agreement (2015) and other instruments. Commitments include net zero goals, interim reduction targets, and other policies as shown in Table 12.1. The reductions to which countries committed are called Nationally Determined Contributions (NDC).

Released in the lead-up to the UN Climate Change Conference COP26, the 12th annual Gap Report (UNEP, 2021) highlighted that national actions and plans under the Paris Climate Agreement fall considerably short of both 2030 commitments and 2050 Net Zero goals. Projected emissions result in overall reductions of only 7.5% by 2030 compared to the 55% needed for a 1.5°C limit to global warming.

The United States re-joined the Paris Agreement on President Biden's first day in office, and then held the Leaders' Summit on Climate in April 2021 (USDS, 2021). The Summit led to the reinstatement of the US-led Major Economies on Energy and Climate Forum. A key outcome of this forum was the global methane pledge which the Australian government refused to sign. Other agreements and partnerships arising from COP26 negotiations included the following areas:

- Ending fossil fuel subsidies
- Putting a price on carbon
- Accelerating transition to EV's (LV's)
- Delivering $100b climate finance commitment
- Phasing down coal
- Phasing out methane
- Protecting vulnerable communities

Table 12.1 Country-specific decarbonisation targets and actions

	Net Zero	2030 Target	Transport specific targets	Dedicated transport plan	Fuel economy stds	Low carbon fuel std	ZEV Weight concessions	BEV/FCEV incentives	Charging infrastructure	Modal shift & multi-modal infrastructure	ETS or carbon price
EU	2050	55%	✓	✓	✓		✓	✓	✓	✓	✓
UK	2050	68%		✓				✓		✓	✓
Japan	2050	46%	✓		✓				✓		✓
China	2060	-			✓			✓	✓	✓	✓
US	2050	52%	Cali.		✓	✓	Calif.	✓	✓	✓	✓
New Zealand	2050	50%	✓	✓		✓		✓	✓	✓	✓
Australia	2050	43%						✓	✓		

12.1 Transport and freight focussed policies

Only 16% of Paris Agreement signatories included transport-related targets in their NDC (ITF, 2021a; ITF, 2021b). Where they do exist, most transport-related decarbonisation policies are focussed on passenger vehicles, public mobility, and infrastructure. Technology improvements and mode shift away from road transport are proposed as solutions for heavy vehicles and freight, but with few specific actions to drive that change. The EU, UK, and more recently NZ, have transport-specific decarbonisation plans.

The European Automobile Manufacturers Association (ACEA) has called for clearer direction along with longer-term binding targets. Without clear policy direction, ACEA suggests the investment and production boost required to transition to fossil-free fuels will not be achieved (ACEA, 2021a). Clear and decisive policy encourages suppliers and customers to move together, reducing transition risks for each.

The most common policies to have emerged for light vehicles include bans on high carbon producing technologies; incentivising transition to alternative solutions such as electric vehicles; and fuel economy and CO_2 regulations (a mechanism that predates COP26 and the Paris Agreement). While countries have implemented a mix of approaches for light vehicles, there is an increasing focus on the application of similar solutions within the truck and bus sectors to abate growing emissions resulting from the increasing freight task. The three key approaches for trucks and freight are described below.

Many of the policies supporting the transition to LZEVs were originally created to solve a different problem – air pollution. Air quality has a much more acute and localised effect on human health, so vehicles that emit low levels or zero tailpipe pollution are seen as a critical, urgent pathway to reduce the disease and economic burden of affected communities the world over. Climate policies have merely amplified what was an already important need.

Many policies for low-carbon vehicles were created for a different problem: air pollution.

12.1.1 Fuel economy / CO_2 regulations & standards

Increasingly stringent regulations are considered an essential policy element to accelerate uptake of new models and technology (ITF, 2021b). Regulations currently apply in all major truck origin markets (US, EU, Japan, China, India and Korea), with over 75% of 2020 global truck sales being within markets that have fuel economy and CO_2 emission standards in place (IEA, 2021c). The U.S. and the E.U. regulations are seeking to reduce CO_2 emissions from truck fleets by 50% and 40% respectively (ICCT, 2019). The International Energy Agency (IEA) suggests further development should include improved compliance testing, such as adoption of a standard WHTC testing cycle, as well as inclusion of Scope 3 emissions to account for emissions associated with vehicle production and disposal (IEA, 2020). One study found that the CO_2 benefit achieved in the US through CARB's higher emissions standards was equivalent to the policy effect of raising fuel pricing by over 145% (Lim, 2019).

12.1.2 Restrictions on sale or road access

Many regions, countries, cities or towns, have *proposed* target dates for total bans on ICE vehicles, which would operate as sales bans. Target years for bans on the sale of new ICE cars are now commonplace (e.g. 2035 in the EU), but less common for trucks. The UK has announced a ban on sales of new ICE trucks by 2035 (Randall, 2021). However, there are few legislative instruments in place to enable this, and unlike light vehicles which are easier to replace with an EV, it is likely that regulators are waiting to see how the technology progresses for trucks before locking in unachievable targets.

However, there are many areas that already operate with restricted road access for trucks based on age and/or emission performance across the EU and Asia. These are increasingly common in regions impacted by high air pollution and noise (Austroads, 2021). Options to restrict road access include:

- Forced retirement, such as setting maximum age limits on vehicles (e.g. 15 years in Hong Kong; 20 years in Singapore), with trucks older than the threshold no longer able to be registered.

Low emission zones: over 200 cities across 12 European Union countries have implemented low emission zones linked to vehicle emissions standards, with the only vehicles allowed to enter the zone being those that meet or exceed a specific regulatory threshold (e.g. Euro VI) (CLARS, n.d.).

12.1.3 Financial incentives and penalties

Subsidies and Rebates

Countries across the EU, as well as China, Japan, India and the US have introduced a mix of subsidies and rebates to incentivise sales of electric and fuel cell vehicles. These incentives range from tax reductions and exemptions such as stamp duty and registration fee discounts, to direct grants and purchase rebates that help close the price gap between conventional vehicles and new technology alternatives.

Plug-in Grants (UK) – supports sales of low emission vehicles with grants varying by class from £150 for mopeds up to £25,000 for large trucks (12,000kg+)

Hybrid and Zero Emission Truck and Bus Vouchers (California) – point of sale discounts to drive commercial LZEV technology transition, allocated by class from $US45,000 to $US198,000.

Carbon Pricing

Greenhouse gas emissions represent a market failure in which the cost of emissions (climate change impacts) is not paid by emitters. Pricing emissions provides an incentive for large emitters to reduce their output.

Figure 12.1 shows many countries are implementing a carbon tax, emissions trading schemes, or some combination of the two. To ensure fair pricing and to avoid carbon leakage (companies migrating to areas without a carbon price), countries are now considering carbon border tax adjustments for imported goods that do not have a carbon tax applied in their origin market.

12.1.4 Differentiated road charging

All trucks pay road charges of some sort, from simple vehicle registration fees to road user charges. An alternative or supplement to carbon pricing is to levy vehicle fees based on the carbon emission intensity of the vehicle, which is done in the UK. This is easy for cars which have a standard fuel consumption or CO_2 test as part of their compliance testing, but harder for trucks which do not have an analogous requirement. Instead, most EU countries link road fees to vehicle age (emissions standard) or fuel type. LZEVs can benefit under such schemes by attracting lower fees and taxes, offset by older and higher-emitting vehicles incurring higher fees (ACEA, 2020).

Eurovignette (EU) – The EU is updating their road charging rules, phasing out time-based vignettes (day passes) over the next 10 years, and instead moving to a CO_2 emissions-based charge.

