Austroads

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Options for Managing the Impacts of Aged Heavy Vehicles

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Abstract

This report investigates policy options for reducing the harmful effects of the oldest trucks operating on Australian and New Zealand roads.

Aged trucks impose a financial burden on the community through their effects on human health and the environment. This study analysed the contribution of aged trucks in two of these areas: their representation in casualty crashes, and their contribution to pollution-related health costs. The analysis focused on heavy vehicles above 4.5 tonnes GVM used in freight transport.

The research identified measures that have been effective in other jurisdictions to influence the use of older trucks. It assessed these options for their likely effectiveness in Australia and New Zealand. The methodology included a literature review, consultation with government and industry, and an options analysis to prioritise suitable measures.

Keywords

Aged trucks, average age, heavy vehicles, end-of-life, freight transport, fleet sustainability, vehicle retirement, fleet renewal, health costs, crash frequency, pollution, emissions.

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About Austroads

Austroads is the peak organisation of Australasian road transport and traffic agencies.

Austroads' purpose is to support our member organisations to deliver an improved Australasian road transport network. To succeed in this task, we undertake leading-edge road and transport research which underpins our input to policy development and published guidance on the design, construction and management of the road network and its associated infrastructure.

Austroads provides a collective approach that delivers value for money, encourages shared knowledge and drives consistency for road users.

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- Department of Transport Victoria
- Queensland Department of Transport and Main Roads
- Main Roads Western Australia
- Department for Infrastructure and Transport South Australia
- Department of State Growth Tasmania
- Department of Infrastructure, Planning and Logistics Northern Territory
- Transport Canberra and City Services Directorate, Australian Capital Territory
- Department of Infrastructure, Transport, Regional Development and Communications
- Australian Local Government Association
- New Zealand Transport Agency.

Summary

The heavy vehicle fleets in Australia and New Zealand are among the oldest in the OECD. Continued operation of the oldest vehicles imposes costs on the community and the environment. This project presents the rationale and evidence for action on this issue and assesses policy options for minimising the harmful impacts of the oldest vehicles operating on Australian and New Zealand roads.

Project Overview and Scope

The analysis covered heavy vehicles above 4.5 tonnes GVM used in freight transport (trucks). It reviewed the main issues associated with the continued use of aged trucks and identified potential policies and other interventions that are most suitable for Australia and New Zealand.

Key Issues

- Australia and New Zealand have old truck fleets, with an average age of 15 and 18 years respectively.
- In the absence of a nationally agreed definition, this study defined an aged truck by year of manufacture (pre-2008), with sub-categories based on emission standard (Euro III, Euro I, ADR 30).
- The aged truck cohort represents a large proportion of the national fleet (56%), because there are few regulatory, policy, or market forces to drive fleet renewal.
- The quality of older trucks affects the community and the environment, but independent assessments of these effects were not found. This study compared crash data and modelled pollution-related health cost.
- There are many government strategies and policy actions underway in Australia and New Zealand for heavy vehicles and freight transport more broadly, but most do not address the issue of aged trucks.
- Targeted policy measures could affect many vehicle owners and operators because aged trucks are used widely across freight segments by different types of operators.

Where and How Aged Trucks are Used

- Aged trucks tend to be less utilised than newer trucks, travelling fewer annual kilometres.
- Rigid trucks in Australia are, on average, older than articulated trucks.
- Some industries rely heavily on aged trucks. While some aged trucks operate in low profit-margin freight segments, there are also many carrying “general freight” which is also carried by younger trucks.
- Any action targeting older trucks (alone) is likely to affect many vehicles/owners, but operators of aged trucks currently have few reasons to upgrade their vehicles.

Effects of Aged Trucks on Health and Safety

- Pre-1996 trucks cause around $200 million in annual pollution-related health costs in Australia. Replacing these trucks could yield a net health benefit of $744–$1,441 million over seven years.
- The cost of emissions from pre-1996 trucks operating in urban areas is 4.5 times higher than in non-urban areas. Measures to reduce the health cost of aged trucks should focus on urban areas.
- Newer trucks (less than 5 years old) have the lowest crash frequency (casualty crashes/billion km) of all age groups. Older trucks have more on-road defects. But contrary to expectations, the oldest group of trucks (>15 years) has roughly the same or lower crash frequency as the middle age group (5-15 years).
- Any direct impact that aged trucks have on overall large loss claims are likely to be minimal. Factors other than truck age have an overriding influence on the overall crash rate.

Review of Policies to Manage Aged Trucks

Aged trucks have proliferated in Australia and New Zealand because they are cheap to operate, have no or few restrictions on where they can be used, have limited barriers to entry, and there is no secondary disposal market.

Governments in other countries have enacted measures to reduce the operation of aged trucks in their jurisdictions. Best practice approaches combine different kinds of measures to achieve the greatest effect. This study examined only those actions that directly affect the aged truck fleet. These comprise four types of intervention: road access restrictions, financial penalties, financial incentives, and retrofit/repower programs.

Initiatives Best Suited to Australia and New Zealand

The range of policy options was narrowed to ten potential actions that could be applied to manage aged trucks. These were assessed and scored against five criteria (fleet coverage, complexity, time, cost, and strength of mechanism) to find the most cost-effective approaches.

The top three measures to emerge from the evaluation were: road access restrictions in the form of low emissions zones (LEZ), vehicle registration fees differentiated by emissions class, and differentiated road user charging. These could be combined with other lower-scoring but complementary measures – such as investment incentives and scrappage schemes – to achieve the desired changes in the aged truck fleet.

Conclusions

Pre-1996 trucks operating in urban areas impose an average pollution-related health cost on the community of between 37 cents and 91 cents for every kilometre they travel in urban areas. Governments are already paying this in consolidated expenditure, which equates to between $3,300 and $21,000 each year for a 1995 truck operating in urban areas. This can be used as a basis for evaluating the cost of any one-off or recurrent actions being considered to influence the age structure of the fleet. These costs do not include safety-related health or social costs, nor other externalities.

The worst of the pollution-related impacts are a short- to medium-term problem. Modelling in this study indicates that the total health impact of pre-1996 trucks halves in approximately four years. Yet each of the top three measures above is also a medium-term opportunity, which means their influence takes effect as the problem shrinks.

This timing mismatch may be overcome by combining the top three measures with other shorter-term interventions. Two of the priority measures – LEZs and differential registration – are particularly suited to combining with investment support and scrappage schemes. There may be a window of opportunity to fund such high-cost support measures as part of the economic recovery stimulus packages for COVID-19.

Response measures could be linked with other policy and program initiatives already underway. In Australia, this includes the Heavy Vehicle Road Reform process. Although no decisions on more direct road user charges are being contemplated, any future move to charge heavy vehicles more directly for their road use could be an opportunity to charge different rates for aged trucks. Similarly, New Zealand could, in future, consider an expansion of the existing road user charge criteria to account for the age of vehicles.

Combining short- and medium-term actions as outlined above could signal to the market that initial supportive action will be followed by stronger action in future. However, outright registration bans are not recommended, given the large number of rural operators that may be affected, whose trucks do not contribute significantly to the major health costs in urban areas.

Glossary

ABS*	Australian Bureau of Statistics *see specific context
ABS*	Anti-lock Braking System *see specific context
ADRs	Australian Design Rules, setting minimum standards for new Australian on-road vehicles.
BAU	Business-As-Usual
CAZ	Clean Air Zone
CO	Carbon Monoxide – a colourless toxic gas, produced by imperfect fuel burn in internal combustion engines
DVS	Direct Vision Standard
Euro 0	Refers to heavy trucks certified in Australia before the first limits for NOx, PM, CO and HC limits were introduced in 1996 (Euro I). The term Euro 0 is used for convenience only, there was no Euro 0 certification standard.
ERVL	Economics of Road Vehicle Limits
ESC	Electronic Stability Control
FUPS	Front Underrun Protection System
GCM	Gross Combination Mass (Maximum mass of fully laden vehicle, including any trailers)
GVM	Gross Vehicle Mass (Maximum mass of fully laden vehicle, excluding any trailers)
HC	Hydrocarbons - a class of air pollutants emitted in vehicle exhaust, produced by imperfect fuel burn in internal combustion engines
HML	Higher Mass Limits – a concession provided to some vehicles to operate above standard mass limits, as defined by the National Heavy Vehicle Regulator (NHVR)
LEZ	Low Emission Zone
NEVDIS	National Exchange of Vehicle and Driver Information System
NHVML	National Heavy Vehicle Mass Limits
NOx	Oxides of Nitrogen – a class of air pollutants emitted in vehicle exhaust
PBS	Performance-Based Standards
PM	Particulate Matter – a class of air pollutants emitted in vehicle exhaust, comprising: PM10 fine particles and PM2.5 ultrafine particles (the number represents the maximum particle size in micrometres)
RIS	Regulatory Impact Statement
RFM	Road Freight Movements (ABS 2017)
RMS	Road and Maritime Services (NSW), now Transport for NSW
RoRVL	Review of Road Vehicle Limits
RSC	Roll Stability Control
SMVU	Survey of Motor Vehicle Use (ABS 2018)
SOx	Oxides of Sulphur – a class of air pollutants emitted in vehicle exhaust
TIC	Truck Industry Council
VKT	Vehicle Kilometres Travelled – represents how much a vehicle is used annually
ZEZ	Zero Emission Zone

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1. Introduction

1.1 Problem Statement

The heavy vehicle fleet in Australia and New Zealand is older than comparable countries. It is widely believed that continued operation of old vehicles imposes costs on the community through:

- Higher levels of air pollution, with associated costs to human health and the environment.
- Lower levels of safety technology, resulting in higher accident risk and mortality/trauma costs.
- Lower energy productivity.
- More wear and tear, poor maintenance, and unreliability – increasing crash risk and operating costs.

Evidence of these effects is required along with effective policies and measures to manage the use of old vehicles and minimise their externality costs.

1.2 Purpose

The purpose of the project was to:

- Confirm the ‘quality’ issues associated with the continued use of aged trucks – including economic, environmental and social costs.
- Identify examples of interventions (policies, programs, regulations, incentives) used in other jurisdictions to reduce the use or harmful impacts of aged trucks.
- Assess the relevance of those examples for Australian and New Zealand.
- Propose measures most suitable for consideration by Austroads and its member organisations.

1.3 Scope

The scope for this project includes:

- Heavy vehicles from 4.5t gross vehicle mass (GVM) used in on-road freight transport, irrespective of ownership: trucks.
- Environmental, economic, and safety implications of these vehicles in Australia and New Zealand.

Aspects considered out-of-scope include:

- Light Vehicles (<4.5t GVM)
- Buses and any trucks used for non-freight purposes.
- Trailers
- Off-road operation, or vehicles that are primarily used off-road (e.g. farms, mines, construction)
- Effects on revenue or road pricing models.

Although the focus of this paper is the heavy vehicle fleet, it is understood that the light vehicle fleet is also relatively old compared with many other developed countries (AAA 2017; EEA 2016). To put the relative impacts of heavy and light vehicles into context, a similar analysis of the light vehicle fleet could be undertaken in future.

1.4 Methodology

The project comprised eight main stages, as follows:

- Problem definition: to refine the scope and review foundation assumptions and data sources.
- Research: to collate information on accident statistics, aged truck users and locations, health costs, and overseas experience with relevant policies, programs and actions to manage aged trucks.
- Issues paper: to define the problem, information gaps and additional research areas.
- Literature review: to augment the research, focused on best practice response measures.
- Analysis and modelling: to quantify and validate the representation of aged trucks in crash data and emissions-related health costs.
- Consultation: discussions with industry associations representing the most likely users of aged trucks and including input from road operators/agencies throughout the project.
- Synthesis and evaluation: to assess the policies and measures used in other jurisdictions and their relevance and likely effectiveness in Australian and New Zealand.
- Report: drafted continuously as the working paper developed, with regular reviews and feedback from the Project Working Group (PWG) comprising representatives of relevant agencies in Australia and New Zealand. The final paper was also reviewed by the Austroads Freight Task Force (FTF).

2. Key Issues

The main issues associated with aged trucks are a combination of symptoms and causes, as well as gaps in the knowledge and data that could support policy responses. The report presents new research and analysis to fill some of the gaps. The key issues are summarised in the points below.

- Australia and New Zealand have an old truck fleet (Section 2.1), but the “old” fleet (the problem cohort) has not previously been defined or agreed (Section 2.2).
- The quality of older trucks affects the community and the environment (Section 2.3), but these effects have not been independently assessed or aggregated (Section 4).
- Aged trucks comprise a large proportion of the fleet (Section 2.2), because there are few regulatory, policy, or market forces to upgrade to newer vehicles (Section 5).
- Corrective action should focus on specific operators/segments, but evidence on who operates aged trucks, and where, is not strong. (Section 5)
- Actions should reflect international best practice (Section 6), adapted for local conditions. (Section 7)

2.1 Age of the Fleet

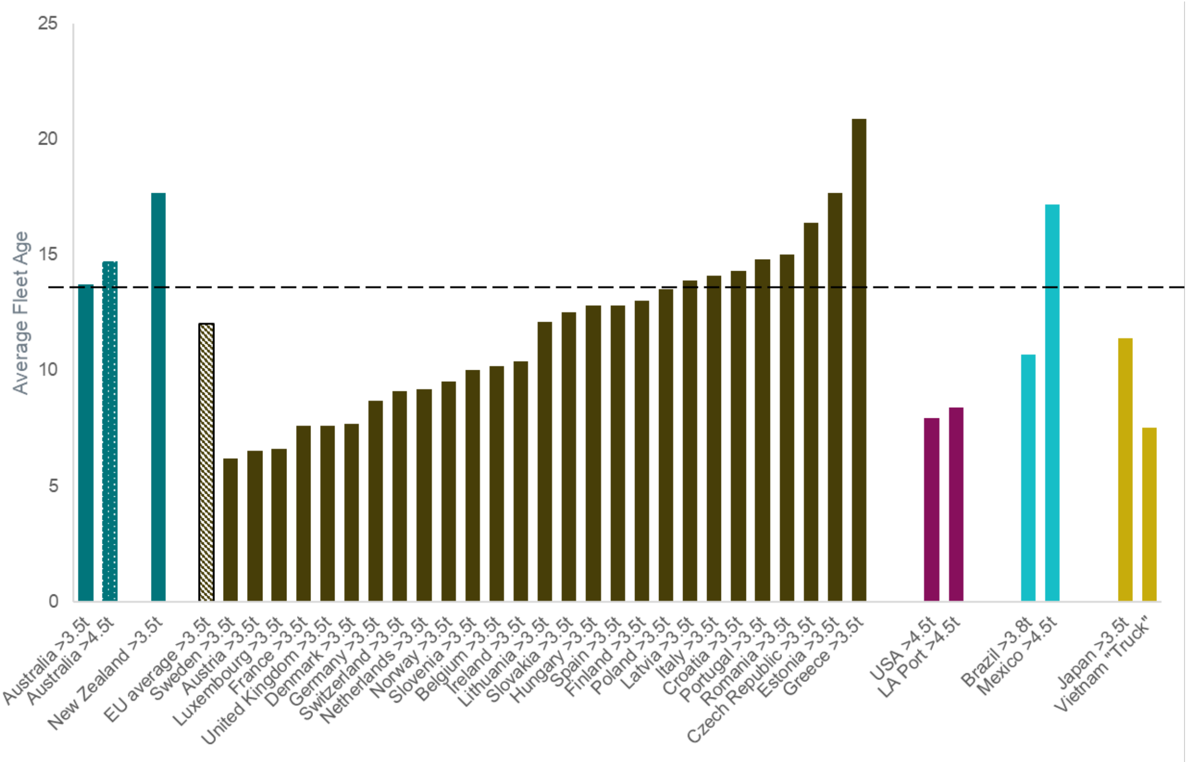
The national fleet of vehicles above 3.5 tonnes in both Australia and New Zealand is older than most other OECD countries. At around 15 years, the average (mean) age of these vehicles in Australia is higher than all but Mexico and a handful of Eastern European countries. The average age of the New Zealand fleet is nearly 18 years (Figure 2.1).

The average age of all trucks includes vehicles in different classes. Typically, rigid trucks are older than articulated trucks, at 15.6 years and 11.8 years respectively (in Australia).

However, simply comparing the average age across countries can be misleading. Segmentation is not consistent across markets, so the available data may not correspond precisely to the same cohort in different markets. For example, some countries keep data for heavy vehicles above 4.5t, while most cover only ‘commercial vehicles’ above 3.5t.

Two trucks of the same age in different markets may also be quite different in terms of safety equipment and emissions compliance. A truck in Australia could produce more emissions than the same age truck in Europe or the US (or even New Zealand, which imports second-hand trucks from Japan), because those markets introduced more-stringent emissions regulations earlier.

Figure 2.1: International comparison of average age of trucks

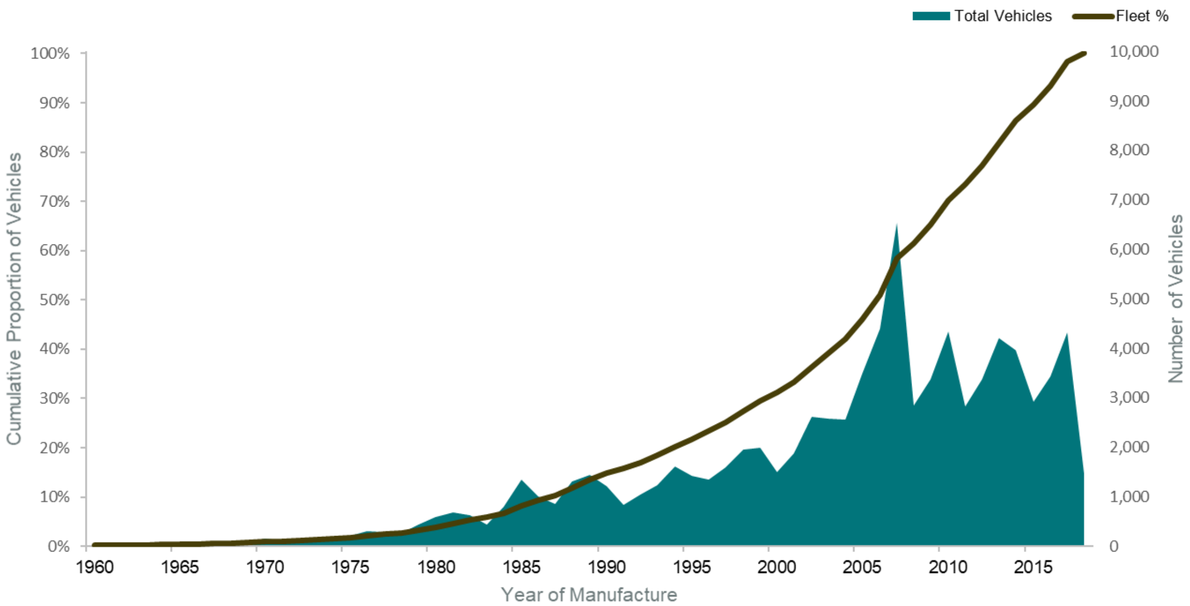


Source: ABS 2019a, NZMOT 2019, ACEA 2018, FleetOwner 2018, SPBP 2018, Statista 2017, FleetOwner 2016, JAMA 2019, Lam et al. 2019

Age Profile

Average or mean age of the fleet gives little indication of the number and distribution of vehicles in different age groups. The example age profile in Figure 2.2 shows that more than 25% of Queensland heavy vehicles in 2019 were over 20 years old. The implication is that any policies based on vehicle age alone may affect a significant proportion of the total vehicles, depending on where the age threshold is set.

Figure 2.2: Age profile example: Composition of Queensland heavy vehicle fleet (GVM>=4.5t)



Source: Derived from Queensland Government Open Data Portal (QLD 2019)

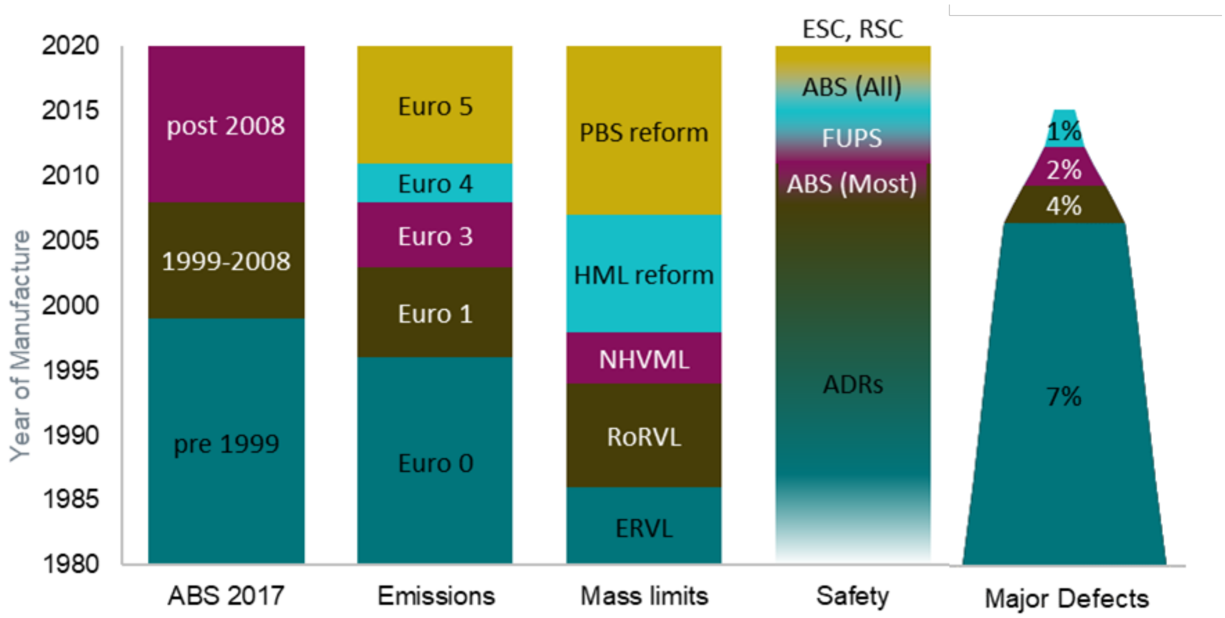
2.2 Defining Older Trucks

In this report, all trucks falling into the target age group are called "aged trucks" which can be further segmented into secondary, smaller cohorts depending on the issue or impact of most concern.[1]

Older trucks are commonly perceived to be of lower quality than newer trucks. While the quality of vehicles in this context is not formally agreed or defined by industry or the literature, various indicators could be used to define an aged truck corresponding to its features or its effect on the community. Figure 2.3 shows some of these indicators along the horizontal axis, including vehicle age (grouped as per motor vehicle census data); applicable emissions standard; mass limit; safety features; and roadworthiness. Other potential indicators of lower quality could include the effects on driver health (noise, cab sealing, ergonomics), breakdowns, and increased road deterioration – but these would not have created any clearer differentiation of aged trucks than those shown below.

The coloured bands for each feature indicate the year (vertical axis) when a shift in regulations or features occurred. Clearly defined colour changes indicate a step change such as newly introduced regulations, while gradual shading indicates changes that occurred gradually over time.

Figure 2.3: Truck age classifications



Sources: ABS 2017, ADR 2019, BITRE 2011, NHVR 2017.

Any one of these indicators might be useful to define older trucks, depending on the issue of concern. However, simply using the vehicle age (in years) could be problematic because it does not provide a meaningful grouping / segmentation unlike some of the other indicators.

For this project the exhaust emissions standard is used to define an aged truck. This indicator provides an easily identifiable feature, distinct transition points, and is consistent with other analyses (TIC 2019a, Austroads 2014) which found emissions to be the major harmful effect of aged trucks on the community.[2]

1 Austroads previously referred to the oldest trucks as "end of life vehicles", but an alternative definition and name was deemed necessary because this terminology has specific connotations in the US and European markets and with the vehicle manufacturers. In some cases, "end of life" means a vehicle that can no longer be used or is being scrapped.

2 TIC estimated that removing pre-1995 (ADR30) trucks from the road could reduce health costs by $1.5 billion over five years to 2024, due to reduced exhaust pollution alone (TIC 2019a). Productivity savings were estimated to have a higher benefit, but there is no clear date that could be used to define an aged truck by that indicator.

Age Sub-classes

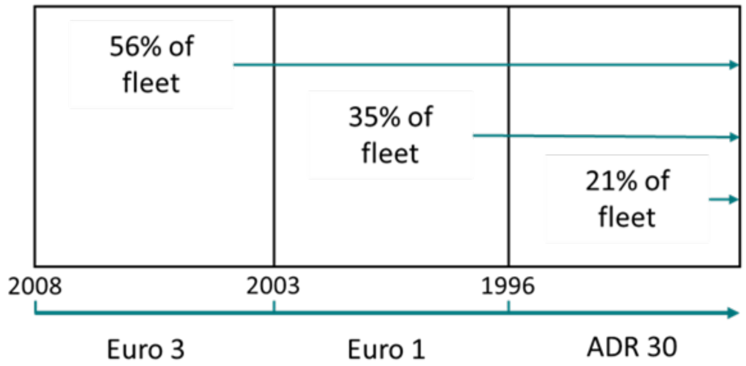
Appendix A shows the progressive tightening of emissions compliance limits over time. Euro IV and Euro V regulations from 2008 onward required a significant reduction in both NOx and PM emissions (more than 75% and 95% respectively) compared with earlier non-regulated trucks (Euro 0 or ADR30).

Accordingly, aged trucks in this study are defined by:

- a fixed threshold year of manufacture prior to 2008 (currently 12 years or older).
- three sub-classes according to their emissions compliance standard.

Figure 2.4 illustrates the three proposed sub-classes and the proportion of the total Australian truck fleet they currently represent. The pre-2008 truck cohort (pre-Euro IV) represents 56% of Australia's truck fleet, while pre-1996 trucks (Euro 0 or ADR 30) comprise more than one fifth of the national fleet.

Figure 2.4: Aged heavy vehicle sub-classes



This stratified definition allows consideration of the harmful effects of each of the sub-classes of vehicles in combination with other factors. For example, policies or incentives to improve urban air quality could be applied to a particular sub-class of aged trucks that operates in urban areas. This approach would not affect the oldest trucks operating outside urban areas, or any "younger" trucks (Euro I onwards).

2.3 Harmful Effects of Aged Trucks

All motorised transport has some negative effect on the community, which is offset by benefits in mobility, economic trade, and access to goods and services. Within industry and government, there is general agreement that newer trucks have a lower community impact than older trucks.

In 2012, TIC estimated the total cost of continuing to operate aged trucks to be between $3.6 billion and $7 billion over a 10-year period (TIC 2013). A more recent estimate was $11 billion over the five years to 2024 (medium scenario) (TIC 2019a).[3]

However, the literature review did not find a comparable independent analysis of these costs. For example, despite newer trucks having improved safety technology, the literature review did not find a clear correlation between truck age and accident frequency or severity. Section 4 provides an initial analysis to test this link. Similarly, the economic benefit of adopting Euro VI emissions standards on new trucks was modelled and published in the RIS, but the cost burden associated with continued use of aged trucks was not found in the literature review. Therefore, an empirical analysis was conducted to quantify these costs (Section 4).

3 This was the medium scenario, but some of the cost (and most of the productivity benefit) assumed an increased uptake of performance-based standards (PBS) on new trucks, not just retirement of the aged truck.

3. Where and How Aged Trucks are Used

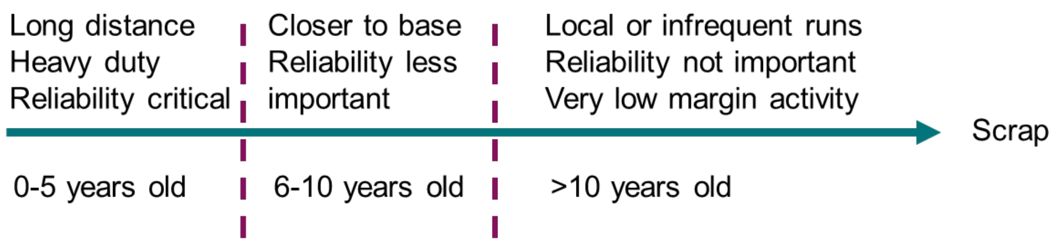
In 2017 there were approximately 700,000 registered heavy vehicles in Australia. The majority of these (500,000) were rigid trucks and around 100,000 were articulated trucks.

The location in which trucks operate is a major determinant of their effect on human health and the environment. Traffic congestion, air pollution, noise and road safety all vary by location. Understanding where aged trucks are used is essential to managing those impacts. Similarly, vehicle utilisation – how much it is driven – is another major factor.

3.1 The Truck Life Cycle

The use of a truck in Australia generally follows the stages shown in Figure 3.1. These distinct life stages, regardless of industry, reflect the type, location and frequency of use, and how reliable the truck is required to be to fulfill its freight task.

Figure 3.1: Typical life cycle of a truck



3.2 Urban vs Regional Effects

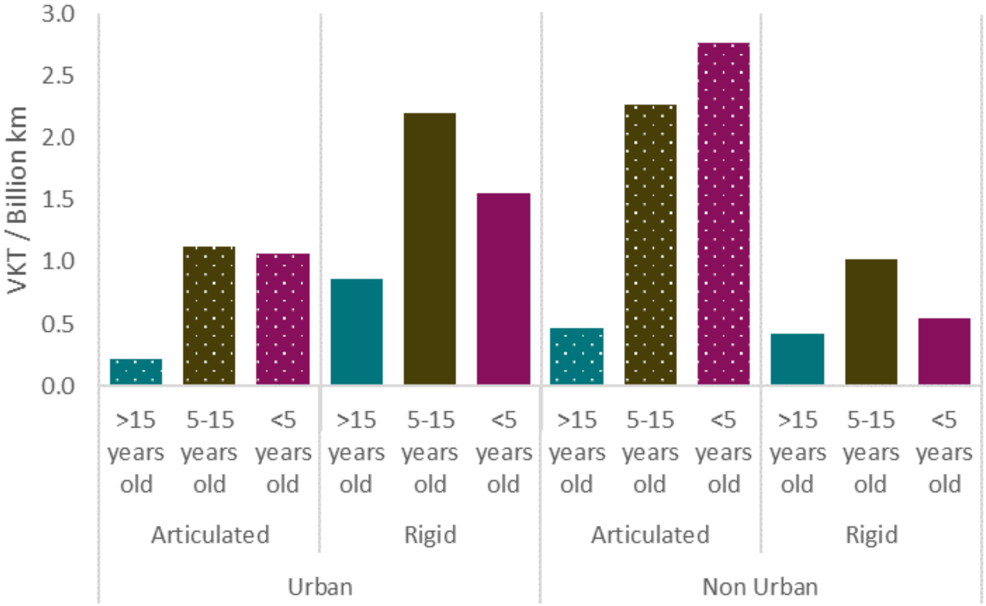
Many data sources can inform an understanding of where aged trucks operate in Australia. These sources include road camera data, one-off studies, the National Crash Database (BITRE 2019), and the Australian Bureau of Statistics (ABS) surveys for Road Freight Movements (RFM) and Motor Vehicle Use (SMVU). However, none of these appear to be currently used for the purpose of identifying where aged vehicles operate. Even detailed studies like the Melbourne Inner West Survey contain data gaps about the use of aged trucks.[4]

To fill this information gap, the ABS SMVU data was used to develop an urban/regional split of aged vehicle usage. Non-freight trucks were not included; and an estimate of VKT for heavy rigid trucks alone was split from the combined light and heavy rigid ABS data (3.5t-4.5t GVM versus >4.5t GVM). Appendix B contains more information on the methodology.

The results of the analysis show that the main locations where trucks are used varies by truck type (articulated/rigid – see Figure 3.2), but the proportion of urban and non-urban use does not vary much by age of vehicle (Figure 3.3).

[4] They found that aged trucks did operate in the Inner West of Melbourne supporting port and other activity at the time of the study, including for container movements. But neither of the official studies confirmed that aged trucks were over-represented in this activity

Figure 3.2: Location of usage – all trucks

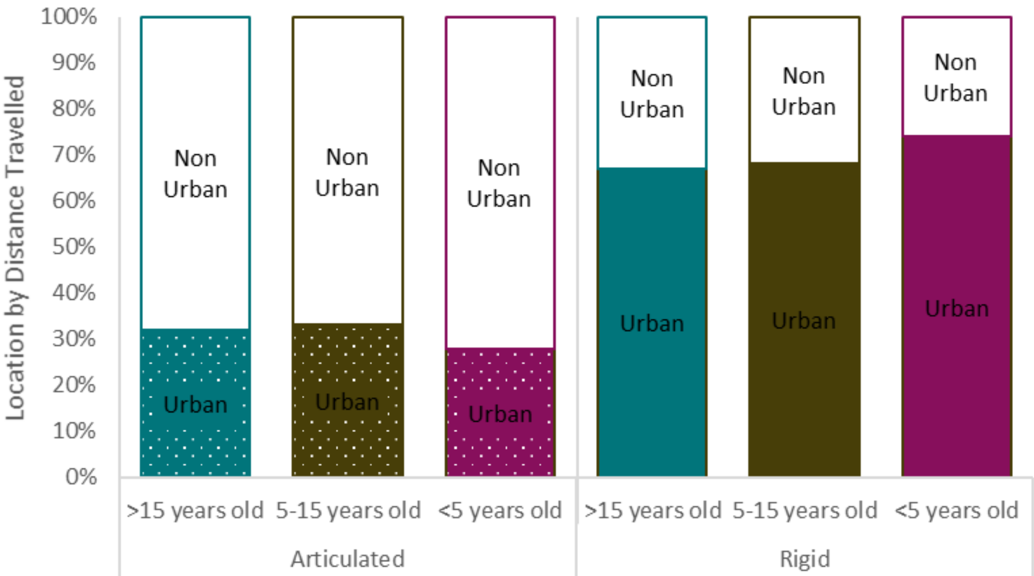


Source: Derived from ABS 2018

The oldest rigid truck cohort travels (in total) almost five times more kilometres in urban environments than the same age group of articulated trucks (Figure 3.2).

Articulated trucks of all age groups spend roughly the same proportion of VKT (~30%) in urban areas, whereas the proportion for rigid trucks is more than double that (65-75% of VKT in urban areas).

Figure 3.3: Urban fraction of usage – all trucks



Source: Derived from ABS 2018

Overall, around two thirds of the freight task of rigid trucks is urban (irrespective of age group), and around two-thirds of the freight task of articulated trucks is non-urban. The consistency between age groups is important, because it contradicts the common view that as trucks age they work more in urban areas. If true, the analysis would show a higher proportion of urban operation for older trucks.

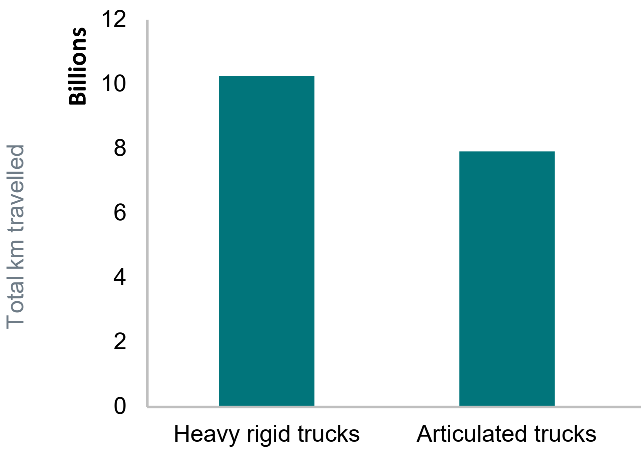
Figure 3.4: Trucks on a regional long-haul route

Source: Austroads

3.3 Fleet Utilisation

Figure 3.5 shows that the total distance travelled by rigid trucks is higher than for articulated trucks. However, this needs to be viewed in combination with the relative number of trucks, which is much higher for rigids. Viewed together, the data indicate that articulated trucks are more highly utilised (km per truck).

Figure 3.5: Heavy vehicle usage

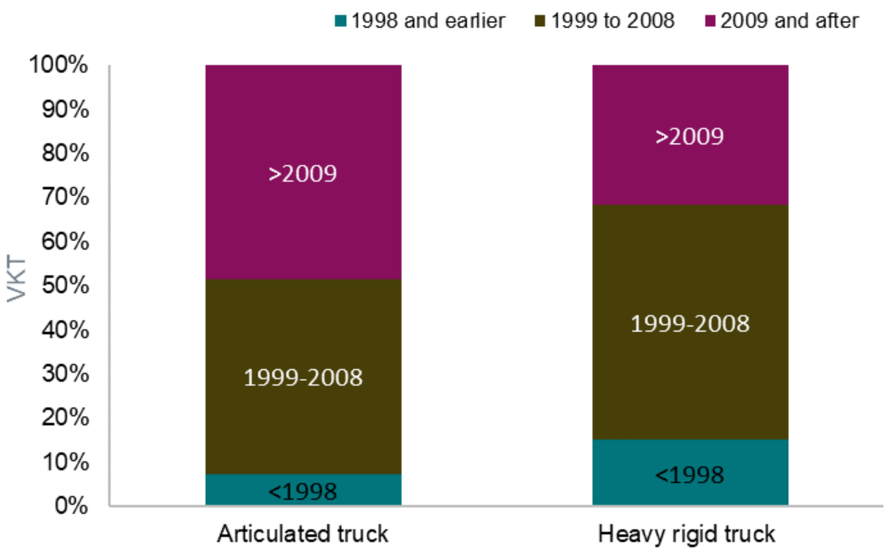


Source: Australian Bureau of Statistics (ABS 2018).

Aged trucks tend to be less utilised than newer trucks, travelling fewer kilometres and operating for less time per year. Although the average age of the fleet is around 15 years, trucks more than 15 years old (1998 at the time of the survey) drove fewer kilometres than their newer counterparts (Figure 3.6). The oldest 50% of the fleet only covers 11.5% of the total distance driven by the whole fleet.

This has a bearing on understanding the level of impact of these vehicles, and by extension the kind of policies that could influence their owners.

Figure 3.6: Australian heavy vehicle utilisation (% of VKT) by year of manufacture



Source: ABS Surveys (ABS 2017)

4. Effects of Aged Trucks on Health and Safety

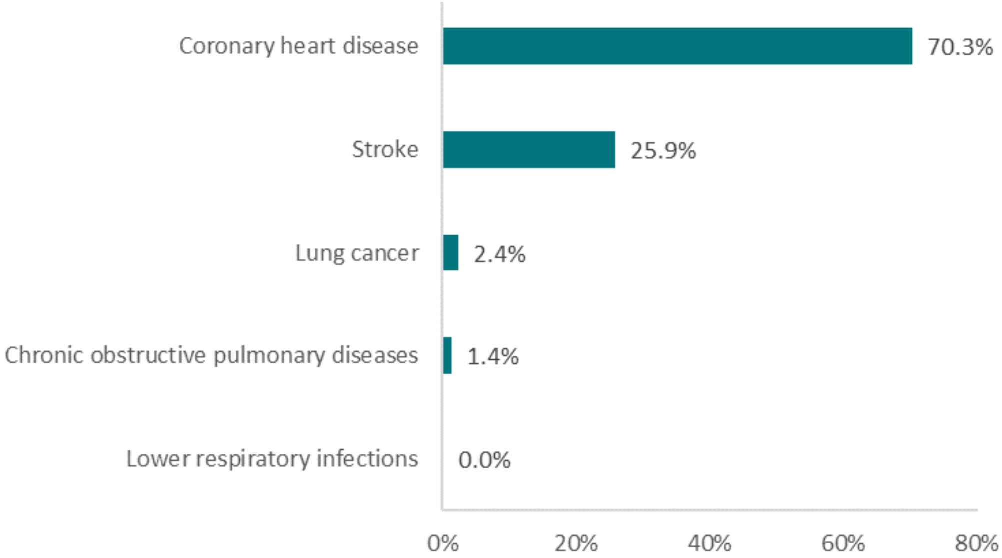
This section develops estimates of the costs of aged trucks to the community using data on vehicle age, vehicle location, and a mileage decay profile for ageing trucks devised specifically for this study. It also considers the proportional representation of aged trucks in road accidents.