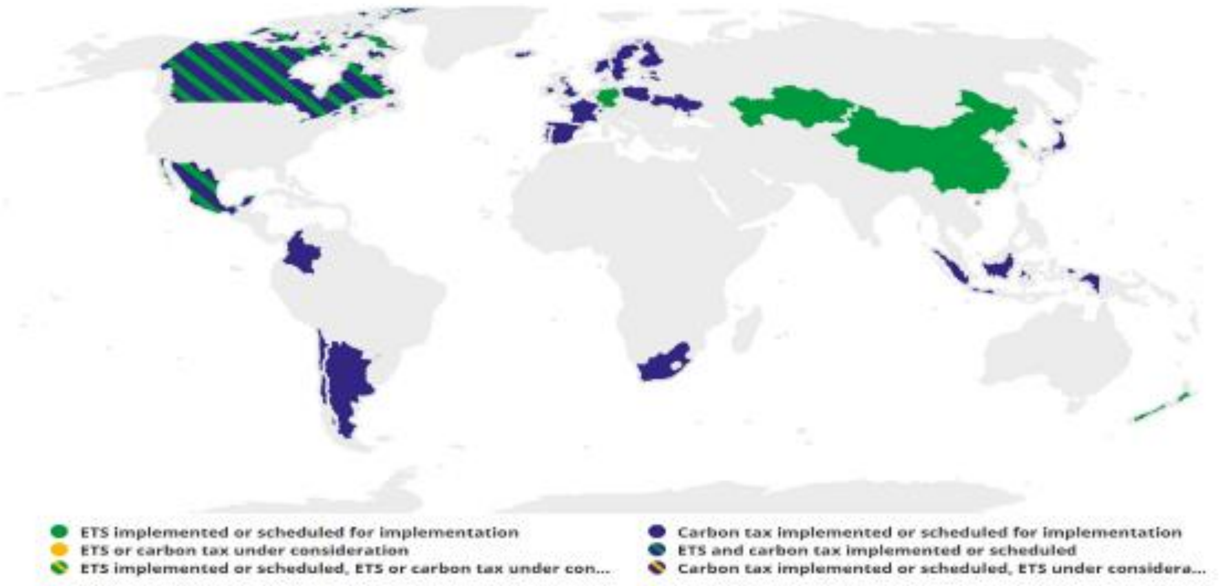


Figure 12.1 Global ETS or Carbon Tax (WO, 2021)

12.1.5 Vehicle scrappage incentives

China has had some success in phasing out older (yellow label) trucks via scrappage payments. EU countries had proposed similar schemes to replace older vehicles with new trucks using COVID recovery stimulus funding. Such schemes can be effective in reducing pollution, but less so for CO_2, as replacing old diesel fuelled trucks with newer diesel fuelled trucks is not considered good long-term policy (Cornelis, S, 2020). Instead, this type of accelerated fleet renewal scheme can be turned to replacing older vehicles with LZEVS to ensure long-term benefits. Examples include the Port of Los Angeles and New York City's program (see below).

12.1.6 Green freight / truck programs

These programs are often funded or co-funded by government to reduce emissions via efficient operation of truck fleets. They include education, recognition, and demonstration elements (IEA, 2020). The US Smartway program is seen as the gold standard for green freight programs. Australia has had several attempts at green freight programs, and while there have been some benefits to these programs, they have not had the ongoing financial support to continue long term.

SmartWay (US) – 3700+ participating fleets saving over $US41.8 billion and 143 Mt CO_2**.**

Objetif CO_2/Fret21 (France) – 1850+ participants who have saved an average 829 kt CO_2-e.

12.2 Policy effectiveness

In 2021, the global market share of LZEV trucks was only around 4.1% (ACEA 2022). If the objective of these policy efforts to date has been to increase the adoption of LZEV trucks, one might say they have not been very effective. However, this seemingly small share represents significant growth year-on-year, and merely highlights that the truck market is a few years behind cars in its rate of technology transition. Few experts would doubt that the transition is underway and will accelerate in coming years. However, due to a lack of effective policies here, the Australian market share of LZEV trucks is much lower than the global average, tracking at just 0.1% in 2022 (TIC July 2022).

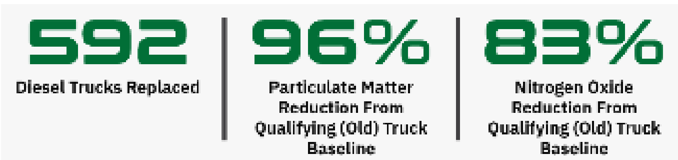
Case Study – Hunt Point Clean Trucks Program, New York City (NYCCTP, 2022)

Air pollution was identified as a leading threat to community health in New York City, attributed to more than 2,000 deaths and over 6,000 hospital emergency visits each year.

The Clean Trucks Program was established to reduce emissions and improve health & environment outcomes. Class 4-8 truck owners and operators within the identified Industrial Business Zones are eligible to participate. The program is managed by the City of New York, with funding from a federal congestions and air quality program.

Rebates from $12k to $185k are available under the program depending on fuel type and truck size. The funding can be used to buy new low emission vehicles, retrofit current fleet vehicles with new technology, or scrap old high polluting vehicles.

Since its launch in 2012 the program has achieved:



Lessons for success:

- Flexible to suit business need, capability, and capacity (buy/retrofit/scrap options);
- Provide a meaningful financial contribution to close the LZEV price gap; and
- Support local manufacturers and operators.

Note: the foundation motivation for this and similar programs is often the human health impact of air pollution, not carbon emissions. LZEVs can address both issues.

13 Australia's Policy Response

With a renewed focus on climate change by the U.S. under the Biden administration, and ever worsening scientific findings from the IPCC, there is mounting international pressure for all countries to act decisively. The rationale for action is clear: risk mitigation, harm minimisation, and opportunity realisation. All are particularly important for Australia as the driest inhabited continent and as a physically isolated island detached from the world's main markets. But politics has shaped our current policy mix, particularly as it affects the transport and freight sectors.

13.1 Political Context

Australia was once seen as a leader on climate change. The federal government implemented Australia's first climate target in 1990, seeking to lower GHG emissions to 20 percent below 1988 levels by 2005, with each state and territory providing a detailed response plan (Taylor, 2014). However, Australia has struggled culturally to transition from an economy based on resources and agriculture to one of "knowledge and the application of technology", favouring policies that sustain traditional sectors rather than new sectors (Charles. M., 2021).

Underpinning the inertia has been twenty years of political and philosophical "climate wars", with very little in the way of bipartisan action from successive Labor or Coalition governments (Crowley K. , 2021). The toxic politics of Australia's climate wars is well documented and analysed elsewhere[3]. In summary, political opportunism surrounding climate change and energy has twisted policy to the extreme, simply to oppose or wedge opponents or to win over a particular electorate. In some cases, traditional ideologies of the two main parties seem to have been abandoned or even swapped. Examples include:

- The then Coalition Government actively "picked winners" and intervened in the energy market by directly funding gas, coal, or electricity projects; and established new protectionist subsidies to support existing fuel refineries.
- The then Coalition Government ignored a chorus of calls from many big businesses telling the government what business needs in terms of meaningful emissions policies and targets, while at the same time the government criticised those businesses that acted, threatening to break up companies in a bid to lower energy prices.
- On carbon pricing, Labor proposed a carbon tax (Rudd), said it wouldn't implement one (Gillard), then introduced a carbon pricing policy that was effective at reducing emissions (but that was dumped as policy by the Coalition Government when they came to power in 2013).
- Having axed the policy, the Coalition then introduced a voluntary "direct action" scheme (the Emissions Reduction Fund or ERF) that establishes a default carbon price. Ironically, Labor's

[3] https://reneweconomy.com.au/the-toxic-political-culture-that-makes-good-policy-impossible-in-australia-40804/

https://www.theguardian.com/commentisfree/2021/apr/21/australias-ambition-on-climate-change-is-held-back-by-a-toxic-mix-of-rightwing-politics-media-and-vested-interests

https://www.themandarin.com.au/140323-the-carbon-club-toxic-politics-must-go-before-australia-can-ever-develop-another-climate-policy/

https://www.afr.com/chanticleer/agl-buyback-decision-shows-energy-politics-poisonous-for-shareholders-20190207-h1ayhx carbon tax saw companies pay $23/tonne, while carbon credits under the ERF have increased to $60/tonne (ABC News, 2022).