4.1 Modelling the Health Costs of Aged Trucks

Air pollution, especially particulate matter (PM), is widely known to affect human health resulting in an estimated 3,000 deaths per year in Australia. PM has been recognised as a carcinogen and the World Health Organisation (WHO) suggests there is no safe level for PM pollutant levels (SOE 2016). As outlined in Figure 4.1 air pollution predominantly causes death through coronary heart disease and stroke.

The mortality, health costs and other productivity losses associated with the effects of air pollution are all borne by society.

Figure 4.1: Diseases causing death from air pollution in Australia



Source: AIHW 2016

The higher exhaust pollutant emissions of older trucks have both social and health consequences. Particulate matter (PM) and oxides of nitrogen (NOx) are the main pollutant components that lead to respiratory and related issues. These generate both a financial cost (to the community and the health system) and a social cost (amenity and quality of life suffer due to poor health).

Exhaust emissions of new Australian trucks have become significantly cleaner over the last 40 years in response to both Australian and international regulations (Appendix A). Since the introduction of Australian Design Rules for exhaust emissions, the limits have been reduced by more than 85% for PM and 95% for NOx. With the future introduction of Euro VI standards in Australia expected around 2027, these reductions will increase further. Therefore, new trucks are much cleaner than older trucks, even when those old trucks were new.

Importantly, regulatory limits apply when trucks are new and emissions-control equipment operates as intended. However, as all equipment deteriorates over time, it is probable that the current emissions of some aged trucks are well above their regulated limit.

This situation is counteracted by the fact that older trucks are used less intensively than newer trucks. They are also likely to carry lighter loads than newer trucks and may have better fuel efficiency (Appendix C).

Few independent or peer reviewed estimates of the health impact of aged trucks take all these factors into account. Those that do are not comparable to the Australian situation because of differences in methodology, assumptions, timing, or difficulty in verifying accuracy. As a result, a new estimate was developed for this project.

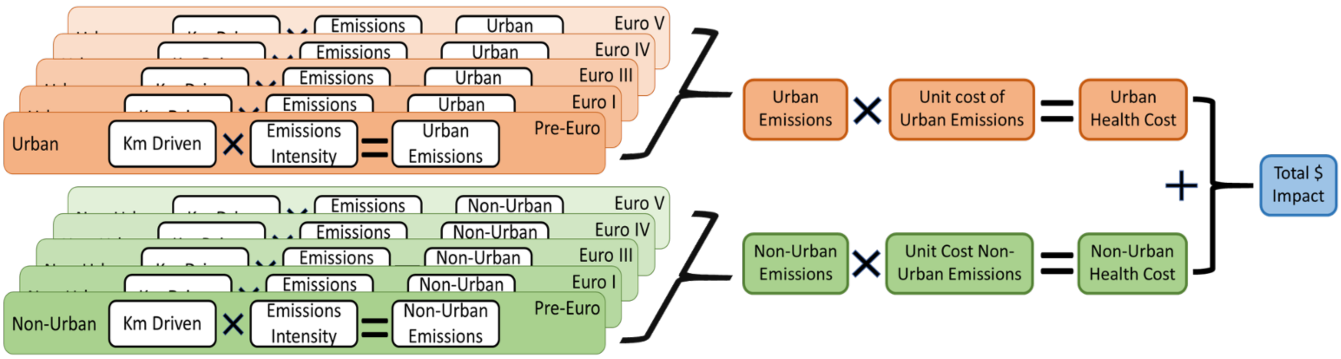
4.1.1 Modelling Methodology and Data

Pollutants only create adverse health impacts when they interact with humans. When used in a rural area with low population density, even the highest-polluting truck has a limited health or financial impact. Conversely, using aged trucks in densely populated areas has a significant impact.

Estimating the health impacts of vehicle emissions requires data from a range of published sources (robust emissions intensity factors and unit health costs, fleet size data, vehicle age data) as well as new data to fill information gaps or improve previous estimates. New information developed for this study included a location profile for the truck fleet (as discussed in Section 3.2), and a decay profile for annual vehicle kilometres as trucks age through their lifecycle.

The methodology for combining these elements is shown in Figure 4.2. Appendix D gives more detail of the health cost calculations.

Figure 4.2: Modelling the health cost of truck emissions



Modelling Scenarios

A business-as-usual (BAU) model for aged vehicle emissions and associated health costs was developed by combining the vehicle usage decay profile with the other factors in the formula above. This used the current fleet as a foundation and applied natural turnover rates.

Two scenarios for removing pre-1996 trucks from the road were then developed to determine the difference in health costs with and without pre-1996 trucks in the fleet. These are hypothetical scenarios that maintain the overall truck fleet at today's level but replace pre-1996 trucks with a different cohort.

The two scenarios were:

- Scenario 1: New-for-old – direct replacement of pre-96 vehicles with new Euro V vehicles
- Scenario 2: Trickle-down – removal of pre-96 vehicles via replacement with the next closest (oldest) suitable vehicle remaining in the market for normal aged truck usage.

These two "limit" scenarios were developed to represent a high and low emissions benefit. They were not intended to show the effect of any particular policy intervention.

4.1.2 Business-As-Usual Costs

The BAU scenario models the health costs from the current fleet, projecting how fleet emissions drop over time due to the higher emissions vehicles (pre-1996, Euro I, etc.) being used less intensively as they age, and ultimately being scrapped.

The estimated health cost of pre-1996 truck exhaust emissions in 2019 was $201 million. This represents around a quarter of the overall emissions health cost of the entire fleet, yet these trucks account for only 4% of the kilometres travelled by all trucks.

If nothing is done to reduce pre-1996 vehicle usage, over time their contribution to health costs will drop, (due to natural attrition) halving every four years. In 2024 the costs are estimated to be $90 million; and by 2029, $38 million. Figure 4.3 and Figure 4.4 show the estimates of these costs for urban and non-urban environments. Primarily due to the higher impact of emissions in urban areas[5], the total health cost for all trucks is more than three times higher in urban areas than non-urban.

For the Euro 0 (pre-1996) vehicles that are the focus of this study, the difference between urban and non-urban cost is closer to a factor of 4.5 times. This suggests that any measures to reduce the negative health cost impact of aged trucks should primarily focus on urban areas.

Figure 4.3: Health costs of heavy fleet exhaust emissions – BAU – Urban

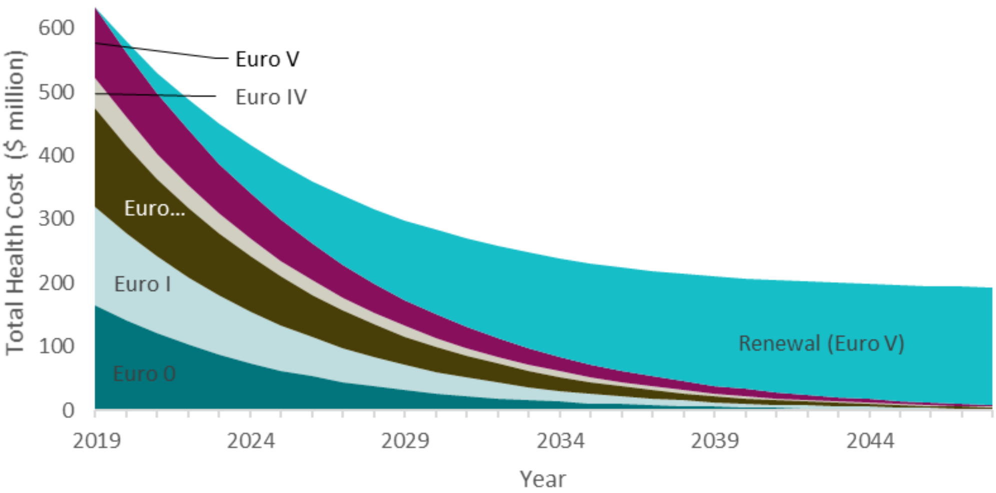
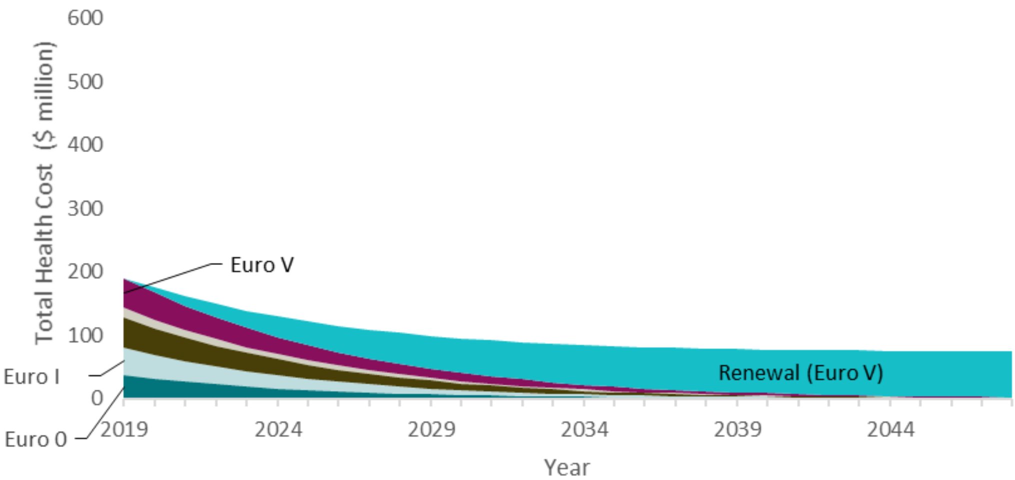


Figure 4.4: Health costs of heavy fleet exhaust emissions – BAU – Non-Urban



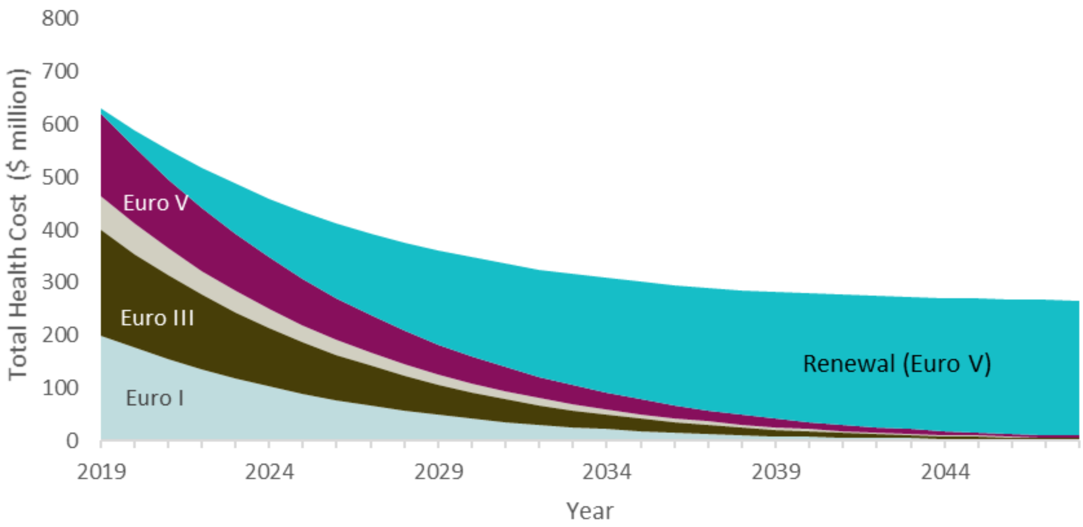
[5] A recent estimate by the Commonwealth indicated that the health cost of emissions in capital cities was between 3x (NOx) and 10x (HC) the cost of emissions in the rest of Australia ($/tonne) (DIRD 2016). This estimate covered all trucks rather than old trucks specifically.

4.1.3 Scenario 1: New-for-Old Replacement

This scenario assumes that, starting in 2019, all pre-1996 trucks are removed from the market and directly replaced with newly purchased Euro V trucks.

In this scenario, Figure 4.5 shows the health cost due to Euro 0 trucks ($201 million) has been replaced by only $9.4 million attributed to their Euro V replacements, representing a reduction in health costs of almost $192 million (95%) over the BAU model.

Figure 4.5: Health costs of heavy fleet exhaust emissions – Scenario 1 New-for-old



4.1.4 Scenario 2: Trickle-Down

The trickle-down scenario models the replacement of Euro 0 vehicles with their next-closest vehicle category in terms of age. It is likely to be more realistic[6] than scenario 1, and assumes that, starting in 2019:

- All pre-1996 trucks are removed from the market.
- All owners replace their trucks with the most similar vehicles available in the current fleet – that is:
  - Previous pre-1996 truck operators will mostly switch to Euro I trucks for their operations.
  - Previous Euro I truck operators will mostly switch to Euro III trucks for their operations, etc.
  - Only when the current stock of existing vehicles is used up are new Euro V vehicles purchased.

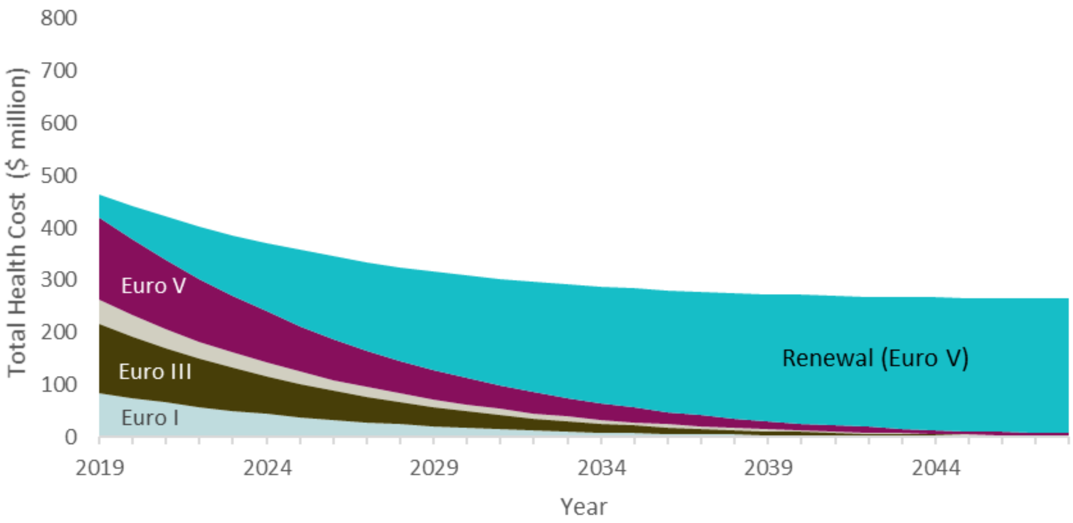
The net number and mix of trucks on the road in 2019 are the same as Scenario 1 (new for old), but the utilisation (in terms of km per year) is more appropriate for the age of the truck.

The results of Scenario 2 modelling (Figure 4.6) show a total saving in health costs of $359 million (compared with BAU), which is $167 million more than the new-for-old scenario. Once again, urban health costs represent the lion's share of the savings.

The total health savings from "trickling down" in the fleet ($359 million) are greater than the existing impact of pre-1996 trucks ($201 million). The reason for this is discussed in the next section.

[6]. On average, pre-1996 trucks are utilised less intensively than newer trucks for a variety of reasons, including the demands of their freight contracts (i.e. it is not necessarily a choice). If the operators of pre-1996 trucks were forced to replace their truck, there is no reason to believe they would use the new truck any differently to the older truck.

Figure 4.6: Health costs of heavy fleet exhaust emissions – Scenario 2 Trickle-down



4.1.5 Modelling Summary

Based on the assumptions in this analysis, truck exhaust pollution emissions are currently costing Australia $823 million per annum (BAU model). This is an externality cost currently imposed on the community. The oldest, pre-1996 (Euro 0) trucks, because of their high pollution levels, account for 24% of the total health cost (Table 4.1), while only doing 4% of the work (measured in kilometres).

The average health cost for a pre-1996 (Euro 0) truck operating in an urban area is $0.91 per km for articulated trucks and $0.37 per km for rigid trucks (an average covering a wide range of vehicle sizes). This represents an annual per-vehicle health cost to the community for a 1995 truck of between $3,300 and $21,000, if all its trips occurred in an urban area. The specific value varies with truck size, type, fuel consumption, age and area of operation.

The trickle-down scenario (Scenario 2) shows a larger health cost saving ($359 million) than the new-for-old scenario ($192 million). The results are summarised in Table 4.2.

This may seem somewhat counter-intuitive: replacing the oldest, most-polluting Euro 0 trucks with the cleanest trucks may seem to some like it should provide the best result. However, the reverse is true: "trickling down" some of the older trucks into what was the Euro 0 category has a more positive effect. This is because of the differing utilisation of the remaining middle-aged vehicles on the road (Euro I, III and IV).

- In the new-for-old scenario, all the middle-aged trucks carry on with the same operators, doing the same as in BAU, while cleaner Euro V trucks are dropped into low utilisation roles replacing Euro 0 trucks.
- In the trickle-down scenario, most of the middle-aged trucks are transferred to previous users of Euro 0 trucks – that is, the most polluting trucks left on the road are now less polluting AND used less than they were in the new-for-old model.

The average age of the fleet represented in scenarios 1 and 2 after the removal of all pre-1996 (Euro 0) trucks drops to 7.9 years in 2019, from 14.8 years previously (ABS 2019a). This is not a recommended intervention but an illustration of the effect on fleet age if there were no pre-1996 (Euro 0) trucks.

After removal of pre-1996 trucks, the relative scarcity of older trucks is likely to increase their value, affecting the cost/benefit to operators of replacing their older vehicles. The likely net effect of removing pre-1996 vehicles from the road would fall somewhere between the two scenarios modelled in this analysis.

Over a longer timeframe the community health benefit of replacing pre-1996 trucks grows significantly, as seen in Table 4.3. Under the trickle-down scenario, removing all pre-1996 heavy trucks from the road in 2019 would reduce health costs by more than $1.4 billion over a 7-year period. This rises to more than $1.8 billion (2019 dollars) over 30 years – a relatively small increase due to the compounding effect of the future discount rate.

Table 4.1: Health costs of 2019 heavy fleet exhaust emissions – BAU

Emissions Level	NOx $ million	PM $ million	NMHC $ million	CO $ million	Total $ million	% of 2019
Euro 0	28.7	158.0	13.7	0.9	201.3	24%
Euro I	33.2	150.2	15.5	0.8	199.6	24%
Euro III	53.9	109.8	35.9	0.6	200.2	24%
Euro IV	27.4	22.6	13.5	0.2	63.8	8%
Euro V	76.1	72.3	9.1	0.2	157.6	19%
BAU (2019)	219.3	512.9	87.8	2.7	822.6	

Table 4.2: 2019 health savings for modelled scenarios

Scenario	NOx $ million	PM $ million	NMHC $ million	CO $ million	Total $ million
1. New for old	24.2	153.6	13.2	0.9	191.9
2. Trickle-down	52.7	268.0	36.6	1.6	358.8

Table 4.3: Total health savings of modelled scenarios over time

Scenario	2019 $ million	7 Years $ million	30 years $ million
1. New for old	192	744	911
2. Trickle-down	359	1,441	1,814

Note: Discount to 2019 prices at 7%

4.1.6 Un-costed Health Impacts

There are other health costs associated with the operation of aged trucks that are hard to model and likely to be smaller than those described above. These include the effects on drivers as aged trucks deteriorate, as well as the ergonomic consequences of earlier designed seats and controls which improve markedly with each new generation of vehicles.

Additional costs apply to employees more broadly (e.g. warehouse and maintenance staff) due to local exhaust emissions at the same rates and costs shown in Table 4.2, as well as workplace injuries caused by increased maintenance and repairs on older vehicles.

4.2 Non-Pollutant Emissions

4.2.1 Greenhouse Gases (CO_2)

Newer vehicles are widely believed to have lower fuel consumption than aged vehicles (ACEA 2016a; TIC 2019a; Lam et al. 2019). And since greenhouse gas (carbon) emissions are directly proportional to the volume of fuel combusted, these emissions should also be lower for new vehicles.

However, emissions regulations (see Appendix A) and other design factors can affect fuel consumption, depending on the technology used to meet the standards. The International Council on Clean Transportation (ICCT) has found the fuel consumption of (European) semi-trailers has remained largely static over the last 10 years. This may be due to engine efficiency improvements being offset by the stricter pollution controls required (ICCT 2018a).