- On the other side, the now Labor Government argued, at the time, for market-led policies but has seemingly abandoned carbon pricing altogether, globally accepted as the most effective market mechanism to reduce emissions.
- After earlier committing to a net zero target in the lead up to a potentially embarrassing international climate conference in Glasgow (COP26), and in preparation for a federal election which it subsequently lost, the Coalition has said it will now reconsider its commitment to the target.

Australia's largest emitting sector, electricity generation, has been the main battleground both between and within political parties. Critics point to more than 20 abandoned energy policies[4] over the last decade alone – all victims of the political tumult.

Close behind the energy sector is the flow-on effect on "mining jobs", a rallying point for a culture war using job security to pit regional and urban electorates against one another. What coal and other fossil fuel employees need is the reassurance of a well-developed and realistic transition strategy that leverages growth in other growth sectors like renewable energy and information to deliver alternative high quality job opportunities. They don't have that yet from either side.

Ultimately, voters will decide how the war continues or ends. Climate change and net zero commitments are becoming increasingly influential in consumer and investor decisions. The business sector has recognised the need and has simply ploughed ahead doing what it sees as necessary in the absence of political leadership. As such, there is unlikely to be a political price for adopting ambitious policies. The national position is already benefiting from commitments and actions of the states and the private sector, such that federal action has become merely supplementary – or perhaps redundant.

Indeed, the states show how twisted the federal debate has become. Regardless of political persuasion, nearly all states adopted net zero targets ahead of the federal government, as well as renewable energy policies and associated transition strategies and action plans.

Since the recent federal election in which the Labor party came to power, and set against rocketing living costs and international wars, the climate debate has been somewhat more subdued. But it hasn't ended. Some Nationals MPs reinstated at the federal election, have been emboldened by their win and are pushing hard to oppose stronger climate action. The Coalition is reviewing its position on Net Zero. Labor is still reluctant to adopt strong regulatory or pricing measures that its opponents might reframe as taxes.

By way of comparison, the various policy commitments and programs proposed by the main three parties at a federal level are compared in the table below.

Table 13.1 Summary of emissions targets and policy commitments of Australia's main three political parties

4 https://www.theguardian.com/australia-news/2021/oct/17/eight-years-20-policies-how-australias-leaders-have-fumbled-and-dithered-on-climate

		LNP Coalition	ALP	Greens
Net Zero Emissions		By 2050	By 2050	Net Zero or negative by 2035
Interim Emissions Reduction Targets		26-28% from 2005 by 2030	43% from 2005 by 2030	Binding annual targets and national emissions limits,
Carbon Price		No Carbon Price	No carbon tax or any new revenue from climate policies. Strengthen the ERF Safeguard Mechanism	Price on carbon - Mirror EU price
Transport specific policies	Standards			Energy efficiency targets and stringent Min energy performance standards
Transport specific policies	Plan	Develop national electric vehicle strategy (due 2020)	Develop a domestic decarbonized vehicle industry strategy	National plan for freight transport outlining transition to net zero transport.
Transport specific policies	Mode		No preference for mode, fair share of funding.	National freight and passenger rail network
Transport specific policies	Energy	Technology road map includes hydrogen and electricity	Cut pollution by moving towards a clean transport system, inc. hydrogen.	Switching transport to clean energy, incl. green hydrogen
Transport specific policies	Programs	$18b Technology Investment Roadmap ($50b private investment) Future Fuels strategy with focus on infrastructure Freight Energy Productivity Program – focused on trials and information Modern manufacturing strategy – modernization and supply chain resilience	National approach to transition to low or zero emission transport sector Adoption of new transport technologies Green industry policy Removal of 5% import tariff Potential changes to FBT to support shift to EVs	Research and develop net zero fuels and transport tech, inc. Green Hydrogen Remove all fossil fuel subsidies. Reporting for all sectors with significant greenhouse emissions Ban on ICE vehicles by 2030

13.2 National Emissions Policy

Australia participates in a range of international bodies as well as bilateral and multilateral agreements. Many of these include climate change and the environment in their agenda or purpose; however, only a few have developed specific agreements, measures, or targets (Figure 13.1). Within these, there is little consequence for non-adherence, limiting their effectiveness as instruments of change. The figure includes the bodies involved (green) as well as the resulting agreements (blue and red text in boxes).

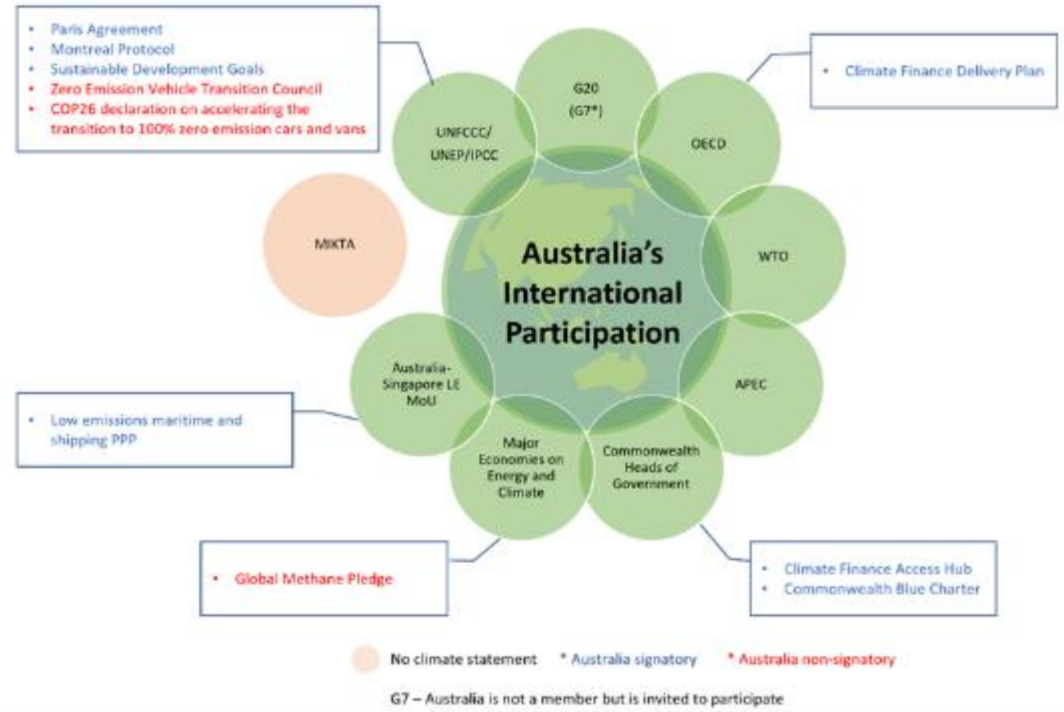


Figure 13.1 International bodies and agreements in which Australia participates

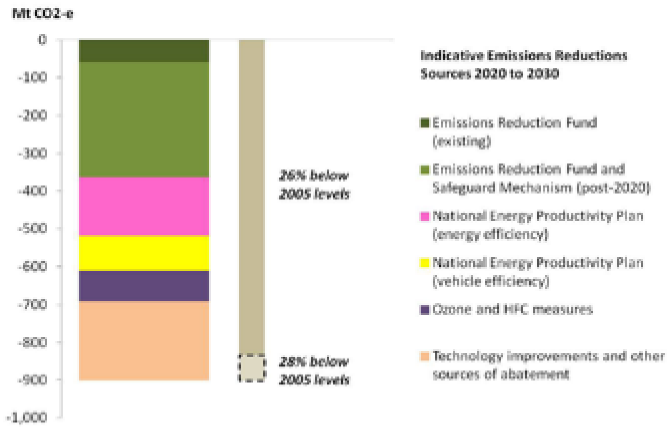
Of the few international bodies to have set actions, the OECD Climate Finance Delivery Plan fell well short of its 2020 investment goal, with Australia one of the few countries singled out for not making it's "fair share" of contributions. More recently, under President Biden's re-established Major Economies on Energy and Climate forum, Australia was one of few countries to not sign the "Global Methane Pledge".

In late 2021, the then Coalition federal government overcame a major internal debate among coalition partners to commit to Net Zero by 2050. The new Labor government also has the same net zero commitment. However, with most states and territories already committed to that goal, the Commonwealth commitment is redundant but perhaps symbolic of a shift in political and economic realities. The plan to achieve this, Australia's Long-Term Emissions Reduction Plan, was released in the lead up to COP26.

Analysis of Labor and Coalition 2030 targets is detailed in the table below. Additionally, the Coalition government developed their plan and modelling to cover the period to 2050. Critics were quick to point out that it has only been costed to cover the period to 2030 (at $20 billion); and that it relies on a 15% reduction via technologies and advancements yet to be identified. It also persisted with a reliance on a 'gas led recovery' that has been controversial from its first mention more than a year before. For transport, it promised a near 75% emissions reduction by 2050, but much of that was modelled on hydrogen uptake and EV policies that were not articulated.

Ignoring the political rhetoric and unrealistic policy projections developed for the 2022 federal election, official government projections show truck emissions will increase by 2030 as discussed in Part A of this report.

Table 13.2 Transport contribution to emissions reductions – LNP and ALP

	Transport specific inclusions	Modeling
LNP Coalition	National Energy Productivity Plan (Yellow) includes the FEPP to improve energy efficiency in Freight – focused on information and trials	
Labor	EV discounts (Tariff and FBT) EV charging infrastructure Real world emissions testing program *Focused on light passenger vehicles 4 million tonnes CO_2-e reduction in transport by 2030	

The Coalition plan includes some key policies and programs for heavy vehicles, bundled under the Future Fuels Strategy (FFS). Sub-programs include the $24.5 million Freight Energy Productivity Program (FEPP), as well as the Future Fuels Fund to subsidise the cost of zero emission vehicles and charging / refuelling equipment. Modelling released shows the plan also relies on transport emissions reduction of up to 71%.

Labor's plan includes specific transport policies; however, these are focused on light passenger vehicles rather than road freight or heavy vehicles.

Both sides show a heavy investment in hydrogen and carbon capture, use, and storage technology (CCUS). This represents a classic 'end of pipe' solution, attempting to fix the problem after it happens (offset) rather than addressing the problem at the source (avoid). This acknowledges that it may not be financially or technically feasible for all industries to adopt zero emission pathways and relies on other sectors to over-achieve on their carbon balance.

In all cases, Australia only accounts for and reports direct emissions (Scope 1 and 2), not whole-of-life emissions upstream or downstream in the value chain (Scope 3). This means that emission from production of items and equipment imported into Australia, or emissions created by burning coal/oil exported from Australia, are not counted in national reporting. Companies are only required to report their Scope 1 and 2 emissions is in line with IPCC practice.

13.3 State level policies, strategies, and plans

As noted earlier, state government targets and policies have until recently demonstrated a higher level of commitment and action than federal policies (CAT, 2021). Examples are provided in the table below, along with colour coding of states to indicate their governing party (Labor, Coalition).

While the ACT's Labor/Greens coalition is the most ambitious in climate targets and policy, they were closely followed by the then NSW Coalition.

Similar to the situation globally, states have focused on light vehicles, passenger transport, and charging infrastructure. NSW has released a fleet incentive program, but this excludes heavy vehicles as the government does not see them as being market ready. Additionally, the NSW fleet program is a more complex reverse auction process based on an abatement per dollar of grant received, compared to a flat rebate per EV for private purchases, despite both schemes covering similar classes of vehicles. It cannot be assumed that governments would use the same policy approach for heavy vehicles as for light vehicles.

Table 13.3 Comparison of state emissions targets and policy commitments

	Net Zero	2030 Target	Transport specific targets	Transport/EV plan	BEV/FCEV incentives	Charging infrastructure	Hydrogen and/or biofuel development	Modal shift & multi-modal infrastructure
QLD (Labor)	2050	30%		✓	✓	✓	✓	
NSW (Labor)	2050	50%	✓	✓	✓	✓	✓	
Victoria (Labor)	2050	45-50%	✓	✓	✓	✓	✓	✓
WA (Labor)	2050			✓		✓	✓	
South Aust. (Labor)	2050	50%		✓	✓	✓		
Tasmania (Lib)	2050	26-28%		✓	✓	✓		
ACT (Lab/Gn)	2045	65-75%	✓	✓	✓	✓		✓
NT (Labor)	2050				✓			

13.4 Specific program support

There are several programs that support improvements in fuel efficiency or support a shift to alternative fuels/electrification, which both lead to emissions reductions. These are summarised below.

Program	Detail	Insights/Opportunities
Emissions Reduction Fund	Intended to incentivize businesses to reduce emissions via a carbon credit program that puts a price on carbon. Credits can be generated through projects involving: • new technology • upgrading equipment • changing business practices to improve productivity/energy use One Australian Carbon Credit Units (ACCUs) for every tonne of emissions reduced or stored. These units can be on sold as offsets or sold back to the government via an auction process.	Emissions aggregators projects–pooling client emissions under a project
National Energy Productivity Plan (NEPP)	Intended to improve energy productivity by 40% by 2030, the NEPP covers a suite of projects and reforms with a "whole-of-system" approach, including energy policy, electricity and transport fuels. While the NEPP hasn't published an annual progress report since 2018 there is some project overlap with other government initiatives such as FFS and FEPP (see below).	Opportunities under: ▪ Modern manufacturing strategy; and ▪ FEPP/FFP.

Program	Detail	Insights/Opportunities
Future Fuels and Vehicles Strategy	Priorities include: • Electric vehicle charging and hydrogen refueling infrastructure • Fleets First approach (Passenger fleets) • Improved information for fleets (FEPP) and motorists • Integrate battery electric vehicles into the electricity grid • Support Australian innovation and manufacturing	Opportunities under: • Modern manufacturing strategy; • FEPP/FFF.
Future Fuels Program	Round two funding through ARENA is seeking to overcome barriers to ZEV uptake by fleets, focused on enabling infrastructure, including charging infrastructure, electrical upgrades, as well as support the acquisition of heavy vehicles. Minimum grant amount is $1M with applicants expected to match funding amount being sought. Smaller operators may need to find partners and submit a joint proposal.	Aggregation of customers for joint bid.
Modern Manufacturing Strategy	Supports mining and manufacturing capability, with a focus on • Upgrading to efficient and transformative manufacturing processes; and • Jobs growth and development of skilled workforce. Delivered through the Industries Road map.	Plant and system upgrades for LZEV production; Possible training for workshop staff in BEV/FCEV skills; Current funding rounds under this program have closed.
Renewable Energy Target (RET)	National scheme to reduce GHG emissions from the energy sector. Allows businesses with small to large scale renewable energy generation capacity to earn certificates for every MWh of power generated. These certificates can be sold to electricity retailers. There is no RET	Companies with onsite infrastructure can sell excess energy generation, improving the transition business case. OEM's involved in infrastructure installation may be able to own and trade these certificates under similar arrangements to current residential solar PV certificates.
Freight Energy Productivity Program (FEPP)	Addressing barriers to the roll out of new vehicle technologies. Investing in early-stage technologies to stimulate the market and drive private sector investment. Giving businesses information to help them make informed choices.	Trials, ratings, demonstrations to collect real world data and case studies. May provide opportunities for manufacturers, fleets and freight customers.

13.5 Current policy gaps and areas for improvement

Most current transport and vehicle policies and regulations were established under the prevailing diesel engine paradigm. The introduction of low and zero emission vehicles requires governments at all levels to review current legislation, policies, and processes to ensure they remain relevant to the new technologies.