In Australia, the Truck Industry Council (TIC) claims that a post-2008 truck is 300 to 600 kg heavier than a pre-2003 truck (TIC 2019a). With all else being equal, this 300 to 600 kg tare increase will increase a truck's fuel consumption and reduce its productivity by reducing the maximum payload it can carry. But the effect is relatively small: In assessing the overall economic impacts of aged trucks, TIC estimated the carbon cost associated with the higher fuel consumption of older trucks was the lowest of all the impacts it analysed. The productivity benefit was largely due to more PBS vehicles than to improvements in fuel efficiency (TIC 2013).

Euro VI regulations could make a difference to CO2 emissions. In Europe there is a proposed CO2 requirement related to amendments of the Euro VI standard. As the Australian government has not yet committed to the adoption of Euro VI, any hypothetical benefit was excluded from the analysis.

4.2.2 Noise

The engine/exhaust noise emitted by older trucks is higher than from newer models. In Australia, heavy vehicles produced after 2007 must comply with ADR 83/00, limiting the highest power trucks to an engine noise of 83 dB. Limits for older trucks are significantly higher – between 97 and 107 dB depending on age and exhaust arrangement (TMR 2017). The effect of this noise will vary depending on the area of operation and the population density.

The Victoria Transport Policy Institute (2020) reviewed several international papers to understand the effects of road traffic noise on society. The paper notes different outcomes in urban and regional locations from heavy vehicle noise.

In the USA, increased levels and frequency of noise have been noted as affecting house values by 5–25%. In Australia, as many as one-third of houses experience significant traffic noise exceeding 68 dB (Brown and Lam 1994).

4.3 Road Accidents

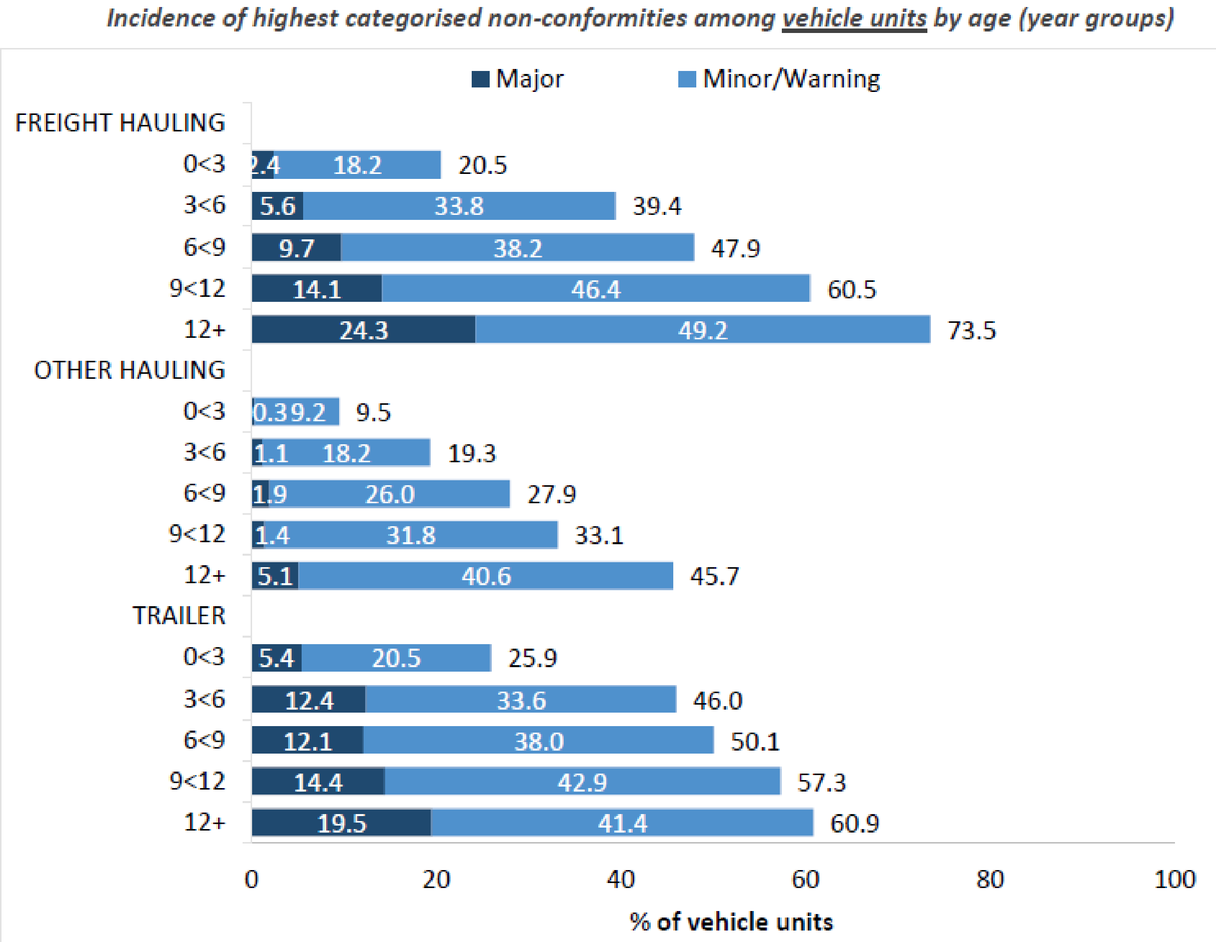
Road safety is a key focus for Austroads and its member agencies, and a priority in the wider community. The health costs associated with motor vehicle accidents are borne not only by the people involved in accidents and their families but also the community in general.

The main risk factors associated with road accidents are elements of the road, vehicle, driver and the environment (fog, rain, daylight, etc). The design and technology in new trucks (particularly safety systems) can reduce some risks associated with the other three elements (driver, road and environment). In Australia, road safety improvements are achieved via the Safe System approach, taking a holistic view of these influencing factors.

Some data supports the view that it is safer to drive a newer truck than an older truck:

- Constant vehicle design improvements in areas like visibility (windscreens, mirrors, lights, cameras); controls (steering, brakes, gearshift); comfort; and connectivity (hands-free phone dialling). All these support a better-equipped and more focused driver, which reduces accident risk.
- Newer trucks are more likely to feature safety-specific technologies. In Australia, around 25% of new heavy trucks are fitted with electronic stability control (ESC), and around 40% of new trailers are fitted with Roll Stability Control (RSC) (NatRoad 2018). A 20-year-old vehicle is unlikely to have either of these, nor a host of other safety-related systems.
- The NHVR roadworthiness baseline study (NHVR 2017) found that older trucks were around seven times more likely to be operating with a major defect than a new truck (Figure 4.7), nominally increasing their accident risk.

Figure 4.7: Older trucks have more defects



Source: NHVR 2017

However, despite these examples, clear correlations between truck age and accident frequency or severity were not apparent in the literature. Published papers on heavy vehicle safety from BITRE, National Transport Insurance and others tend to correlate many other parameters (driver age, time of day, number of passengers, vehicle faults, direction of travel, etc.) with crash and casualty data, but not the age of the vehicle. Although it seems obvious that higher risks (e.g. defects) might increase the frequency of crashes, the empirical link between truck age and actual crash data does not appear to have been widely studied.

4.3.1 Road Accident Data

To validate the view that new trucks are safer (and by inference, that older trucks are more likely to crash), the relative frequency of old trucks involved in crashes was compared with that of their newer counterparts.

The study analysed three years of crash data (2016–18) from The National Crash Database, provided by BITRE. Any crashes involving multiple casualties are only recorded as a single incident.

As older trucks are used less than newer trucks, the crashes were grouped by vehicle age, and records were normalised by those groups' VKT. The ABS SMVU provides a breakdown of VKT by truck type (ABS 2018). This was used to normalise the raw number of crashes to a frequency indicator (i.e. crashes/billion km), consistent with the kind of metrics seen in other road safety research.

The data associated with rigid trucks was scaled to give an estimate of VKT for heavy rigid trucks alone, excluding light rigids (more detail in Appendix B).

4.3.2 Crash Frequency

If the lower levels of safety equipment on older trucks correspond to a higher crash risk than for newer trucks, then crash rates for older trucks would be expected to be higher. Table 4.4 shows the number of incidents recorded over three years (2016–18). To be meaningful, these figures need to be related to the number of vehicles in each category and the volume of activity (measured as kilometres travelled). Note that cause of crashes was not considered in this analysis.

Table 4.4: Total crash incidents recorded 2016–2018 by age of truck

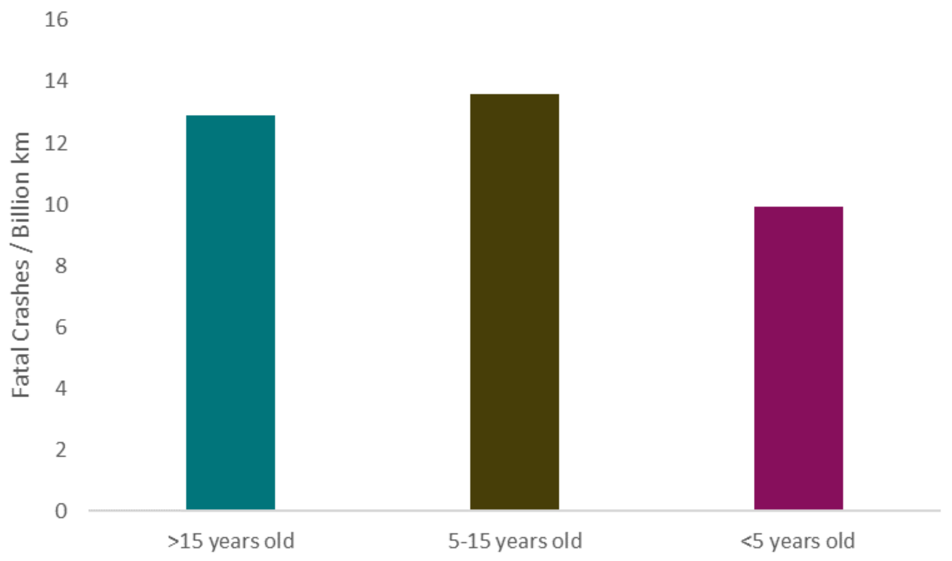
Truck Age	Casualty Crashes	Fatal Crashes
>15 years old	1358	63
5–15 years old	4452	221
<5 years old	2404	145

Source: BITRE 2019

Overall crash frequency (fatal and non-fatal)

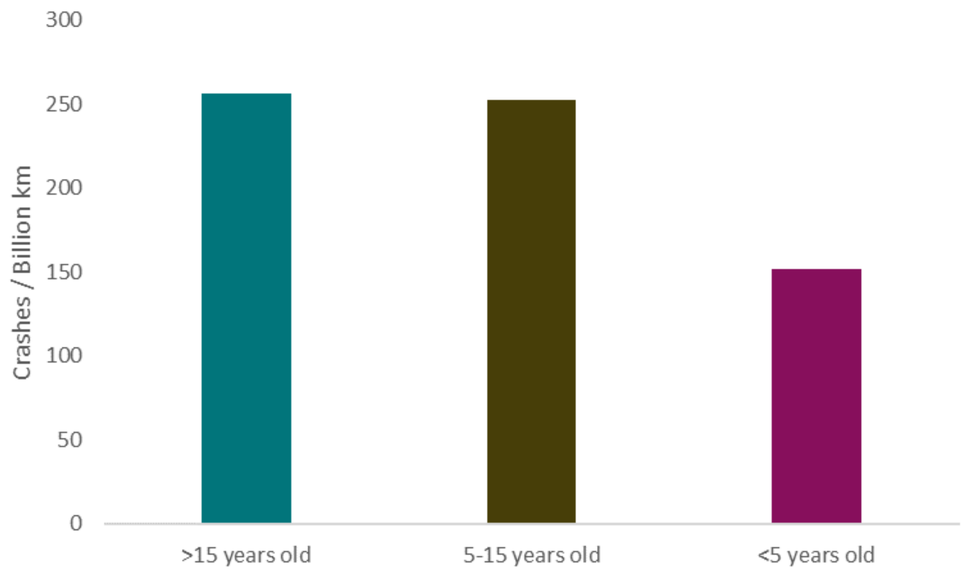
Figure 4.8 and Figure 4.9 show crash frequency (crashes/billion km) by vehicle age group for fatal crashes and casualty (non-fatal) crashes. These figures confirm that the newest trucks (<5 years) have a lower incidence of crashes per billion km travelled (both fatal and casualty). The incidence of crashes (both fatal and casualty) is similar for the oldest trucks (>15 years old) and middle-aged trucks (5-15 years). But contrary to popular belief, the oldest age group has a lower frequency of fatal crashes than the middle-aged group.

Figure 4.8: Number of fatal crashes per billion km – all trucks



Source: Derived from BITRE 2019, ABS 2018, ABS 2019a

Figure 4.9: Number of casualty crashes per billion km – all trucks

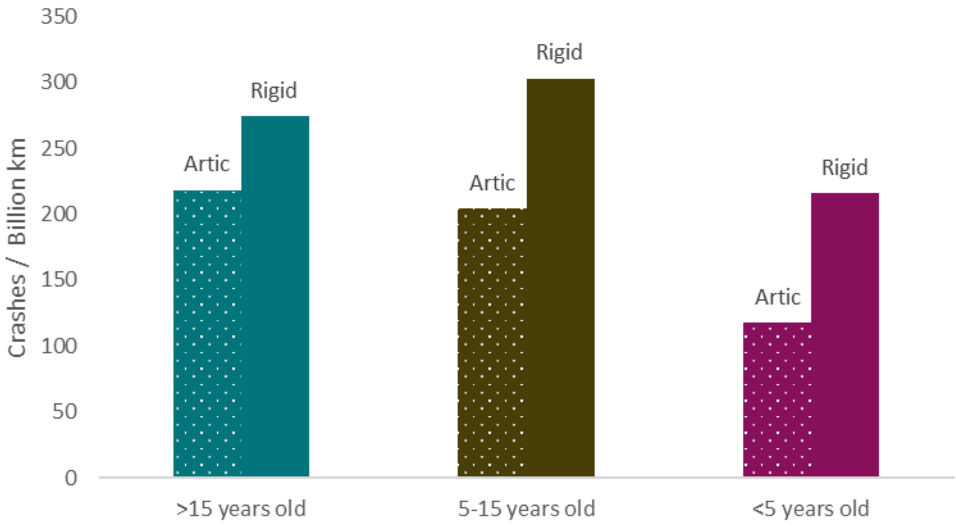


Source: Derived from BITRE 2019, ABS 2018, ABS 2019a

Crash frequency by truck type (rigid or articulated)

Investigating the rate of crashes by type of vehicle reveals a difference in crash frequency for rigid and articulated trucks (Figure 4.10). For all truck age groups, the crash frequency for rigid trucks is significantly higher than for articulated trucks. For articulated trucks, the oldest trucks have the (slightly) highest crash frequency; and for rigids it is the 5-15 years-old trucks that crash most frequently.

Figure 4.10: Number of crashes per billion km – articulated and rigid



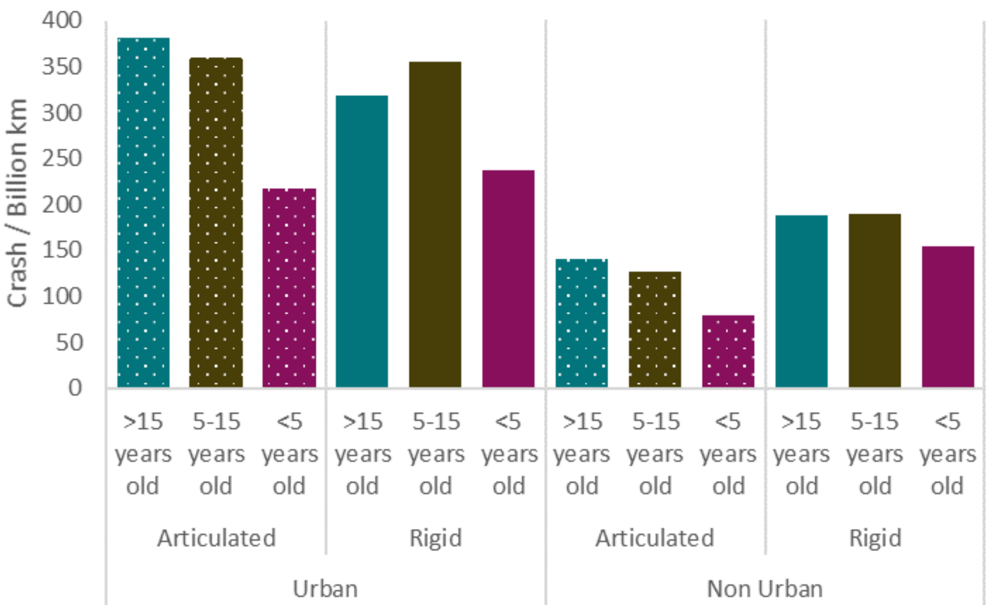
Source: Derived from BITRE 2019, ABS 2018, ABS 2019a

Crash frequency by location

The rate of crashes is higher in urban than non-urban areas (Figure 4.11) for trucks of all ages and types. Looking at the highest and lowest results, it is the oldest articulated trucks used in urban areas that account for the highest crash frequency of all groups. Meanwhile, the newest articulated trucks travelling in non-urban areas, often servicing interstate and regional long-haul freight, have the lowest crash frequency rate.

Looking just at rigid trucks, non-urban use results in a lower crash rate than urban use for all age categories, and the non-urban crash rate is relatively similar regardless of vehicle age group but with newest trucks lowest. In urban areas, the 5–15 years-old group is most likely to be involved in an urban casualty crash. The crash rate for the middle-aged cohort (5–15 years) operating in urban areas is essentially the same for articulated and rigid trucks.

Figure 4.11: Crash frequency by location

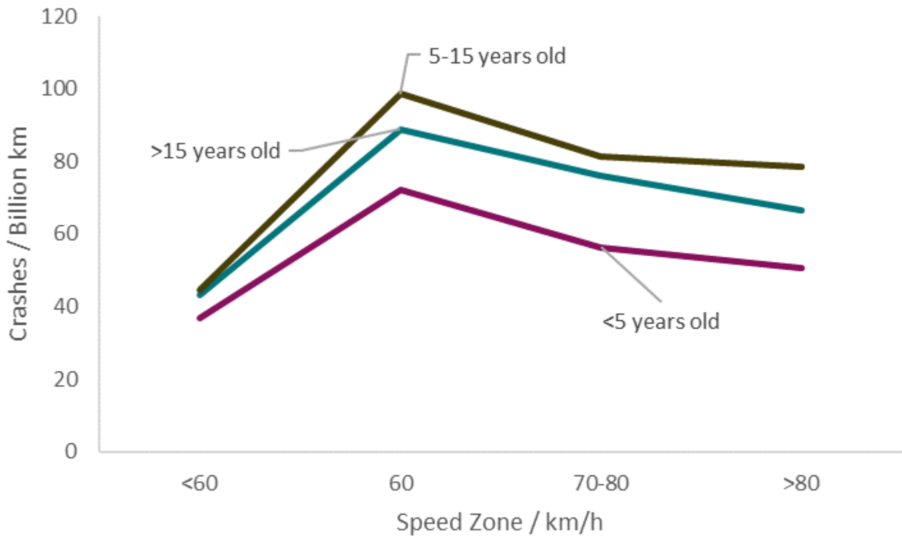


Source: Derived from BITRE 2019, ABS 2018, ABS 2019a

Crash frequency by speed zone

Another related perspective is the crash frequency by speed zone, as shown in Figure 4.12 for rigid trucks. The data indicates the speed zone at the location of the crash, not the speed at which the crash occurred.

Figure 4.12: Crash frequency by speed zone – Rigid trucks



Source: Derived from BITRE 2019, ABS 2018, ABS 2019

Some insights from the rigid truck data include:

- The newest trucks have the lowest crash frequency, and the relative difference between the different age groups stays quite constant across speed zones (i.e. the profile of the curves is similar).
- Regardless of age group, rigid trucks crash most often in 60 km/h zones.
- The crash frequency is highest for the middle age group (5-15 years) in all speed zones.