Fuel excise, road user charges and fuel tax credits. Fuel excise is intended as a user pays mechanism for governments to raise funds for road infrastructure construction and maintenance. The excise is included in the price of fuel at the pump at a current rate of 48.8 cents per litre for petrol and diesel, and 15.6 cents per litre for LPG. For heavy vehicle operators this amount is reduced by the application of the Fuel Tax Credit and Road User Charge. This enables fuel used for business that is not on public roads to be reimbursed for the fuel excise, while the road user charge provides a reduced fuel excise rate for on road business purposes.

Table 13.4 Fuel excise factors for use on public roads

Fuel Excise	Heavy vehicle road user charge		Fuel tax credit	
Included in the sale price	Used to reduce the fuel tax credit (**RUC**)		Full tax credit* (**FTC**)	Actual tax credit (**FTC-RUC**)
48.8c/L	Liquid fuels (diesel)	28.8c/L	48.8c/L	20.0c/L
	B5, B10, B20	28.8c/L	48.8c/L	20.0c/L
13.0c/L	>B20 to B100	13.0c/L	13.0c/L	0
15.6c/L	LPG	15.6c/L	15.6c/L	0
30.3c/L	LNG/CNG	30.3c/kg	30.3c/kg	0
0	BEV	0	0	0

*Full tax credit is paid for non-public road use.

Other than biodiesel up to B20, alternative fuels pay a road user charge at the tax credit rate and therefore do not derive any of the fuel excise discount currently available with Diesel.

Transitioning to ZEVs removes the need to refuel using any of the liquid or gaseous fuels above, and therefore reduces the road funding potential for governments via the fuel excise. To maintain a user pays model, States are looking at different ways to impose road user charges for ZEVs. Currently operational in Victoria and planned for implementation in New South Wales, these charges are included in annual vehicle registration fees based on a distance travelled rate. This creates an additional administrative burden for fleets as evidence of km travelled needs to be provided to determine the amount due.

Heavy vehicle registration fees. Accounting for approximately 40% of cost recovery for heavy vehicle road use, these charges are fundamentally based on the number of truck axles and mass. Due to the added mass of LZEV technologies, such as batteries in a BEV, registration caps may need to be considered to reduce the price premium of new technologies and improve the total cost of ownership business case for fleet transitions. Some states and territories have provided registration discounts or fee "holidays" for ZEVs, as used in some overseas markets to incentivise ZEVs.

ADR's and Axle Mass. Alignment of the Australian Design Rules to overseas regulations. The Euro VI emissions standard and equivalents from Japan and the USA, already active for many years in Europe, Japan and America, will commence from 1st November 2024 for NEW model heavy vehicles and for ALL mode heavy vehicles from 1st November 2025 (ADR80/04) in Australia. This has put Australia 8 to 14 years behind these major global markets (the truck's/engine's country of origin). Depending on when Euro VII and equivalents are adopted overseas, that misalignment with international regulations will likely re-emerge. The ongoing implications for the Australian market include:

- Increased cost of trucks accounting for redesign of new overseas models to suit older, non globally aligned, Australian standards.
- Delayed introduction of new "cleaner" emission technologies to the Australian market

LZEVs already suffer a payload penalty, however Australia's lower axle limits exacerbate this and thereby add a further barrier to market adoption. In 2021 European countries announced that they would allow LZEVs to operate with an additional axle mass allowance of up to 2000kg (over a similar diesel ICE truck) to account for the payload disadvantage associated with the additional weight of a LZEV. Australia currently lags Europe with regard to axle masses for diesel trucks by typically 1000kg, now with the additional European axle mass allowance of up to 2000kg, the same LZEV in Europe can operate with payloads of up to 3000kg greater than the same LZEV in Australia. That is a significant productivity loss for Australian LZEV operators, compared to their European counterparts.

In addition to engine emissions (Euro VI) and axle mass, regulations governing maximum, height and width are also different in Australia than overseas (e.g. 2.5 metres width versus 2.55m or 2.6m in the EU and US respectively). This also limits importation of overseas models to Australia, significantly reducing LZEV availability here. Potential solutions to the above issues include:

- Fast track regulation harmonisation – ensuring Australian regulations remain in line with international counterparts, allowing higher axle masses, increased dimensions and the latest global engine emission technologies.
- LZEV specific mass concessions – As per other regions, such the EU and US, Australia should implement LZEV mass concessions, to remove the payload disadvantage associated with LZEV technologies.

Mass and time curfews. Curfews are used in most states to control noise in urban areas. While the COVID-19 pandemic saw states temporarily lift curfews to assist with resupply, the long-term use and purpose of curfews for LZEV's needs to be considered. BEV and FCEV technology is quieter and does not produce tailpipe emissions. Urban amenity can be enhanced with ZEVs whilst also satisfying industry calls to permanently remove curfews. States should consider ongoing curfew exemptions for these technologies.

Appropriate targeting of incentives. This is particularly important when seeking to effect change within a disparate truck industry. Over 90% of road freight operators have fewer than 5 trucks, operating on low margins and limited capacity to undertake detailed research into new technology and energy analysis. While current government support programs are welcomed by large companies, it is difficult to see how these complex grant programs with high minimum grant thresholds and complex application processes can be accessed directly by resource poor small operators. Direct cash incentives, such as those available to consumers for electric cars, may be more effective.

Investing in supply is just as important as stimulating demand. Nations that have existing vehicle manufacturing industries and policies to increase the uptake of ZEVs have moved to support local factories to transition to LZEVs. From as far back as 2010, when technology winners were less clear, European, US, Japanese and Chinese governments were supporting manufactures to develop capability and capacity in ZEV manufacturing[5]. Policies have typically formed part of economic recovery or innovation acceleration programs focused on domestic manufacturing. Policies to promote in-country manufacturing are as important as those supporting the demand side[6].

Incentives have included direct funding and low or no interest loans to vehicle, battery, or fuel system manufacturers. ZEV sales targets and mandates have also been supportive in sending a message to the industry that the transition will occur and galvanising their investment. This has been particularly noticeable in China where central planning supported by sales targets, incentives, and investment encouragement has solidified their position as the world's larger producer of ZEVs[7].

For a country like Australia, with a healthy truck manufacturing industry but isolated from other markets, support for the transition to new technologies may be essential.

[5] https://theicct.org/sites/default/files/publications/ICCT_VEPstudy_Mar2011_no4.pdf

[6] https://theicct.org/the-transition-to-electric-cars-how-can-policy-pave-the-way/

[7] https://theicct.org/publication/power-play-how-governments-are-spurring-the-electric-vehicle-industry/

Free market approach: increasing or decreasing choice in vehicles? Lessons from cars.

The UK market makes for an interesting comparison. Starting with approximately the same market share for electric vehicles as Australia in 2011 (0.2%), the subsequent decade has seen EV sales jump to more than 20% of the UK market due to regulations, strong policies, and incentives; while Australia languishes at around 2%. February saw an all-time record for EVs market share in the UK, with 26% of all sold vehicles that month having a plug.

The former Coalition government insisted it was maintaining consumer choice by not regulating fuel efficiency or carbon emissions, and not subsidising low emission vehicles. But such an approach in fact results in less choice and fewer opportunities to switch to a greener vehicle. Significant demand for new electric vehicles is currently going unmet, with EV waiting times stretching well beyond one year and some car brands suggesting they could sell six times more than they do currently. But the supply of vehicles from their parent companies is constrained as models and production volume go to markets with stronger carbon policies, while Australian customers wait for leftovers.

This example relates to the market for light vehicles, half of which are purchased privately in a semi-emotional consumer decision. But half of all new light vehicles are also sold to fleets who mostly make decisions based on commercial not emotional factors, and it includes light commercial vehicles (utes and vans - the smaller cousins of trucks). So, it also serves as a relevant warning for a potential future for the truck market.

Supply chain shortages affecting microchips and other components are already well documented, resulting in some truck models having waiting times over a year. Should government continue a hands-off approach to LZEV supply – the most globally in-demand segment of the truck market – then just like in the car market, truck suppliers will be forced to compete for volumes with other markets that are hands-on (in terms of mandatory requirements and incentives), and we are likely to go down the same path as the car market for ZEV supply.