A similar analysis of crash data for articulated trucks reveals:

- There is a higher crash frequency in the highest speed zone, regardless of age.
- The relative difference between new trucks and the oldest trucks is quite similar across each speed zone (similar shaped curves); but the youngest cohort (<5 years) crash less frequently than older trucks.
- The oldest trucks have the highest crash frequency in all speed zones, but the rate is similar to the middle-aged group (5-15 years-old) in all but the 60 km/h zone.

In summary, the newest trucks have the lowest crash frequency of the three age groups but the oldest group of vehicles (>15 years) do not always exhibit the highest frequency of casualty crashes.

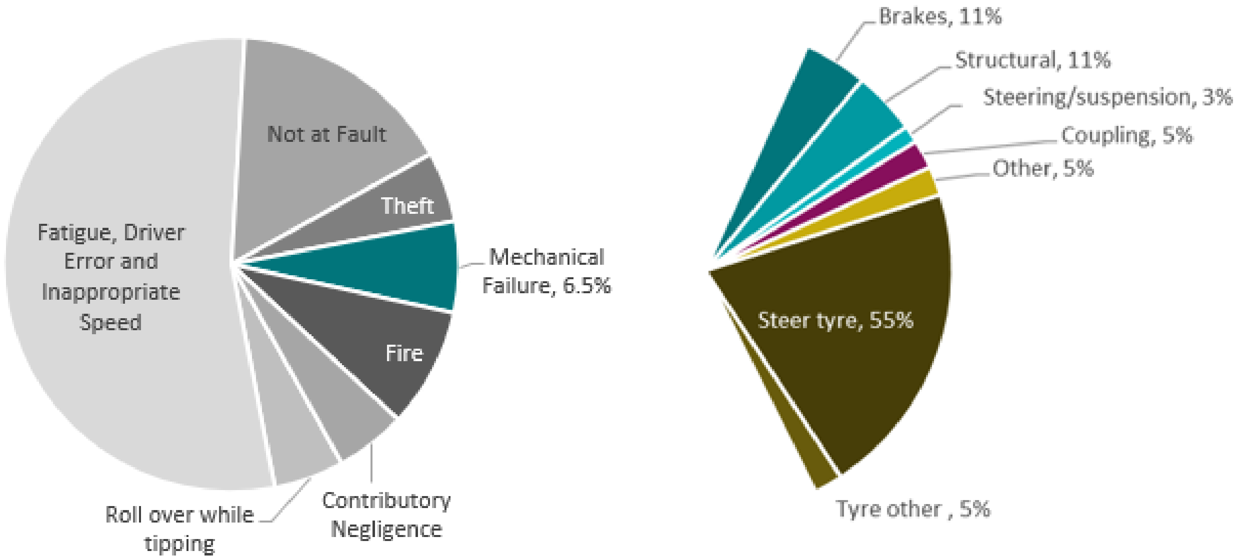
4.3.3 Crash Causes

The representations of crash frequency above do not suggest that vehicle age, or even speed or vehicle type, caused the reported crashes. A 2019 report by the National Truck Accident Research Centre (NTARC) suggests that up to 83% of multi-vehicle fatal crashes with heavy vehicles are caused by a third party (NTARC 2019) – that is, not caused by the truck driver or the truck. This statistic remained similar (80%) in the most recent NTARC report (2020).

This finding means that vehicle age is unlikely to have been a significant factor in those fatal crashes, nor for a large proportion of casualty crashes.

Other causes of heavy vehicle “large loss” insurance claims (>$50,000) noted by NTARC are shown in Figure 4.13. These include driver behaviour which was the cause of 54% of all major claims.

Figure 4.13: Causes of major heavy vehicle losses and mechanical failure incidents by sub-cause



Source: Derived from NTARC 2019

Around 80% of losses were caused by non-vehicle related factors (combining driver, other “not at fault”, “negligence” and “theft”). Of all major losses, just 6.5% were attributed directly to mechanical issues, with 60% of these due to tyre failure which can occur on trucks of any age.

In all, less than 2% of large loss claims were due to mechanical issues that might be attributed to mechanical condition, which in turn might or might not be attributed directly to the age of a vehicle.

Combining the crash frequency data presented earlier with the crash cause factors above, the implication is that the oldest cohort in the fleet (>15 years) has a similar or lower crash frequency than the middle-aged cohort (5-15 years), and that vehicle age is not likely to be a major causal factor in most of the crashes that do occur. This contradicts the common perception that aged trucks are a bigger road safety burden on the community.

5. Why Aged Trucks Are Used: Market & Policy Drivers

An understanding of the typical users of aged trucks, and the freight sectors they are used in, is a necessary basis for evaluating the kinds of policies that may be effective in managing the age and users of the fleet. Existing policies and anticipated technology changes are also important factors in understanding the context of the aged truck problem.

5.1 Types of Freight Carried by Aged Trucks

Aged trucks may be used in any operation where uptime is not critical, public image is not important, and when margins are particularly low. Austroads members and consultees engaged for this project suggested it is more common for smaller operators on the edge of an industry servicing low-margin freight tasks to use aged trucks than it is for larger corporate organisations. Common applications for aged trucks were identified as:

- shipping port and rail terminal container movement
- local container delivery into metropolitan areas
- large waste-bin transport (scrap metal etc)
- quarrying and earthmoving
- civil contractors and earthmoving companies (often using ex-linehaul trucks with modified bodies)
- farmers for local use on-road and off-road
- remote and rural delivery (e.g. firewood sales in New Zealand)
- ancillary transport of manufactured goods (about half of all trucks), where aged trucks may be used on an occasional basis and for small consignments when a hire and reward service is not cost effective.
- sectors that utilise specialised bodies on a rigid truck chassis, particularly in waste management
- occasional use to cover downtime or peaks, where an older truck may be retained in a fleet to fill any gaps when other trucks are unavailable.

To validate these views, the ABS Road Freight Movements survey data (ABS 2017) was analysed to assess the use of aged trucks in different commodity sectors.

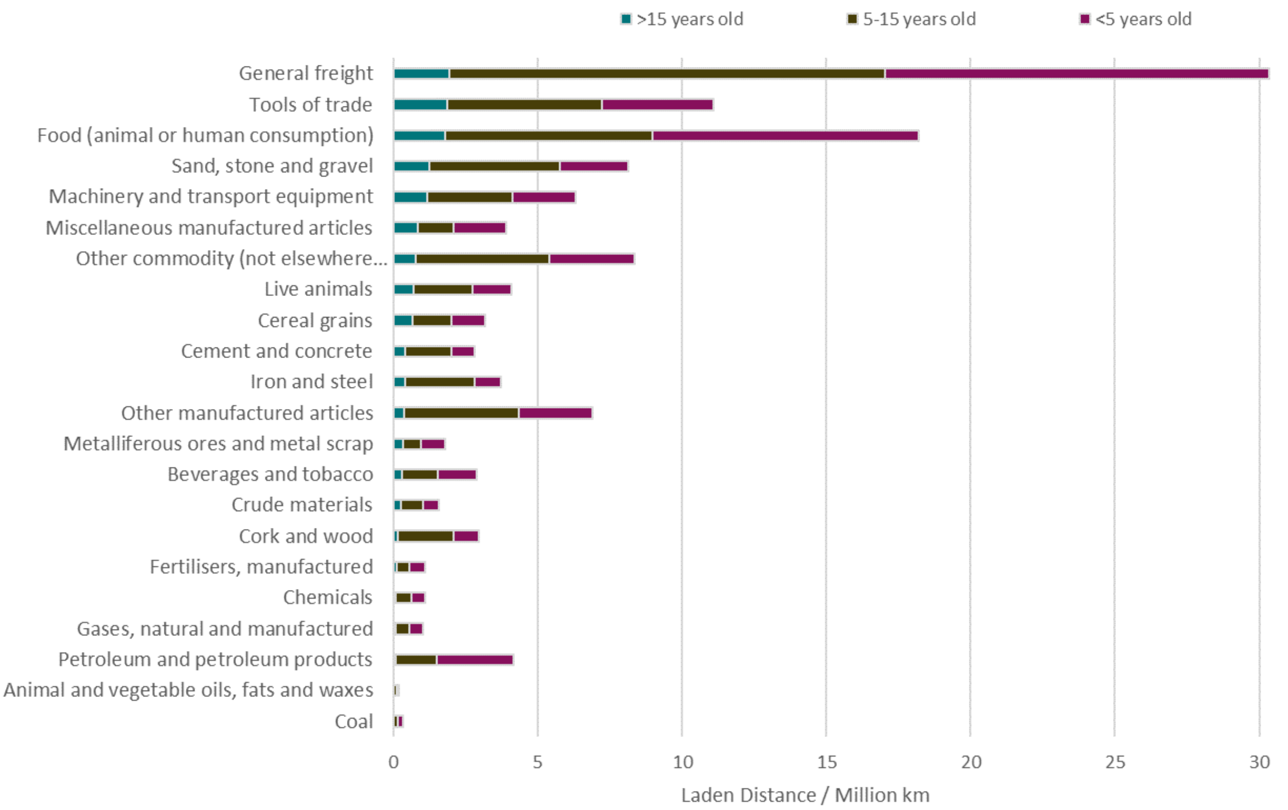
Figure 5.1 shows the relative freight task (laden kilometres) for different types of freight commodities. The categories are sorted to show the highest use of older trucks at the top. Figure 5.2 is another representation of the same data, sorted by the percentage of the overall commodity task carried out by older vehicles – again ranked with highest proportion of task carried by older vehicles at the top.

These two perspectives show the difference between industries that might be perceived as the “problem” (the greatest distances driven by older trucks, Figure 5.1), and those with the highest reliance on aged trucks (measured as proportion of total, Figure 5.2). No commodity is common to the top three of both figures.

The top three commodities in terms of reliance on the oldest trucks includes miscellaneous manufactured articles, cereal grains, and machinery. These are the industries most likely to be affected by any policies introduced to manage or restrict aged trucks, regardless of actual kilometres travelled. But even in the sector most reliant on aged trucks (Miscellaneous), those trucks do just over one fifth of the total task (Figure 5.1).

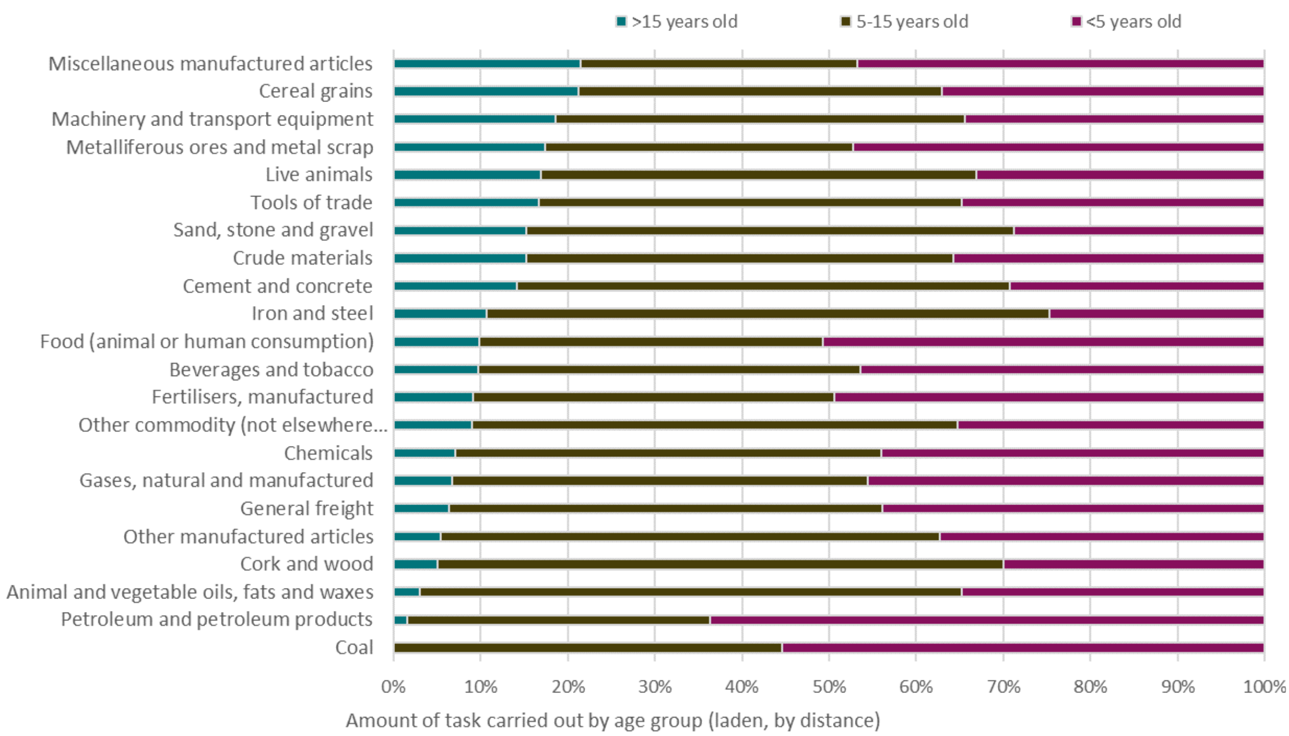
General freight is the commodity with the highest number of kilometres travelled in the oldest truck cohort, but that cohort still carries less than 10% of the total general freight task.

Figure 5.1: Commodities using older trucks – All trucks – Distance



Source: ABS 2017

Figure 5.2: Commodities reliant on older trucks – All trucks – Proportion of total



5.2 Covid-19 and Other Market Shocks

The emergence of COVID-19 in early 2020 is an example of market disruption that is impossible to predict. The effects of COVID-19 on the freight sector are still emerging and changing with time. Different freight segments are affected in different ways, at least in the short term:

- Some have seen major declines (e.g. air freight, container imports, fuel distribution or hospitality).
- Some have seen little change (horticulture and construction).
- Others have seen major increases (supermarket supplies and last-mile delivery).

The natural response to such a crisis may be a tendency to hold on to vehicles for longer (increasing heavy vehicle fleet age in Australia and New Zealand). Pandemic-related government stimulus measures could be used to counter this effect.

5.3 Policy Context

There are numerous initiatives currently underway in Australia to shape policy for the heavy vehicle industry but consideration of aged vehicles in these policies varies significantly. In many cases regulations or standards typically affect only new vehicles. Recent examples include the Regulation Impact Statements associated with the review of Fuel Quality Standards, the introduction of Euro VI for heavy vehicles, and the fitment of Automatic Emergency Breaking (AEB).

Areas of policy focus include the following.

Vehicle productivity. Increasing productivity while reducing the number of truck movements has been achieved though performance-based standards (PBS) and higher mass limits (HML). Introduced in 2007, PBS has enabled benefits in safety with 46% fewer major crashes per kilometre than conventional heavy vehicles, and PBS vehicles are much younger at just four years old compared with the broader heavy vehicle fleet (NHVR 2019).

Safety. The Medlock report (2018), noted that safety focused programs including TruckSafe, the National Heavy Vehicle Accreditation Scheme (NHVAS) and Western Australian Heavy Vehicle Accreditation Scheme (WAHVA), could be extended to further regulate the operation of heavy vehicles. The review concluded that owners of newer vehicles are more likely to opt into such schemes and to have fewer vehicle defects. However, truck age is not directly addressed in the recommendations.

One of the stated aims of the National Freight and Supply Chain Strategy, and its associated Action Plan, is to improve efficiency and sustainability and to support heavy vehicle road reform (TIC 2019b). However, the actions do not directly address the use of aged vehicles or known problems like the ageing fleet.

The National Road Safety Action Plan 2018–20 includes an action to “investigate the introduction of safer, cleaner heavy freight vehicles by minimising regulatory barriers” (TIC 2019c). However, if the mechanism only supports more new models and technologies, it may not directly address the issue of aged trucks (adding new vehicles to support the growing freight task, without removing older vehicles).

Reforms to the regulation landscape are currently being assessed for both the Heavy Vehicle National Law (HVNL) and Heavy Vehicle Road Reform (HVRR) by the COAG Transport & Infrastructure Council. The HVNL focus is “facilitating and regulating the use of heavy vehicles on roads in a way that promotes public safety; and manages the impact of heavy vehicles on the environment, road infrastructure and public amenity” (NHVR 2020). The National Heavy Vehicle Charging Pilot is exploring options for more direct road user charging, which in future may be a mechanism to manage aged truck impacts.

The Truck Industry Council’s Modernising the Australian Truck Fleet (TIC 2019a) outlines a mechanism to reduce the impacts of aged trucks by accelerating fleet renewal with a combination of incentives for cleaner vehicles and discouraging use of older trucks. It is not clear if these recommendations have yet been accepted or adopted by government.

Apart from the industry plan from TIC, the policies outlined above mostly take an indirect approach with no specific, direct action for managing or retiring the oldest trucks.

Figure 5.3: An older truck operating in urban Melbourne

Source: MOV3MENT / A2EP

5.4 Barriers to Upgrading the Aged Truck Fleet

The reasons for heavy vehicle operators to continue using older trucks can be explained from both an operator and a market perspective. Understanding these reasons is important when considering measures to influence operators to switch away from aged trucks.

5.4.1 Individual Operator Perspective

Individual operators use aged trucks for many reasons which include those below.

- Margins are so low in some operations that there is simply no capacity to replace an ageing truck and cashflow is more important.
- Although some transport business models may generate enough profit to invest in newer trucks, those funds may be invested elsewhere or taken as profit, as there is limited incentive to upgrade.
- Sectors requiring specialised bodies to carry out their work need to extend the truck's life to extract all the value from the revenue-earning portion of the truck (e.g. garbage trucks).
- Many believe that older trucks are more reliable, durable, more likely to keep going, and more easily repaired.
- Some owner drivers have an emotional or cultural attachment to their older truck. It represents their identity, their brand, or their social standing. Keeping an older truck going is sometimes a labour of love.

The SWOT analysis (Figure 5.4) classifies the compelling reasons for truck operators to continue using aged trucks. Chief among these is the simplicity and lack of barriers to market entry. Aged trucks are also more likely to have low acquisition costs, simpler repairs, and fewer regulatory or access restrictions.

Figure 5.4: SWOT analysis of aged trucks from fleet perspective

Strengths

Low capital cost
Simple/low technology
Easy to repair
Low total cost of ownership

Weaknesses

Breakdowns, More downtime
Failing inspections
Occupant safety
Higher fuel consumption
Possibly lower payload

Opportunities

Competitive on low margin operations
Minimal depreciation
Easy to turn over in second-hand market
Many alternatives/large market

Threats

More compliance focus by authorities
Risk of increased fines
Poor public perception/brand devaluation
Impact staff health (diesel exhaust)
Exclusion zones/curfews

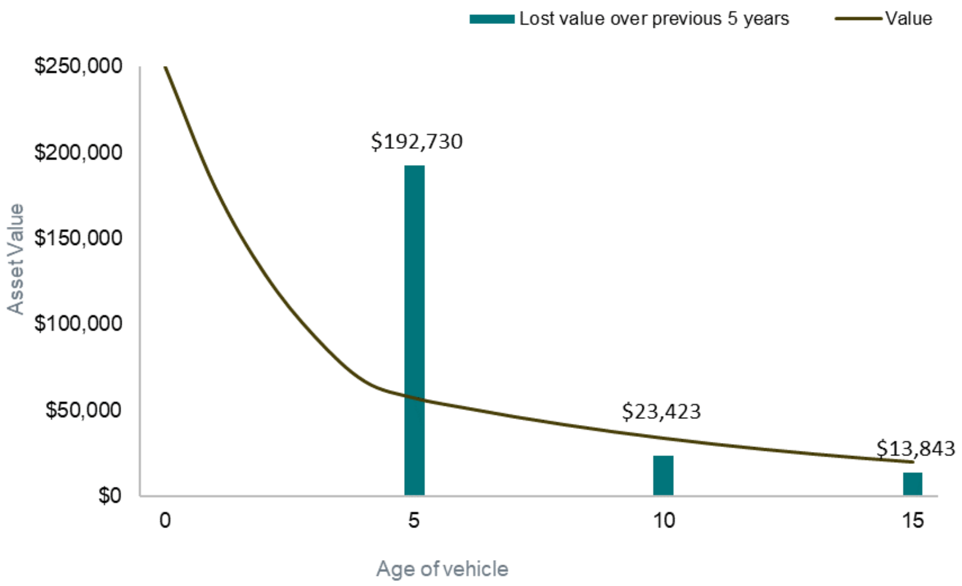
One of the greatest contributors to whole-of-life costs for a heavy vehicle is depreciation (TMR 2011). New vehicle depreciation is a significant cost for smaller operators and is influential in encouraging operators to continue using aged trucks.