14 Industry Context

Frustrated by the political seesaw on climate policy and the resultant lack of progress at a federal level, the rest of the community has moved ahead of government. There is an intensifying push by consumers and investors to support companies demonstrating a commitment to climate action. Almost a quarter of ASX200 companies reported net zero commitments in 2021 (Figure 14.1), representing more than $1 trillion dollars (50%) of market capital, and triple the previous year's result (ACSI, 2021). Corporate commitments are linked to the weight consumers place on social responsibility, with 60% of climate poll participants supporting more climate action even if it involves significant cost, and 74% stating the benefits of taking further action on climate change outweighs the costs (Lowy Institute, 2021).

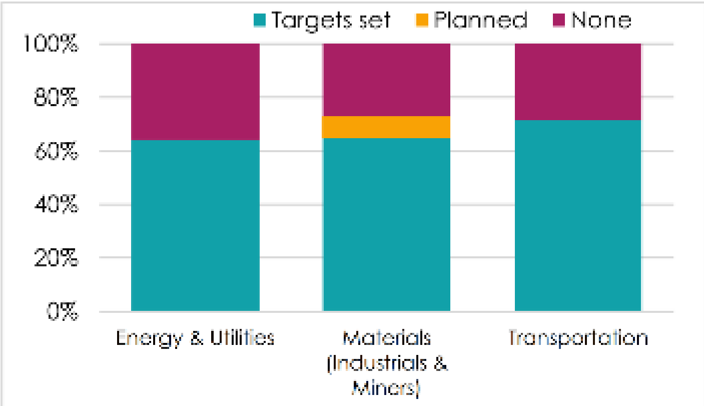


Figure 14.1 Targets set by ASX200 companies by industry (ACSI, 2021)

The level of accountability and reporting by these companies varies from public announcements of decarbonisation targets, through to more stringent requirements such as inclusion of Scope 3 emissions and executive performance targets. Examples of some prominent companies are listed in Table 14.1.

Emissions Targets	Net Zero Commitment	Scope 3 Targets	Link to Exec Salary
94 Companies, including:	49 companies, including:	Amcor	AGL Energy
AMP	BHP	BHP	Ampol
BHP	Rio Tinto	Boral	BHP
BlueScope Steel	ADBRI	CBA	Beach Energy
Coca-Cola Amatil	Fortescue Metals	Coca Cola Amatil	BlueScope Steel
Fisher & Paykel Healthcare	Ampol	Fisher & Paykel Healthcare	Origin Energy
Insurance Aust.	Origin Energy	Origin Energy	Orica
NAB	AGL	REA Group	Oil Search
Origin Energy	Transurban	Rio Tinto	Rio Tinto
QBE Ins	Wesfarmers	South32	South32
Suncorp		Santos	Santos
Transurban		Transurban	Woodside Petroleum
Westfield		Westfield	
Woolworths		Woolworths	

Table 14.1 ASX200 climate change reporting (not exhaustive) (ACSI, 2021)

Many industry groups in Australia had long held public positions supporting stronger action on climate change well before the Coalition government's adoption of a net zero target in October 2021. While welcoming the shift in position, both then and after the recent federal election, calls remain for stronger action at a national level to provide investment certainty and assistance for affected sectors.

Australian Industry Group indicated a 43% target was "consistent with our trading partners and the directions industry has called for". Regardless of who is in government, the important step is the policies to get there, with industry needing "ambitious, predictable and efficient policy frameworks" (AIG, 2021).

Australian Retailers Association has a net-zero roadmap and joined the UN's Race to Zero Accelerator Pledge. Their pathways include increasing data capture and data quality, continuing to improve fuel efficiency, and a transition to electric and hydrogen vehicles (ARA, 2021).

The transport sector comprises many players including road and infrastructure owners and managers, vehicle manufacturers and dealers, fleets, freight and logistics providers, freight customers, and private motorists. All need government to provide stable policy settings. The central call from industry bodies is for a clear national plan with supporting policies and programs including a mix of regulation and incentives. Transport sector bodies representing various stakeholders support strong climate action, with three examples below.

- **Roads Australia, Infrastructure Sustainability Council, and Australasian Railways Association** recently published a collaborative report – The Journey to Net Zero – which it described as a 'call to action' to transform the sector as it decarbonises, including the need for a national strategic approach.
- **Federal Chamber of Automotive Industries (FCAI)** represents car manufacturers (TIC's Light Vehicle counterpart), raising concerns with Australia lacking a long-term vision for low emission vehicles, seeking national government policies that provide strong signals around targets, infrastructure, and incentives.
- **Australian Trucking Association** called for "a stronger plan to help businesses buy zero emission trucks", particularly accelerating battery electric truck uptake in metro freight operations (ATA, 2021).

This is indicative of an increasingly global driver for the uptake of LZEVs due to Environmental, Social and Governance (ESG) requirements within businesses and corporations. ESG has emerged as arguably one of the strongest influences for the current uptake of LZE trucks in the freight and the supply chain sector. With many freight consignors and consignees making binding pledges to transition to a low, or net zero, freight pathway. Whilst these ESG commitments are economically viable for goods where the freight component is relatively small compared with the delivered goods worth, it remains to be seen if ESG will drive LZE trucks across the majority of road freight and supply chain operations in Australia where the cost of freight becomes a significant cost in the overall cost of a product, or service.

14.1 Impact on the truck industry

In the life cycle of a truck, it is the end users – logistics providers, fleets, equipment operators – that emit greenhouse gas emissions when they move freight on trucks powered by fossil fuels. Typically, these companies are influenced (or required) by their freight customers to reduce emissions as part of the goods supply chain. One of the few pathways they have available is their choice of truck; at which point, the ability to reduce emissions is dependent on the vehicle manufacturer – TIC's members.

At the same time, the regulatory burden to reduce truck emissions – both carbon and criteria pollutants – also falls on vehicle manufacturers. However, the truck market is capital intensive, highly fragmented, low margin, and (in Australia) very slow to change due to long asset life and the lack of a viable international second hand market for aging trucks (older trucks stay within Australia). Truck manufacturers cannot merely discontinue their diesel ICE trucks, switching to new LZEV technology "overnight" without risking losing their existing customers, who may find that current LZEVs are not an economically viable business option, or are unsuited to their operations (e.g. long haul, remote area transport, etc).

Table 14.2 International Net Zero Pledges and Partnerships (Australia focused)

	Members/Signatories
ITF Corporate Partnership Board members	ABInBev, Airbus, Allianz Partners, Alstom, aramco, Argo, Arrival, Autocrypt, Bosch, cruise, ExxonMobil, Iberdrola, kakaomobility, Michelin, MM, NXP, PTV Group, RATP Group, Rolls Royce, Shell, Siemens, SNCF, spea, TIER, Toyota, TotalEnergies, Trucknet, Uber, Valeo, voi., Volvo, Volvo
COP26 EV Pledge (Manufacturers and Au Gov)	Ford, Mercedes-Benz, Volvo, Jaguar, GM, BYD, Government of South Australia, State Government Victoria, ACT Government, NSW Government
European Manufacture Pledge: to phase out sales of diesel-powered trucks by 2040	MAN, IVECO, Ford, Volvo, Daimler, DAF, Scania
EV100 Switching owned and contracted fleets (up to 7.5t) to electric	zomato, IKEA, agl, AstraZeneca, BT, Deloitte., LeasePlan, Unilever, gsk, Lime, Novartis, novo nordisk, origin, Rentokil Initial, Siemens
Drive to Zero Accelerate ZE commercial vehicle uptake	Siemens, IKEA, BYD, Scania, BAE Systems, SEA Electric, DHL, Lion, Unilever, Volta Trucks
UN Race to Zero Halve all scope emissions by 2030	ARV, Scania, BT, H&M, Colgate Palmolive, Levi's, IKEA, Brambles, Ricoh, McKinsey & Company, Asahi, Volvo, PepsiCo
Road Freight Zero WEF: Advance deployment of ZE fleets and infrastructure by 2030	Electrolux, Volvo, acea, Agility, alice, Maersk, BMW, Calstart, bp, citi, Daimler, DHL, Energy Transitions Commission, H&M, IKEA, Heineken, HSBC, IRENA, Michelin, nab, Nestlé, PepsiCo, Shell, Transport Decarbonisation Alliance, Siemens, Smart Freight Centre, Scania, DB Schenker, Unilever

As decarbonisation begins to transform industries, capital-intensive and emissions-intensive sectors may require additional support to create low-carbon products as the market undergoes a long and uncertain transition process. The auto industry is one of those industries. But unlike the now extinct car manufacturing industry, Australia still has a healthy truck manufacturing industry. Almost half of heavy-duty trucks sold in Australia are manufactured here, whilst approximately 95% of all trucks sold require a secondary manufacturer, or body builder, to compete the truck and meet the operators' application requirements (TIC, 2022).