Using factors provided in the Economic evaluation of road investment proposals: Harmonisation of non-urban road user cost models (Austroads 2005), and applying representative kilometres travelled for a prime mover (TradeTrucks 2019), Figure 5.5 shows how depreciation can affect whole-of-life costs over time. In this example, a 10-year-old truck would lose nearly $14k of value over the following five years of ownership, whereas a new truck will lose a significantly greater $193k in value, costing 14 times as much over a similar period. The differences would be even greater if the 15/20-year-old or even 20/25-year-old brackets of the aged trucks were considered.

Trucks generally travel longer distances in the early years than they do towards the end of their life, and these odometer values have a large effect on a truck's value. If newer trucks were used in the low mileage applications in which aged trucks are traditionally used, their depreciation loss would, to an extent, be reduced by this lower mileage.

Key to all of these issues is the economic model underpinning aged truck operations: low margin contracts and, often, small businesses in highly competitive operations. Many transport fleets have average net profit margins of just 3% of revenue (Ferrier Hodgson 2014).

Figure 5.5: Changes in depreciation and residual value over 15-year truck life



Source: Derived from Economic Evaluation of Road Proposals, (Austroads 2005; TradeTrucks 2019)

5.4.2 Market Perspective

Numerous push and pull factors encourage operators to use aged trucks for their freight tasks.

Push factors are policies and regulations that encourage or ensure aged vehicles are removed from service (Figure 5.6).

There are currently few, if any, policy measures that could act as push factors in the Australian and New Zealand markets, despite many freight-focused policies and programs. There are few barriers to entry and a lack of disincentives for operating aged trucks in most sectors and locations. This freedom afforded to operators, combined with limited regulation or disincentives, likely encourages the use of aged trucks.

Pull factors are those that draw an owner to upgrade to a newer truck. These could include customer considerations such as image or reliability, as well as financial considerations that make the business case for change.

A key pull factor missing in Australia and New Zealand is a secondary disposal market for used older trucks. Both countries are the end of the line in a truck's life. New Zealand allows importation of used trucks, so is a disposal market for the places providing these trucks. Australia does not allow used imports; however, it also lacks a market to which end-of-life trucks can be sent (Figure 5.6).

The main benefit of a disposal market is the effective floor for residual values, since there is still demand for old trucks in good condition. Instead of a truck being used until it is worth only the value of parts or scrap (a few thousand dollars), a secondary market ensures the truck commands a higher price, earlier in its life, in the export market. This creates a floor on the resale value, minimising depreciation, which is the largest component of total cost of ownership.

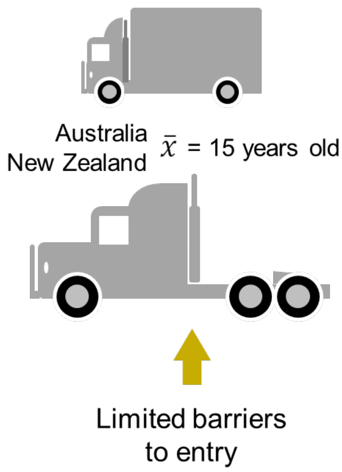
In the UK trucks tend to be exported at around 10 years old to African nations that are right hand drive[7]. The higher value for a used truck provided by another market acts as a barrier to the continued use of older trucks in some western markets. This higher residual value provides a financial incentive to upgrade to younger (even if not new) trucks, which is one factor in the lower average age of the truck fleet in those markets.

[7] https://www.abbas-trucks.com/

Figure 5.6: Push and pull factors impacting heavy vehicle age

Pull

Jurisdiction	Disposal market
Australia	Nil
New Zealand	Nil
UK	West Africa
Europe	Eastern Europe, Central Asia
USA	Central & South America



Push

Jurisdiction	Direct Aged truck management
Australia	Nil
New Zealand	Nil
UK	LEZ, £ penalties, grants
Europe	LEZ, € penalties, grants
USA	LEZ, grants

5.4.3 Social Licence perspective

Some of the aged truck burden results from their effects being unpriced externalities in Australia. Exhaust emissions, vehicle noise, congestion and greenhouse gas emissions are all costs borne by the community rather than internalised and paid by the operator. The lack of a price signal on these impacts means there is no incentive or penalty associated with different levels of performance. An aged truck that emits many more times the pollution per kilometre of a newer truck is not charged a higher fee for those emissions (polluter pays principle), despite its much higher impact on community health costs. Internalising that cost or regulating to reduce it could lead to a quieter, cleaner and more efficient fleet.

To date, there does not seem to be an appetite from successive Australian governments to price these externalities by imposing legal or economic measures to support the industry's social license. Social license is essentially the informal acceptance by the community of an industry's right to operate. As noted by Gehman (2017), social license is balanced with two other types of license (legal, economic). So, when community impacts or costs from a particular industry are deemed an issue (e.g. transport-related air pollution in London), social licence activity can leverage legal licence as it has done in that city resulting in a low emission zone.

The Australian freight industry has broadly recognised social licence as important to its continued operation, investigating ways to support this with public education. The Freight and Logistics Council of WA (2019) is currently undertaking a study to identify efforts made by the global freight industry to improve its social licence, which could potentially guide action locally. The Austroads project *Best practice approaches to road freight and communities* (Austroads 2020a) developed communications tools and guidelines for the development and maintenance of a united message between public agencies and industry in their effort to communicate the value of freight to the general public. Improving the public perception of the freight sector is also an action under the National Freight and Supply Chain Strategy.

At an individual level, some businesses value social licence as highly important to their ability to trade, particularly well-known brands that rely on reputation (e.g. supermarket chains). Meanwhile, many of the smaller businesses that operate aged trucks often do not rely on reputation for their trade, so it may not be as strong a driver for them individually. However, the need to meet a growing freight task via increased freight movements that may increasingly impact the community through congestion and noise, means that social license will likely become increasingly important to the industry as a whole.

5.5 Future Forces: Technology Disruption

Several factors are expected to disrupt the freight industry in the near future, with changes in consumer expectations, increased connectivity, increasing levels of fleet electrification, hydrogen, and new transport models coming on to the market.

New Freight Platforms

Freight sharing systems including on-demand platforms and aggregators are likely to increase their overall market share in the coming years, with consumers and small businesses attracted by the convenience of live tracking and transparent costs. This has the potential to further reduce profit margins at the lower end of the freight market, possibly even encouraging continued use of aged trucks unless the new aggregators control fleet quality through their procurement and contract terms.

Decentralised Manufacturing

Manufacturing items locally with 3D printing from raw materials (also called additive manufacturing) is expected to shift the freight task in coming years. Transporting raw materials rather than finished products is likely to reduce the volume of freight required. In addition, it could potentially reduce the mass of materials moved due to reduced packaging requirements and reduced wastage of finished stock. Margins for the last-mile and raw material delivery are likely to dictate the effect on the use of aged trucks.

New Energy Sources

New energy sources are being introduced to the heavy road freight sector including battery electric, biofuels and hydrogen. Some of these fuel sources can enable low and zero emission operation and reduce greenhouse gas emissions. Combustion fuel alternatives such as biodiesel have the potential to reduce carbon emissions, but they continue to emit combustion pollutants from the truck exhaust at a similar level to that of oil-derived diesel (NRCAN 2020).

Both battery electric and hydrogen powered vehicles eliminate harmful tailpipe emissions. If the electricity source to charge the battery or to produce hydrogen is generated by fossil fuels, it can create pollution at the powerplant affecting the local area (Austroads 2020b).

The rate at which these new energy technologies will be adopted into the truck fleet is not known. New truck operators will be the first to adopt these technologies as they emerge on new models. Operators of older trucks are more likely to be the 3rd/4th/5th owner of a truck, so are unlikely to see the technology until much later. As a result, without significant intervention these new technologies will likely have a limited impact on aged vehicles in the timeframe of their natural attrition.

Figure 5.7: Tesla Semi truck with two-axle trailer

Source: Tesla

Alternative Modes of Transport

It is expected that the use of rail for interstate freight will increase with the completion of the inland rail connection on the east coast of Australia. The shorter distances of road freight required at both ends of the line (and intermediate stops) may favour aged trucks with their low margins, unless this is actively managed. The primarily urban nature of this activity may increase the health impact of aged trucks.

At the same time, the urban and last-mile freight task has been increasing rapidly as consumers exploit on-line shopping and retailers reduce stock holdings to move to just-in-time delivery models. This trend is expected to continue and even grow strongly, increasing congestion (DIRDC 2018).

Some providers are trialling alternative delivery methods, including drones and autonomous delivery robots. The impact on aged trucks is likely to be limited, as small package delivery is generally carried out by smaller vehicles, often under 4.5 t GVM. However, with competition comes lower margins, and with minimal barriers to entry, aged trucks may find a niche in this growing sector. Again, this would further exacerbate the negative impacts identified above.

6. Policies to Manage the Use of Aged Vehicles

A review of all heavy vehicle programs globally (which number in the thousands) was beyond the scope of this project. This research therefore focused on measures intended to have a direct effect on reducing the number of aged trucks or age of the fleet. Examples of measures with direct and indirect effects are provided in Table 6.1.

Measures with direct effects will ensure the use of aged trucks is reduced or restricted (even if only in specific areas), or that these vehicles are replaced or retired. Incentives to buy new vehicles were considered an indirect measure because, although they may result in a reduction in fleet age, as the freight task is also growing the outcome might simply be an increase in the total fleet size with no retirement of older vehicles. Actions that only affect the new vehicle market (such as Euro VI adoption) can also take up to 35 years to filter through the entire in-service fleet (DOI 2018), which is too slow to avert the worst of the community impacts associated with aged trucks.

Table 6.1: Examples of direct and indirect policies affecting aged trucks

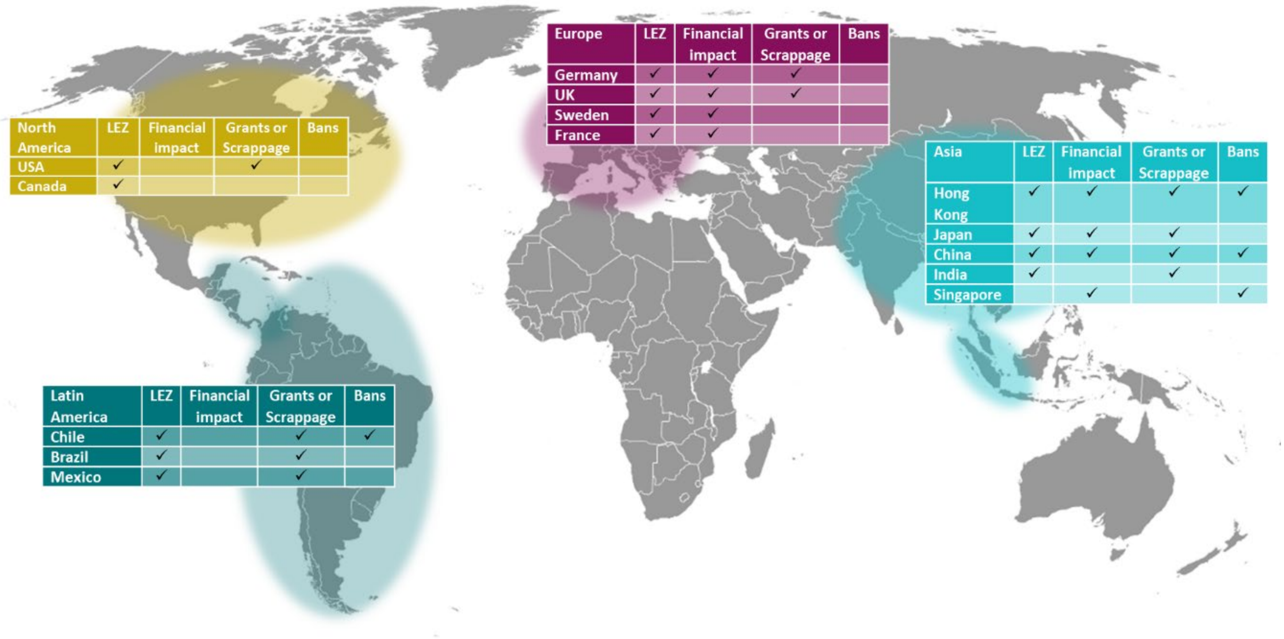
Direct Impact on Aged Trucks	Indirect Impact on Aged Trucks
Restricted access to road network	Internal combustion engine or diesel bans for new sales
Low emissions zones (exclusion/fine)	Incentives to buy new vehicles
Targeted scrappage schemes	Alternative fuel conversion programs
Increased costs and fees (registration/tolls)	New Zealand's low emission vehicles contestable fund
Repower/retrofit programs directed at aged trucks	

Direct measures were grouped under four categories based on the mechanism used to achieve their objective:

- **Road network access restrictions**, such as LEZs which restrict access to specific kinds of vehicles.
- **Financial penalties** or differential fees on operating aged trucks
- **Financial incentives** and grants to replace aged trucks – such as scrappage schemes, investment allowances, and 'cash for clunkers' programs.
- **Repower, retrofit or upgrade** programs targeting the emissions of old trucks.

The use of these policies is widespread across the globe (Figure 6.1). More detail and examples of the four kinds of policies are provided below in Sections 6.1 to 6.4.

Figure 6.1: Examples of policies targeting aged vehicles by region



North America	LEZ	Financial impact	Grants or Scrappage	Bans
USA	✓		✓	
Canada	✓			

Europe	LEZ	Financial impact	Grants or Scrappage	Bans
Germany	✓	✓	✓	
UK	✓	✓	✓	
Sweden	✓	✓		
France	✓	✓		

Asia	LEZ	Financial impact	Grants or Scrappage	Bans
Hong Kong	✓	✓	✓	✓
Japan	✓	✓	✓	
China	✓	✓	✓	✓
India	✓		✓	
Singapore		✓		✓

Latin America	LEZ	Financial impact	Grants or Scrappage	Bans
Chile	✓		✓	✓
Brazil	✓		✓	
Mexico	✓		✓	

6.1 Access Restrictions

Restricting access to the road network is an effective, albeit strong, measure to control the types of vehicles used by operators. Restrictions can be either general exclusions from the road network (such as setting an age limit or other criteria for all trucks); or area-specific access restrictions such as are commonly used in congestion zones or LEZs. The line between these two approaches can be blurred, but specific examples are provided below under each group.

6.1.1 International – Age or Emissions Limits

The strongest control measure identified in the research involves outright bans preventing aged vehicles from accessing the road network once they exceed a particular age or emissions class threshold. This approach has commonly been used in areas that suffer the worst impacts from air pollution and noise, for example, Hong Kong, Chile, Singapore and Vietnam.

- Hong Kong has an age limit for all registered heavy vehicles as part of its Clean Air Plan, which began in 2012. Since 2014, the age limit operates as a registration ban on trucks older than 15 years. However, that is just the latest stage of a coordinated plan that combines both bans and incentives for early upgrades/replacements. The policy progressed from bans on early pre-Euro trucks, through Euro I and Euro III vehicles – so that the minimum standard in late 2019 was Euro IV for all trucks on the road. Complementary incentives were sizeable, with the greatest support at just under $50,000 to replace a 12-year-old Heavy Goods Vehicle. Combining access bans with scrappage incentives meant the Clean Air Plan removed older trucks from Hong Kong's roads and reduced the average age of the fleet from nine to four years over a 5-year period (EBHK 2013).
- In Singapore, the statutory lifespan of a goods vehicle is 20 years, beyond which they must be deregistered or scrapped. (Lam et al. 2019)
- In Vietnam, trucks are not allowed to operate past 25 years old. (Lam et al. 2019)
- In Chile, mining and forestry vehicles require renewal every five years.

Some cities and countries have either implemented, or announced their intention to implement, rules banning older diesel vehicles, including trucks. For example, a ban on the use of old diesel trucks includes a collaborative announcement by Athens, Mexico City, Paris and Madrid that they will stop the use of diesel-powered cars and trucks by 2025 (Coren 2018).

At least a dozen countries and more than 20 cities have committed to bans on the sale of new diesel or petrol vehicles. However, for this project, bans on new sales are considered indirect measures that do not directly target older vehicles. Indeed, sales bans could potentially prolong the life of the oldest trucks in the fleet, as those operating them may not be in a financial position to purchase diesel alternatives, or they may not be confident in new technologies which are yet to be widely proven.

6.1.2 International – Low Emission Zones (LEZ)

Low emission zones and some “congestion zones” either prevent access to an area for highly polluting vehicles or aged vehicles, or deter entry by charging higher access fees for those vehicles compared with other cleaner vehicles (UAR 2020). Pure congestion zones that simply charge all vehicles an access fee during peak travel periods are not classified as an LEZ in this paper.

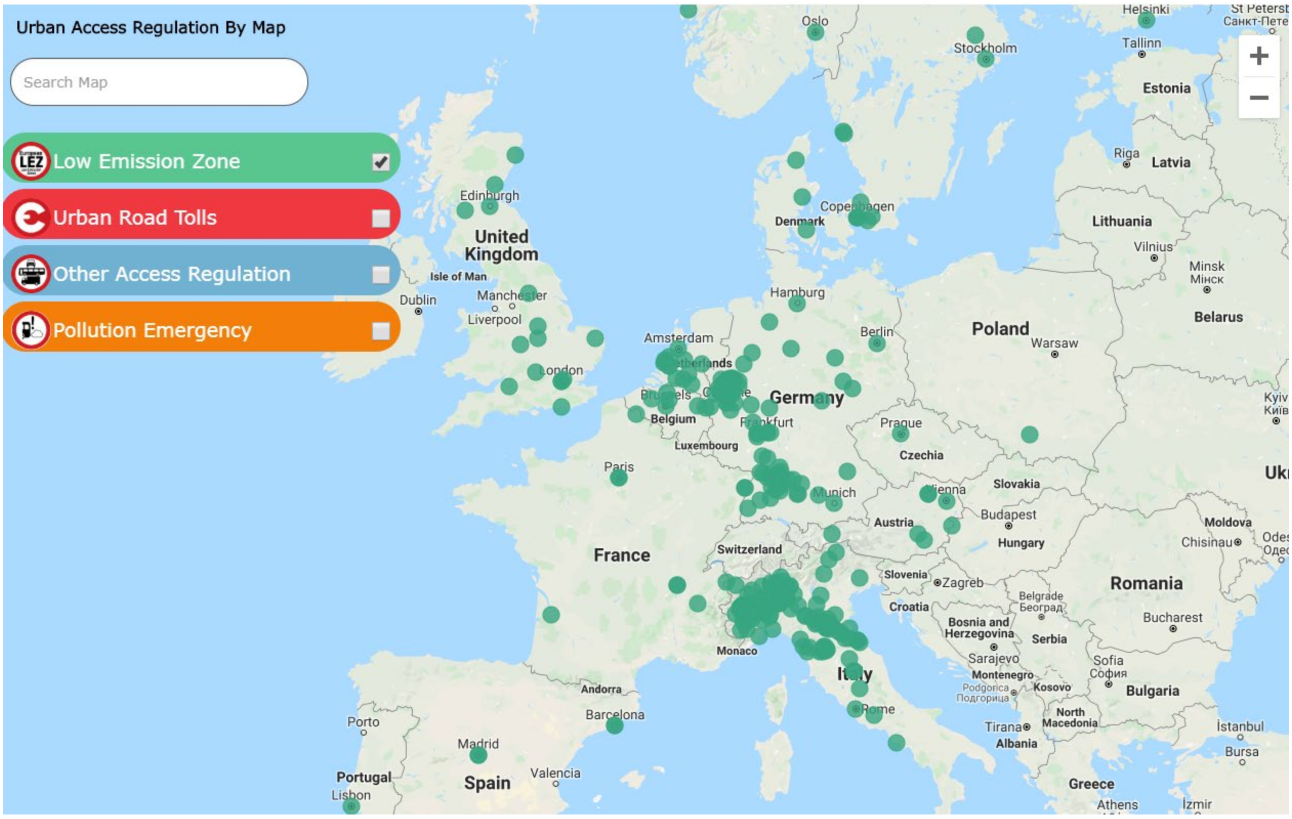
LEZs are common throughout Europe with 58 E-Zones (environmental zones) in Germany alone, many ZFE (Zone à Faibles Émissions) in France, and many more in Italy and other EU countries. Hundreds of these zones have been deployed in urban centres by local authorities (Figure 6.2). The minimum emissions standard varies by country or region, but typically requires Euro III as the minimum for diesel heavy vehicles. In some cities, Euro V will be the minimum from 2020.