Despite record truck sales supported by COVID-era investment allowances and increased freight demand, limited uptake of LZEVs over the last decade has slowed decarbonisation of the industry to a crawl. LZEV models can cost 2-3 times more than a conventional ICE truck, making it difficult for an operator to look beyond the initial capital cost, even where the total cost of ownership presents a strong business case.

Original equipment manufacturers are developing finance options such as loan and lease package options and pay-per-km operating contracts, to help their customers afford to transition. This can soften the bottom-line impact of an initial purchase, but it doesn't reduce the price gap.

Similarly, OEM's are partnering with each other as well as infrastructure and energy providers to establish offerings to support customers in their transition to decarbonised fleets. For example, Volvo and Daimler are collaborating to accelerate the introduction of viable, reliable hydrogen fuel cell trucks.

Australia Post conducted a 6-month trial before adding 20 light-duty Fuso eCanters to their fleet in late 2021. The trucks will be leased over 6 years and returned to Fuso at the end of the contract. With a range of up to 100km the trucks will be used for urban parcel delivery in capital cities.

Origin 360EV Fleet – Origin, as an energy provider, has embarked on a one stop fleet management offering that includes passenger EV's, charging infrastructure and energy plans. With integrated reporting and billing this operating lease model may be appealing to fleet operators and owner drivers looking to avoid initial capital constraints, as well as the administrative benefits of all fleet costs coming on a single invoice.

These growing customer, consumer, government, and internal factors (with overseas products increasingly incompatible with the Australian market due to our unique regulatory requirements) are creating a perfect storm of pressure on Australia's truck suppliers. Weak domestic policies leave the Australian Road Transport Industry as the "piggy in the middle" (Figure 14.2) – required to manage global change through a domestic road freight policy environment that is largely geared towards "business as usual".

The former government's "technology not taxes" approach was focused on upstream technology such as energy and fuel suppliers or charging infrastructure. Neither of these are sectors the truck industry operates in. State governments are mostly focused on supporting passenger vehicle transition with downstream consumer incentives such as purchase rebates and stamp duty/registration fees. These approaches lack direct support for truck manufactures to develop and supply new low emission truck technologies for Australia. As well as our Australian unique dimension and mass regulations, there is another barrier constraining the ZEV market, it is securing sufficient supply in a global market where all new Australian truck sales amount to less than 1% of total international truck sales annually.

While Round 2 of the Future Fuels Fund includes grants for the purchase of electric and hydrogen trucks, these predominantly support the end user but are unlikely to result in additional truck supply into the market. With 85% of Australian fleets operating 5 or fewer vehicles, the high eligibility thresholds on project value may limit the effectiveness of this program in influencing uptake beyond the largest fleets in the market.

None of this fund appears to be available to manufacturers that want to increase model availability – a significant barrier to LZEV uptake. Yet key lessons from past market failures of alternative fuels – CNG, LNG, LPG, and even biofuels – is that the supply side of the equation must be fixed first, or at least simultaneously, if the industry is to confidently expand into a sustainable market size.

With ongoing raw material shortages predicted, particularly for electric vehicles, the IEA calls for long-term policy actions to provide the certainty needed for investment in supply side expansion. This sentiment is echoed across industry bodies.

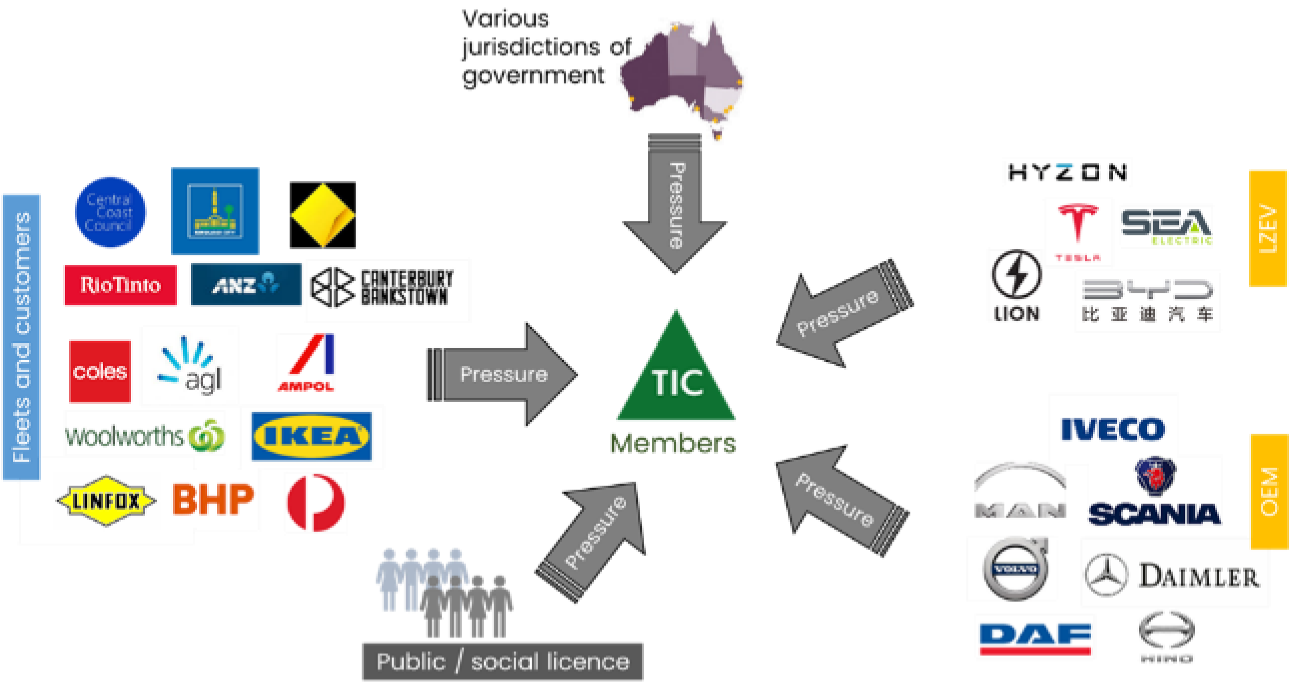
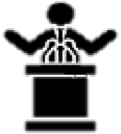


Figure 14.2 Combined pressures on Australia's truck suppliers

Overview of current environment for new and future truck related LZEV technology:

					
Political	**Economic**	**Social**	**Technical**	**Regulatory**	**Environmental**
▪ Global uncertainty in oil supply countries ▪ Market lead approach being relied on ▪ Focus on passenger/ public fleets and infrastructure ▪ Technology focus is on light vehicle infrastructure	▪ FFP round 2 supports purchase and infrastructure, but limited opportunity for OEM transition costs ▪ COVID stimulus opportunity to buy back better ▪ Availability/access to global supply chains: cost impacts (AdBlue, oil, semi-conductors)	▪ Health benefits in LZEV uptake in urban areas ▪ Employment and reskilling opportunities ▪ Sector cultural norms may slow uptake ▪ Newer models are also associated with newer safety standards	▪ Euro VI implementation Nov 2024 to Nov 2025 ▪ No planned CO_2 emissions standard ▪ Weight exemptions opportunity for most applications ▪ Low demand limiting model redesign and availability	▪ ADR's restrict model availability (without redesign). ▪ BEV exemptions incentives have been used globally, LEZ, transit lane, weight exemptions	▪ CO_2 emissions from freight task will increase without transition to LZEV. ▪ Diesel engine exhaust is a contributor to air pollution in major cities. ▪ Globally industry is driving stronger environmental targets than those being set by governments.