Non-European examples of LEZs include:

- The San Pedro Bay Ports Clean Air Action Plan (CAAP 2006) includes the Clean Truck Program in the Port of Los Angeles. This achieved a 90% reduction in truck air pollution by banning trucks that did not meet certain emissions standards. Trucks entering the port must sign up to the Port Drayage Truck Registry. Higher-polluting vehicles are simply prohibited from registering. Pre-1989 trucks were banned in 2008; pre-2007 compliance was banned in 2012; and in 2018, only vehicles newer than 2014 were permitted access (POLA 2019).
- The success of this program has spurred the development of the Clean Air Action Plan (CAAP) update 2017, advancing the Clean Trucks Program with both exhaust pollutant and CO2 emission goals, continuing to phase out older trucks and transition to zero emissions trucks by 2035 (SPBP 2017). This plan is complemented by pilot projects to prove the commercial viability of current zero, or near-zero emissions vehicles (such as Battery Electric Vehicles, Fuel cell Electric Vehicles, Advanced Diesel, Advanced Natural Gas and Hybrid Electric Vehicles) (SPBP 2019).
- London ULEZ (Emissions): currently allows Euro VI only, with limited choices for retrofitting older standard vehicles. Penalties of £100/day apply for driving non-compliant heavy vehicles in the ULEZ. In 2021 the zone for heavy vehicles will be increased to include the larger LEZ (North and South Circular Roads) (TFL 2019b).
- London ULEZ (Safety): Trucks >12t have an additional safety requirement, a minimum one-star Direct Vision Standard (DVS) rating. This is planned to ramp to three stars in 2024. If the vehicle manufacturer DVS rating is not high enough, there are options available to retrofit (TFL 2019b). Non-compliant vehicles are charged £550/day.
- Mexico City has had a form of restriction on its roads since 1989, with older vehicles restricted from accessing the inner-city zone one weekday per week in an attempt to reduce air pollution. However, a study of an expansion of the program to include Saturdays found it had “virtually no discernible effect on pollution levels” and that there was no evidence that the initiative shifted road users to lower-emission transport modes (Lucas 2017).

- Sao Paulo, Brazil, initially installed a daytime exclusion zone (ZMRC) for large trucks in the city centre in 1986 and expanded the zone in 2008. Only 3.5t urban delivery trucks called Veículos Urbanos de Carga (VUC's) are exempt from the exclusion (and others under special circumstances). This has increased congestion because more trucks are required to deliver the freight task. To combat this, trials of out-of-hours deliveries provided shorter travel times at night and went on to be a citywide volunteer initiative in 2016 (Yoshizaki 2016).
- Delhi and other cities in India have proposed an age cap and differentiated taxation based on emissions certification level.
- The city of Oxford in the UK is in the final stages of introducing the next level of emissions-based exclusion zone called a Zero-Emissions Zone (ZEZ). The zone initially levies a £10 fee on any vehicle that generates tailpipe emissions, leaving electric vehicles as the only fee-free option. This initiative is also set to grow from a small number of streets in the centre to a wider area as part of a wider zero emissions strategy by the local authority. The impact is expected to be low, with a number of exemptions out to 2024 (Oxford 2020). However, peak body organisations for freight operators have responded unfavourably, noting there are limited options available on the market to comply with the proposed ZEZ (de Prez 2020).
- The UK Government has developed a framework of four classes of Clean Air Zone for local governments to use. Three of the four classes require heavy vehicles to be at least Euro VI level emission standard. This national initiative requires local authorities to act where air quality is above the limits set in the World Health Organisation (WHO)'s air quality guidelines (DEFRA 2017).

Figure 6.2: Low emissions zones in Europe



Source: www.urbanaccessregulations.eu, and copyright Sadler Consultants Europe GmbH and EU

LEZs can induce some displacement effect, where larger fleets replace the vehicles operating in an LEZ first. Dablanc et al. (2015) found that, while the LEZ increased investment in newer vehicles, some smaller operators were forced to relocate or go out of business. Although a direct causal link has not been established, a study of LEZs in multiple European countries showed a reduction of 15%–30% in the number of transport and logistics firms operating in cities with an LEZ. The authors believe the LEZs have forced efficiency improvements, and thus benefitted the urban freight transport market (Dablanc et al. 2015).

6.1.3 Australia and New Zealand

Smart Freight Partnership (Victoria). When new, the West Gate Tunnel development in Melbourne included measures to reduce impacts on local streets prior to its completion, when a series of 24/7 bans will be implemented for heavy vehicles. In 2017, the Victorian Transport Association (VTA) and the Maribyrnong Truck Action Group (MTAG) submitted the Maribyrnong Cleaner Freight Initiative (CFI) to the Victorian Government (VTA, MTAG 2017).

The CFI measures to reduce the impacts of trucks through the inner west included permitting access for cleaner trucks, increasing vehicle visibility, reducing speed limits, employing technologies for enforcement, conducting a community awareness driver training program, increasing monitoring and introducing new heavy vehicle curfews. There was some opposition to the CFI proposal, including concern that small operators would be unfairly affected by restrictions (Reynolds 2019).

In July 2019 the Victorian government announced the Smart Freight Partnership – Inner West. The partnership consisted of the Victorian Government, VTA and MTAG. This was an Australian first, ‘encouraging the use of cleaner vehicles to deliver safer conditions for drivers and residents’ (Pulford, J. 2019; MTAG 2019). The proposed scheme leveraged existing curfews to allow Euro V trucks more operating time than older trucks in the specific area. It was intended to bring the industry, inner west community, and government together to achieve better community amenity while managing heavy vehicle movements in the inner west.

Following further investigation, the Victorian Government was unable to commit to the introduction of an Environmental Freight Zone as proposed by the VTA and MTAG (DoT Victoria 2020). As a result, MTAG publicly withdrew from the partnership (MTAG 2020), and hence the Government will not proceed with the commitment to the Smart Freight Partnership – Inner West.

SPECTS New South Wales. The Safety, Productivity and Environment Construction Transport Scheme was conceived to improve the safety, environmental performance and productivity of trucks in the NSW construction industry (RMS 2019). Voluntary participation confers greater network access and the ability to carry more material (PBS level 1), but requires meeting conditions including Euro V engine, GPS tracking, and various vehicle safety systems and equipment. Initial uptake was low, but changes were introduced in June 2019 to remedy this. The program is mentioned here for the purpose of highlighting another Australian scheme, but this program does not reduce the use of aged trucks directly (the main purpose being to reduce vehicle trips and congestion via productivity).

Grain Harvest Management Schemes (GHMS). Many states in Australia have some sort of mass concession for heavy vehicles that are involved in the harvest of grains, allowing a variance of 5–10% above the general mass limit (GML) for that vehicle. Since 2017 Victoria has linked the mass concession to a minimum emission standard (ADR80 which is equivalent to Euro I).

In the recent NHVR review of GHMS programs, the Victorian Department of Transport submission noted the exclusion of pre-Euro I trucks provided benefits (encouraging newer vehicles to be used) and challenges (not many farmers having compliant trucks to use) (DoT Victoria 2019). Significantly, among several other benefits, the program has seen a marked reduction in the age of the fleet used, which was a key objective of the scheme. (DoT Victoria 2020).

However, in a submission to the NHVR review, the Victorian Farmers Federation (VFF 2019) claimed that the emissions-based exclusion was a reason that the participation rate was “very low”, as the average age of the fleet is 29 years. NatRoad, an industry association representing truck operators, stated in its submission that the emissions-based exclusion “makes no sense”, citing maintenance and safety considerations as more relevant (NatRoad 2019).

Construction contracts. Construction traffic for large inner-city developments, such as the Barangaroo site in Sydney and Queen’s Wharf in Brisbane, has a societal impact. Some projects place conditions on the specification or features of trucks allowed to enter the construction site. This leads to younger, better-equipped trucks being used and reduces impacts on the site and surrounding urban areas. For example, the Melbourne Metro project required side under-run protection for all heavy vehicles engaged in the project (TradeTrucks 2020).

6.2 Financial Incentives and Disincentives

This category of measures combines ‘carrots’ (incentives, discounts, exemptions) with ‘sticks’ (disincentives, penalties, taxes, fees). It includes any kind of financial cost levied at a higher rate for vehicles of a certain age or emissions level. Examples include differential registration fees, road tolls, LEZ access fees and road user charges.

6.2.1 International

Lam et al. (2019) describe several countries that use this approach, including:

- Vietnam: an additional surcharge on top of the road user charge is proposed for vehicles according to age (5-year-old trucks pay 10% extra, 10-year-old trucks pay 20%, 15-year-old 30%, and 20+ years 40%). Each of the age categories would also see a 1% year-on-year increase.
- Singapore: surcharges were introduced on vehicles more than 10 years old to keep the average age low. This is in addition to the statutory limit for 20-year-old and higher trucks. Only 6% of the fleet is older than 17 years, compared with Australia where almost 20% of the fleet is older than 23 years.
- Germany: the annual registration fee or road tax is determined by the emissions standard and vehicle size (GVM), with the most polluting vehicles attracting fees up to three times higher than other classes.

In the UK there was a differential annual road tax distinguishing pre-Euro IV and newer vehicles. The discounted rate for lower emissions trucks was removed at the end of 2016 bringing all diesel heavy vehicles to the same cost for yearly road tax (HMRC 2014).

The Netherlands, Luxembourg, Denmark and Sweden have adopted the Eurovignette road toll charge for all local and visiting heavy vehicles over 12 tonnes. The toll is based on the emissions class of the truck, with the monthly cost varying from €235 to €125 for Euro VI (DKV 2019).

From 2002 Japan increased the cost of annual truck registration by 10% when a vehicle reaches 11 years old. Other reductions apply to low-emission vehicles leading to a difference in annual tax costs between new trucks and an 11-year-old truck of 35% (Aichi 2010).

6.2.2 Australia and New Zealand

In Australia, diesel fuel sales include a fuel excise duty. For truck operators, a portion of the duty can be claimed back for any on-road business activity via the fuel tax credit administered by the Australian Tax Office. The remaining duty is classified as the road user charge.

Eligibility to claim the fuel tax credit relies on meeting one of four environmental criteria introduced in 2006, which affects some aged trucks. Trucks with GVM over 4.5 tonne manufactured and/or fitted with an engine prior to 1996 (before ADR 70/00) are required to satisfy these criteria for the operator to claim the rebate. A vehicle primarily used for primary production or on an agricultural property is exempt from meeting the environmental criteria (ATO 2019).

The four environmental criteria are not onerous enough to be considered a disincentive to operating an aged truck. Two relate to maintenance schedules and inspections. The third – passing a DT80 emissions test – no longer appears enforceable in most states as testing facilities have progressively closed in NSW, Victoria and South Australia (Queensland was not open at time of writing).

The total duty applied to diesel is 42.3 cents per litre (ATO 2020). In the 2019–20 financial year, the amount that can be claimed back if an aged truck is compliant is 25.8 cents per litre. Where an aged truck is compliant with the environmental criterion, and assuming it travels 10,000 km in the period with a fuel consumption of 40 L/100 km, the fuel tax credit would be $1,032.

Although the mechanism is intended to manage aged vehicle emissions and provides a reasonable monetary incentive for compliance, the loss of such a small credit is unlikely to discourage an operator prepared to flout the environmental conditions. In comparison, the London LEZ charges the equivalent of A$540 per day for access by a Euro III or older truck. The total charges increase again if entering the smaller ULEZ (TFL 2019a).

New Zealand levies duty to support road maintenance through its road user charge (RUC) on vehicles over 3.5 tonnes GVM. This levy is not taxed at source (fuel point of sale) but is purchased separately in units of 1,000 km from the NZ Transport Agency or intermediaries. The charge differs based on the number of axles and mass of the vehicle. There is no differentiated rate for the age or emissions standard of the vehicle (NZTA 2020).

6.3 Grants or Scrappage Incentives

A common term for these kinds of measures is “cash for clunkers”. They include any specific financial incentive offered to fleet operators to encourage or accelerate the retirement of their aged vehicles. Examples include a grant, loan, accelerated depreciation, tax or other financial instrument that is paid to the owner when an old vehicle is removed from service.

The payment is intended to subsidise the high capital cost of a newer truck. For greatest effectiveness, the incentive should require evidence that the aged vehicle has been scrapped or de-registered. This approach is distinct from more general fleet stimulus or modernisation programs that can potentially reduce the average age of the fleet but do so by increasing new truck sales.

6.3.1 International

Following are recent examples of support schemes to remove older trucks from the fleet:

- London, UK: Complementary measures to the London ULEZ include a support package for affected organisations. Small business (up to 50 employees) operating heavy vehicles including buses in the London area are eligible for £15,000 for replacement of each non-compliant heavy vehicle, up to a maximum of three vehicles. In addition, van owners (<3.5t) will also receive £7,000 when scrapping their old vans or £9,500 when switching to an electric van (London 2020).
- Birmingham, UK: In conjunction with the introduction of a clean air zone (CAZ), Birmingham City Council committed to providing scrappage incentives to local business with non-compliant heavy vehicles. Within the £38 million support being provided from the UK Government, a minimum of £5.4 million from Birmingham’s CAZ funding will go to the scrappage scheme for both light and heavy vehicles (Birmingham 2019). A further £10 million to support truck and bus replacement or retrofit will also be offered to support compliance (Birmingham 2018).

- China: China ran scrappage programs nationwide from 2009 to 2015, specifically focused on pre-Euro III diesels and pre-Euro 1 petrol vehicles. These became known as yellow label vehicles (YLVs) due to a concurrent labelling program. It was estimated that in 2011 the 15.6 million YLVs (16% of vehicles) accounted for 87% of particulate pollution produced by the national fleet (ICCT 2015). The net benefit of the program for the wider Beijing-Tianjin-Hebei (BTH) region was calculated as 20 billion yuan (approx. A$4.6b) with a cost–benefit ratio of 1:2.49, which would be far higher at the city level (Zhou et al. 2019).
- India: A truck scrappage scheme suggested by the Transport Minister in 2015 is expected to be introduced in 2020. Measures discussed include 10 or 20-year age limits, Bharat Stage IV (Euro IV equivalent) emissions requirement, incentives in the form of scrap value of old vehicles, excise duty waivers on the new vehicle, and manufacturer discounts (Vardhini 2019).
- Chile's 2009–10 truck scrappage scheme, Cambia tu Camion (Change your Truck), aimed to remove 500 (4.5%) of the trucks aged 25 years or older.
- Vietnam: A proposed fleet modernisation program encourages truck owners to replace older trucks with newer vehicles. Trucks older than Euro II would be eligible for financial support (registration discount, rebates, and dealer discounts) if scrapped and replaced by a newer vehicle conforming to Euro IV (Lam et al. 2019, pg122).

6.3.2 Insights

A review of scrappage schemes globally (ICCT 2015) identified several aspects that are important in the design of such schemes.

Firstly, a strong focus on air quality was common in the more successful programs. Secondly, the materiality of the grant is an important feature to optimise. If set too low, it does not provide adequate motivation, but if set too high, the scheme results in a very high cost of abatement.

Similar optimisation is also required for differentiating payments based on:

- vehicle age (very old vehicles will likely not have much remaining "task" to perform before naturally retiring).
- vehicle size and vehicle type (some of which are more likely to contribute to urban pollution).

Several other insights for policy makers and regulators were gleaned from the review of international schemes:

- Any grant or incentive offered needs to be large enough to make the case compelling for fleet owners – or be supported by other measures. The current Hong Kong scrappage scheme was preceded by a less successful scheme in 2007 that provided a one-off grant to encourage early replacement of pre-Euro and Euro I diesel trucks. This scheme engaged only around a quarter of eligible vehicles. The low uptake was attributed to the payment being too low to incentivise fleet owners (CAN 2012).
- The cost-effectiveness of scrapping schemes (in terms of abatement cost, $/tonne pollution) varies. The Mexican national program operating from 2004 to 2010 returned a cost of abatement of US$2,150 per tonne of NOx avoided, and US$22,103 per tonne of PM2.5 (INECC 2010). This contrasts with the US Carl Moyer Program which has an estimated cost of NOx abatement of between US$1,500 to US$5,100 per tonne.
- Grants or incentives should only be paid after proof of scrappage is provided – typically via an independent scrappage certificate – to ensure the truck does not re-enter service.

6.4 Retrofit and Repower Programs

6.4.1 International

An alternative to retiring an aged truck is to modify it to reduce its level of emissions output, or to repower it with a cleaner, later-specification engine. Many trucks already undergo some kind of engine replacement, repower, or reconditioning/refurbishment at some point, such as 1.2 million kilometres travelled or 15 years of service.

A typical refurbishment uses an engine or parts similar to what was originally fitted. However, government retrofit/repower programs subsidise the installation of an engine or exhaust treatment system that upgrades the environmental performance of the vehicle to make it less polluting. Some retrofit equipment such as exhaust upgrades (e.g. diesel particulate filters or exhaust catalysts) can be fitted outside the normal refurbishment schedule as they do not require significant time off the road. These initiatives aim to reduce the emissions of the truck rather than taking it off the road. This means all the other systems of the truck (brakes, suspension, electrical system) which are not upgraded remain as old, worn and unreliable as the original vehicle, which could be seen as problematic by policymakers.

It is important to distinguish retrofits and repowers from alternative fuel conversions like CNG, LNG or LPG which are not considered a direct intervention to improve or upgrade aged vehicles.

Some overseas examples of retrofit/repower programs include:

- **USA:** The US Environmental Protection Agency (EPA) has supported retrofitting diesel engines with exhaust treatment equipment, funded via the Diesel Emissions Reduction Act (DERA). The ICCT (2017) reports that from 2009 to 2013 the program provided $520 million in grants to retrofit emission equipment or replace diesel engines. Table 6.2 details the types and numbers of equipment upgrades supported by the DERA program. The most common upgrade by far was engine replacement, which represented more than twice the number of installations of all other upgrades combined.

  The EPA estimated the value of the pollutant emissions reductions achieved by DERA in terms of monetised health benefits over the life of the affected engines would be up to $11 billion and 1,700 fewer deaths (ICCT 2017).

Table 6.2: US EPA DERA program coverage

Activity	Volume affected
Engines supported	58,800
Diesel oxidisation catalysts (DOCs) fitted	18,000
Diesel particulate filters (DPFs) fitted	3,000
Engine repower or replacement	6,000

Source: ICCT 2017

- **Birmingham, U.K.:** As part of the Birmingham City Council's CAZ plan, city-based truck and bus operators are being offered £10 million in funding to support retrofit or replacement of non-compliant vehicles (Birmingham 2019).
- **Tokyo, Japan:** As part of regulations to manage pollution, in 2000 the Tokyo Metropolitan Government (TMG) required diesel vehicles to be retrofitted with particulate control devices if they were to continue to operate in the TMG region. The retrofit program was extended in 2003 and went on to be adopted by other prefectures adjacent to the TMG. The emissions requirements were tightened in 2005 to align with new truck standards. Non-compliance could result in a Y500,000 (A$6,500) fine and public naming. These vehicles are no longer in service and the retrofit program has ceased as new vehicle emission regulations have taken effect (DieselNet 2015a).

- **Europe:** Some European nations have allowed older vehicles fitted with retrofit emissions control equipment to be considered compliant with later, more stringent emissions standards. For example, a DPF fitted to a Euro III truck could be considered equivalent to a Euro IV vehicle for the purpose of LEZ access. This is an example of best practice coordination of different kinds of measures (retrofit and LEZ, and in some cases financial incentive/disincentive) – even if the ultimate effectiveness of a retrofit solution depends on the limits of the LEZ and the technology available to upgrade the diesel engine. A retrofit emission control (REC) device certification scheme was developed by the EU to ensure the integrity of devices that can be adopted by individual nations (DieselNet 2015b).