LOW & ZERO EMISSION TRUCKS DISCUSSION PAPER

PART D:

AN EFFECTIVE PATH FORWARD

15 Ten Key Insights

1. **LZEV UPTAKE WILL BE DRIVEN BY THREE KEY FACTORS** Fleet uptake of LZEVs indicates how quickly the market is changing, and therefore how quickly emissions can be reduced. It is mostly driven by the following key factors:
   (i) a positive business case (Total Cost of Ownership savings)
   (ii) confidence in the technology, including certainty in cost savings, reliability, and longevity
   (iii) vehicle and fuel availability (supply)
2. **THE BUSINESS CASE FOR LZEVS IS STILL NOT COMPELLING** There has been limited uptake of LZEVs because the business case works in only a few applications. Technology costs remain high, and there is a lot of uncertainty or ambiguity about major cost elements (fuel price, maintenance cost, resale value). Some of this can be solved with more and better information for fleets, but government policies and financial support can help bridge the financial gap in applications that are still not viable on their own.
3. **CONFIDENCE WILL ONLY COME FROM WIDER USE AND CLEAR POLICY** Dissemination of information via case studies, demonstration events, drive days, and other easily accessed formats is the only way to show the industry that it works. This is an area that TIC members can work with other suppliers (fuels, charging) and government to transform industry views and accelerate the confidence curve. Familiarity and competitive pressure will then drive uptake, provided there is sufficient supply.
4. **ALL LZEV OPTIONS HAVE TO ENTAIL SOME COMBINATION OF OPERATIONAL/AVAILABILITY COMPROMISES**:
   - Renewable diesel is not produced in great volume and currently costs more than diesel
   - There is currently no production of renewable gas for transport; it also involves payload penalty; the cost is significantly higher than diesel; and there are concerns about methane leakage into the atmosphere
   - BEVs suffer significant weight penalty, and operational range limitations in long-haul applications
   - PHEV and HEVs are not widely available, and only suited to a smaller niche of urban applications
   - Hydrogen entails a mass and volume penalty, and much higher vehicle fuel costs than diesel and BEV (today)
   - Availability of models and supply volumes is a critical factor for all technologies and fuels

   Policies can help alleviate some of these issues (e.g. mass concessions, infrastructure co-investment)

5. **NO CLEAR WINNER** No LZEV alternative is well suited as a diesel substitute across all applications except perhaps renewable diesel, which is one of the most supply constrained options and will see competing demand from other heavy vehicle sectors and transport modes (mining, construction, agriculture, rail, shipping). It is also not a true zero emission option because combustion still produces noxious tailpipe emissions, but it entails few operational compromises so could be a fast early path to enable initial carbon reductions. This means the long-term outlook is likely to be a patchwork of options best suited to specific applications or regions. These will compete for finite capital, so one or two 'winners' may need to emerge; or a credible plan for progressing all options.

6. **CLEAR VISION AND A BALANCED PLAYING FIELD ARE REQUIRED** Government enthusiasm for exporting hydrogen should not dictate it as the winner for local use in transport. Early support is essential, but the commercial case needs to exist for fleets without requiring ongoing, long-term subsidies to make them switch. Operators don't want to be enticed to alternatives that are cheaper when subsidised but may be more expensive than current, when subsidies are removed and fleets are "locked in" to a specific technology. Instead, government should develop a long-term vision, or roadmap, for transport energy and emissions. This should include early wins that apply to the legacy fleet, long-term targets, key indicators and milestones along the way, and transition support for affected industries. A once-in a century disruption cannot be navigated without clear vision and a plan.
7. **SUPPORTING POLICY IN AUSTRALIAN IS STILL AD-HOC** Australia has recently introduced incentives that could support a switch to LZEVs for a small number of trucks. This includes grant support to bridge the gap to higher up-front costs of BEVs and FCEVs, as well as charging/refuelling infrastructure for commercial fleets. However, this is a small step compared with markets where the scale of change is recognised and addressed with an integrated package of measures (power generation for example).
8. **THERE IS FUNDING FOR FLEETS (DEMAND) BUT NOT PRODUCERS (SUPPLY)** The outlook for supply of LZEV models to the Australian truck market is limited by what the OEMs will bring. Currently planned models will lead to a low but growing sales share by 2030. More could be done to influence and support manufacturers to bring models and volumes to the market to avoid them falling down the priority order to more progressive or more ambitious global markets. No policies or limited policies means OEMs have to fight for supply with one arm effectively tied behind their back. Government policy can have a big influence here, with the current EV situation in the car market (with wait times of 12-18 months and chaotic 'lotteries' for small volumes of vehicles) serving as an example of needing to progress supply at the same time as demand.
9. **A NEED TO LOOK TO THE PAST, WHEN PLANNING THE FUTURE (ENERGY NETWORKS NEED TO GROW BEFORE OR WITH VEHICLE MODEL AVAILABILITY)** Lessons from past failures of alternative fuels in Australia should be heeded. At one point, biofuels were well supported but were left to falter as supporting policies were removed or changed before the market matured. Similarly, natural gas (CNG and LNG) was once heralded as the truck fuel of the future; but it failed (twice) because supply of vehicles and fuel was not sufficiently supported with consistent, long-term policies. Co-ordination between private sector players (OEMs, fuel suppliers, networks) is also essential to future success, to avoid the 'chicken and egg' scenario.
10. **UNSUPPORTED, LZEV EMISSIONS REDUCTIONS WILL BE SMALL BEFORE 2030** 'Leaving it to the market' will result in limited LZEV supply and uptake, which in turn will result in minimal reduction in carbon emissions – potentially not even enough to overcome the effect of a growing freight task. Large-scale emissions reductions require stronger policies and a clear, long-term strategic vision or roadmap from government, to decarbonise all sectors, including the heavy vehicle road transport sector.

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Appendix A Modelling Assumptions

- BAU: Assumes the current truck task increases according to the reference case growth forecasts from BITRE, and no changes in truck productivity (L diesel per t km).
- Scenario 100% ZEV: Newly introduced BEV and FCEV provide a 100% reduction in CO_2 emissions compared with a diesel truck
- Scenario 100% LEV: New HEV, Biodiesel, RNG and Other options provide 50% CO_2 reduction compared with a diesel truck
- OEM LZEV: Growth in LZEV uptake from 2020 is in line with OEM's average expectations in 2030, based on survey responses. The proportion of ZEVs to LEVs is based on currently proposed ZEV and LEV model releases. Total LZEV uptake is optimistically assumed to be at the upper end of survey results – by 2030, 40% of Light duty truck sales are LZEV and 20% of Heavy and Medium Duty sales.
- Other assumptions and notes:
    - Includes all trucks above 3.5t GVM, including vans, but not buses.
    - Truck numbers based on latest (2021) ABS Motor Vehicle Census
    - Includes ABS data for both Freight and Non-freight vehicles (the few non-freight vehicles are assumed to be rigids)
    - 2022 Truck task (VKT) based on latest (2020) ABS Survey of Motor Vehicle Use
    - Model uses an average age profile: in reality some trucks will retire early due to crashes or failures, a few will have very long lives (NEF6184)
    - Individual truck utilisation (annual km) reduces as trucks age (NEF6184).
    - No trucks change in-use between Diesel, ZEV & LEV.