Broadly speaking, the ICCT (2017) notes that retrofit programs are most successful where the technology is well matched to the engine or vehicle it is fitted to and verified. The application of such a program is easiest to administer when certain vehicle types or fleets are targeted.

Electric Conversion

Considering the rapid shift to electric vehicles occurring in the new vehicle market in some countries, and the intention of many cities and countries to ban fossil fuel vehicles (particularly diesel engines), one kind of retrofit that may become more common in future is the installation of batteries and electric motors to replace the diesel powertrain in older trucks. An electric powertrain is well suited to heavy vehicle applications, with high torque at low motor speeds for load carrying.

Electric conversion could turn some of the most polluting vehicles on the road (aged trucks) into zero-emission vehicles. As battery prices continue to decline, this could be achieved at a cost much lower than the purchase price of a new truck.

6.4.2 Australia and New Zealand

NSW RMS conducted trials and targeted retrofits of diesel particulate filters to trucks entering the state’s ports across a trial and two phases between 2010 and 2012. A total of 79 pre-2003 trucks accessing Port Botany, Port Kembla, the Port of Newcastle, and Cooks River Rail Yard were upgraded. The breakdown of units is shown in Table 6.3.

In addition, a program of over 500 trucks from 2005 to 2011 is mentioned in a report by EPA NSW (2014). This action was combined with similar retrofits to non-road diesel vehicles including cranes, earthmoving equipment and generators as part of the Clean Machine Program.

Table 6.3: NSW Ports diesel retrofit program

Activity	Period	Pre-2003 trucks upgraded
Diesel Retrofit Demonstrative Program (Port Botany only)	2009/10	26
NSW Ports Diesel Retrofit Program Phase 1	2010/11	32
NSW Ports Diesel Retrofit Program Phase 2	2011/12	21

Source: Transport for NSW 2020

An example of electrification conversions comes from New Zealand, involving the conversion of waste management trucks with the assistance of the Low Emission Vehicle Contestable Fund (EECA 2018).

6.5 Policy Lessons for Australia and New Zealand

The review of initiatives described in this chapter indicates there is no single measure that will on its own reduce the effects of aged trucks, and that response measures need to be tailored to each situation. Policy measures should relate to the problem of concern: resolving an urban air pollution problem should target urban trucks, while resolving a national road safety problem should target the national fleet (if vehicles are the cause of crashes) or particular routes (if road conditions are the cause). The appropriate focus ensures the policy response is most effective on the problem it is trying to solve, while minimising unintended consequences for industry.

Combinations of measures have been successful in other markets – typically, tough rules or penalties flagged early, combined with softer incentives. The International Energy Agency[8] recommends that emissions programs or efficiency policies should be developed as packages, specific to each sector, and combine different types of measures such as regulations, financial incentives/penalties, information, and labelling.

This coordinated approach also appears to have been the most effective in the countries discussed above.

Examples of policy combinations include:

- LEZs typically combine access and differentiated fees to incentivise/penalise different types of vehicles.
- Some European retrofit programs have been incorporated into eligibility criteria for LEZs, and may also change the road tax/registration fee class in which a vehicle resides.
- In Hong Kong, the combination of incentive payment and a pending prohibition date was more effective in achieving the program objectives than just an incentive payment in the initial phase, with 90% of eligible diesel trucks phased out prior to the final deadline (Loh 2015), although the initial less-effective payment was also lower.

Policy efficiency is also achieved if targeted measures can be aligned with existing schemes, policies and programs. For example, in Australia, new measures could be aligned with the actions underway as part of the Heavy Vehicle Road Reform package and the National Freight and Supply Chain Strategy.

6.6 Industry perspective

Consultation with representatives of transport associations and specific industry associations sought to identify their views on policies that could potentially affect their members. Some participants were not particularly concerned about the cost to society from aged trucks and felt that externality costs should not necessarily be recovered. Most industry associations (and fleet operators) are focused on reducing costs for all transport companies and not adding to the overheads.

However, most consultees noted the desire to move operators and the industry away from older trucks. In general they defined an aged truck in years, rather than emission regulation, often mentioning that more than 10 or 12 years was considered “old”.

Comments on the types of interventions to reduce the impact of aged trucks are summarised below.

- In general, mandates are not popular and there is a preference for well-crafted incentives. Interventions should support the target cohort to want to change to a newer, less damaging/polluting truck:
- An incentivised scrappage scheme should require crushing/disposal of the old truck. Such a measure should be available even if the operator is not purchasing another truck, to get it (and its parts that can extend the life of other trucks) out of circulation. An extra incentive could also be linked to replacement with a cleaner truck (e.g. Euro V), even if that replacement is not new.

8 https://www.iea.org/media/training/eetw2016/day1ppt/3Policies.pdf

- The Australian diesel Fuel Tax Credit could be made unavailable to older trucks. However, this is likely to have limited impact as many aged truck operators are unlikely to be claiming it back now anyway.
- Mechanisms developed to recover funds for road wear and damage (e.g. road user charges) should remain solely for that purpose without additional environmental levies added to them.
- Registration costs could be higher for older trucks, ramping up each year from an initial age (often cited as 10–12 years old). This mechanism should aim to have the cost for a 20-year-old truck very high (e.g. $20,000 p.a.) to provide significant motivation to upgrade to newer trucks.
- Contracts from government should impose requirements for trucks to be of a certain emission standard or be under a certain age to be eligible for contracts or projects.
- A graduated and targeted approach is likely to result in the desired change. Leverage community support to build consensus that change is required. Strike a balance so that industry, community and government work to a common goal.

When considering potential solutions to the aged truck problem, consultees typically focussed on new truck purchases and greater access for PBS vehicles (indirect measures), rather than direct measures targeted the aged trucks.

7. Evaluating Options for Australia and NZ

The broad range of policy options presented in Section 6 was narrowed to 10 potential actions. These actions were allocated to one of the four categories of actions with direct effect on aged heavy vehicles: access restrictions, financial instruments, scrappage schemes or retrofit/repower. Each action was assessed against five criteria using a scoring system to determine the most appropriate measures for Australian and New Zealand jurisdictions (Table 7.1).

7.1 Assessment Methodology

Each of the 10 potential management actions was assessed against five criteria:

- Coverage – the level and extent of involvement of different jurisdictions, and vehicle fleet coverage.
- Implementation complexity – the extent to which the action will be challenging for industry/government.
- Implementation time – the expected timeframe required to implement the action with consideration for the levels of regulation and inter-jurisdictional engagement required.
- Cost to implement – the cost to government to complete the action. An action may be revenue positive or quite costly for the tens of thousands of target vehicles.
- Strength of mechanism – considering both the effectiveness of the action and its impact on industry.

Scores from one (poor) to five (good) were awarded according to the effect of the action in relation to that criterion and its relevance to Australia and New Zealand.

The scores were tallied across all criteria, and the combined score for each action was used to provide a ranking.

Table 7.1: Criteria scoring legend

Score	Coverage	Implementation			Strength of mechanism
		Complexity	Time	Cost	
5	Federal action or national coverage	Relatively easy* for government and industry	<12 months to implement	<$100m	High impact
3	Requires state action / covers regional fleet	Hard* for either government or industry	12-24 months to implement	$100m-$400m	Moderate impact
1	Only local vehicles or government	Hard* for both government and industry	>24 months to implement	>$400m	Low impact

** As these terms can be subjective, "hard" was interpreted as requiring significant regulation, consultation, policy, business changes, or multiple levels of government (or some combination of these). "Easy" was interpreted as being achievable with relatively few changes in these areas (e.g. simply changing assessment criteria and involving just one level of government or none).*

7.2 Results and Insights

7.2.1 Scores

Table 7.2 shows the scoring for each action by individual criteria and the total score, shaded to highlight the best (23) and worst (11) total scores.

Table 7.2: Assessment scores for individual criteria and overall total

Category	Action	Coverage	Implementation			Strength of mechanism	Total
			Complexity	Time	Cost		
Restricted access to road network	Ban all aged trucks	5	1	1	5	5	17
	Low emissions zones (exclusion with fine)	3	3	3	5	5	19
Financial penalties	Increased registration by age	5	3	3	5	5	21
	Differential tolls	1	3	5	5	1	15
	End fuel tax rebate	5	3	3	5	1	17
	Road user charge	5	5	3	5	5	23
Financial incentives	Targeted scrappage schemes	3	3	5	1	3	15
	Investment support	5	3	5	3	1	17
Repower / retrofit programs directed at aged trucks	Exhaust treatment	3	5	3	3	1	15
	Electrification	3	5	1	1	1	11

7.2.2 Individual Actions

Three actions achieved high scores individually: road user charging, increased registration fees and low emission zones.

Road user charging was considered the most effective individual action, particularly where the mechanism already exists such as in New Zealand. Australia is currently assessing road user charging for heavy vehicles through the HVRR program and could incorporate an environmental differential into its new road charging framework if this is considered early enough in the design stage. This would provide a mechanism for addressing the externality costs of aged truck pollution with pricing by kilometre travelled and/or location of kilometres.

Differentiating registration costs by vehicle age or emissions technology is a disincentive to the continued use of aged trucks through the polluter pays principle. This action was considered particularly strong as it has broad coverage (national) and could be designed to be effective while still being revenue neutral (offsetting higher revenue from more polluting trucks with lower revenues from less polluting ones).

Low emissions zones are effective for controlling vehicle access to areas of high pollution and/or high population (which leads to high health costs). They can be relatively easy to implement, but coverage depends on uptake across the country and the boundaries of a given zone.

The actions that scored least favourably include retrofit programs (both electrification and exhaust treatment) and a targeted scrappage scheme, in both cases due to their expense and their voluntary nature. They could, however, be used as complementary measures to support the higher-scoring actions.

7.2.3 Combined Actions

As outlined in Section 6.5, it is advisable to use a combination of actions where their attributes are complementary. Some actions that scored poorly individually can be strong support measures. The grid in Table 7.3 identifies the combinations that are likely to be effective (labelled “good”).

A penalty or restriction is usually combined with a supportive action, sending a reinforcing signal to operators about the intended outcome. Access restrictions (low emission zones or bans) coupled with scrappage and financial support schemes are particularly well suited. Two examples of this approach are in Hong Kong (ban and scrappage payment) and Birmingham (CAZ).

Some combined actions will span multiple jurisdictions. For example, if a local government were to implement an LEZ, this may require the state or national government to support any financial incentives or vehicle upgrades due to the costs involved. This interaction of different jurisdictions or levels of government may stall progress on a suite of measures if all parties are not aligned. Therefore, the “owner” or responsibility of any particular measure becomes an important consideration.

Table 7.3: Effective combinations of actions

	Ban all aged trucks	Low emissions zones	Increased periodic registration	Differential tolls	Road user charge	Targeted scrappage schemes	Investment support	Exhaust treatment	Electrification
Ban all aged trucks		None	None	None	None	Good	Good	Some	Some
Low emissions zones	None		None	Good	Some	Good	Good	Good	Good
Increased periodic registration	None	None		Some	Some	Good	Good	Some	Some
Differential tolls	None	Good	Some		Some	Some	Some	Good	Good
Road user charge	None	Some	Some	Some		Some	Some	Some	Some
Targeted scrappage schemes	Good	Good	Good	Some	Some		Good	Some	Some
Investment support	Good	Good	Good	Some	Some	Good		Good	Good
Exhaust treatment	Some	Good	Some	Good	Some	Some	Good		None
Electrification	Some	Good	Some	Good	Some	Some	Good	None	

8. Conclusions

Active management of the fleet by governments, through effective policy measures, is required to minimise or avoid negative community impacts from aged trucks.

The modelling showed that Euro 0 (pre-1996) trucks are imposing an average health cost on the community of between 37 cents and 91 cents for every kilometre they travel in urban areas. This is a cost that governments are already paying in consolidated expenditure, which equates to between $3,300 and $21,000 each year for a 1995 truck operating in urban areas. This estimate can be used as a basis for evaluating the cost of any one-off or recurrent actions being considered to manage the fleet. It also highlights the importance of ensuring that any new measures implemented do not allow the externality cost (or the vehicle) to return after the intervention.

The costs above do not include safety-related health or social costs. The oldest trucks were not shown to crash at significantly higher rates than middle-aged trucks. Further research may be required to identify and correlate causes of crashes in accident data to provide insights on aged-based differences.

The three most favourable policies to emerge from this study are some form of road user charging, differential registration fees, and road access restrictions on older trucks in urban areas via the use of low emission zones. These scored highly for fleet coverage, relatively low implementation cost, and perceived strength as a mechanism to influence the target cohort. Jurisdictions seeking to manage the use of aged trucks should examine these measures prior to looking at other options.

The collapse of the Smart Freight Partnership in Victoria should not discourage the future use of LEZs, as overseas experience shows they are becoming widely adopted and increasingly effective.

The problem of Euro 0 (pre-1996) trucks operating in urban areas is a short-to-medium term problem. The modelling indicates that the total health impact of Euro 0 trucks halves over approximately four years. So, in eight years (by 2028), this will reduce to only 25% of the current health impact. Each of the three priority measures proposed is also a medium-term opportunity meaning that, by the time they can be established in policy and practice, they would be addressing a much smaller problem. At that time, attention could turn to the next cohort (Euro I trucks), for which the health cost impact is currently very similar.

This timing mismatch may be overcome by combining the measures above with shorter-term interventions. Best practice examples from overseas showed that combining measures provided the most effective outcomes. Two of the priority measures – LEZs and differential registration – are particularly suited to combining with investment support and scrappage schemes, which both scored well for coverage of the fleet and implementation complexity/time. While the expected cost for both these shorter-term measures was considered high, there may be a window of opportunity to fund such support measures as part of the economic recovery out of COVID-19 stimulus packages.

Another best practice approach is to link actions with other policy and program initiatives already underway. In Australia, although the HVRR process is not currently considering changes to road user charging, this may, in future, be a mechanism to manage aged trucks with price signals based on their community impacts. Similarly, New Zealand already has a road user charging mechanism which could be adapted to account for the age of trucks (or their emissions standard) with fees adjusted to reflect the externality cost of higher pollution levels that the government is already paying through other agencies (e.g. Health).

Without a secondary disposal market for aged trucks in Australia and New Zealand, changes are only likely through measures that are clear and emphatic. Outright registration bans are not recommended given the number of rural operators that may be affected despite their trucks not contributing to major health costs in urban areas. But combining short- and medium-term actions as outlined above could provide the necessary market signal that initial supportive action will be followed by later stronger action.

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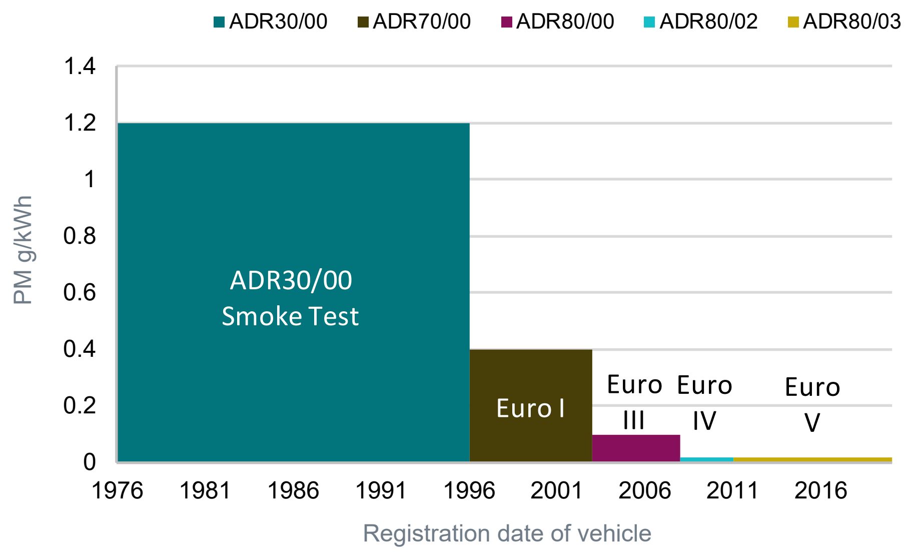
Appendix A Heavy Vehicle Emissions Standards

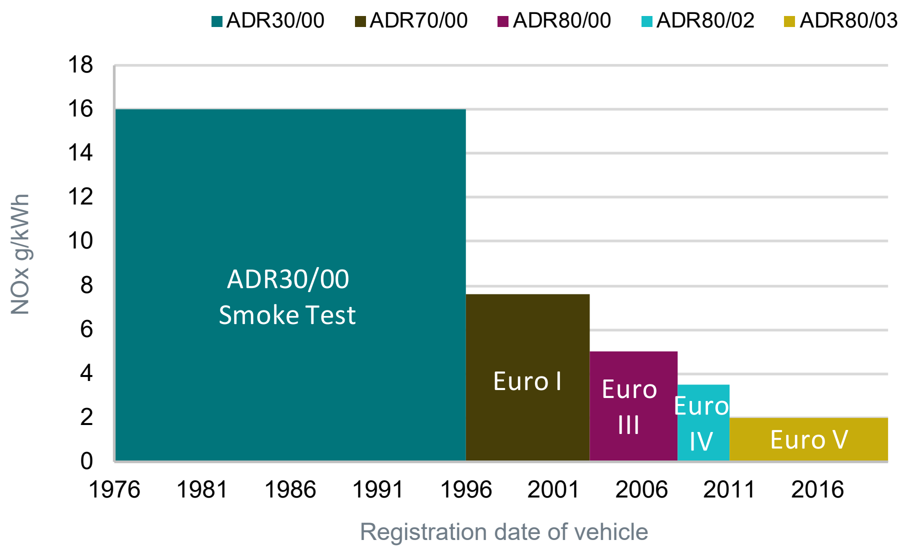
Exhaust emissions of Australian trucks have become significantly cleaner over the last 40 years, in response to both Australian and international regulations. Figure A.1 and Figure A.2 below show that the average PM and NOx exhaust emissions of an aged truck will be far higher than a modern truck. This is a representation of the regulatory limits applied when the truck was new and when emissions control equipment is operating as the manufacturer intended. However, all equipment deteriorates over time and it is possible, or even likely, that some proportion of aged trucks operate well above their regulated emissions limit.

Figure A.1: Aged truck average particulate matter (PM) exhaust emissions



Source: Data from Truck Industry Council (TIC 2019a)

Figure A.2: Aged truck average nitrogen oxides (NOx) exhaust emissions



Source: Data from Truck Industry Council (TIC 2019a)

There are risks in simply comparing the average age of the Australian or New Zealand heavy vehicle fleet with those in other countries. Segmentation can be quite different across markets, and the available data may not correspond precisely to the same cohort in different markets. For example, some markets have data for heavy vehicles above 4.5t, while most cover only “commercial vehicles” above 3.5t.

Two trucks with the same age in different markets may also be quite different in terms of safety equipment and emissions compliance, as well as other features. For example, emissions regulations were introduced at different times in different markets, so:

- The same aged trucks would produce higher emissions in Australia than in Europe or the US. At the time of Euro III introduction in the EU, Australia was only at Euro I and the US in its third generation of NOx regulation. A 12-year-old Australian truck is therefore likely to have similar NOx emissions to European and US trucks that are 15 and 16 years old, respectively.
- New Zealand imports a high proportion of its used trucks from Japan (more than 50% in the 1990s (NZTA 2019)). While the average age of trucks in New Zealand is three years higher than Australia, the standards that many of these trucks were built to comply with in Japan were more stringent than the standards that applied to new trucks in Australia at the same time. So, while older, the NZ fleet may be as clean or cleaner than the Australian fleet.

Accordingly, comparing age in years across different international markets is not a valid approach if the objective is to understand the “quality” of aged trucks or their social and economic burden.

Appendix B Aged Vehicle Usage (Location, Load)

B.1 Locations of Aged Vehicle Use

The location in which a truck is used has a great bearing on its impact to society, whether that be from the perspective of traffic congestion, air pollution, noise or road safety. So, understanding where aged trucks are used is critical to managing those impacts.

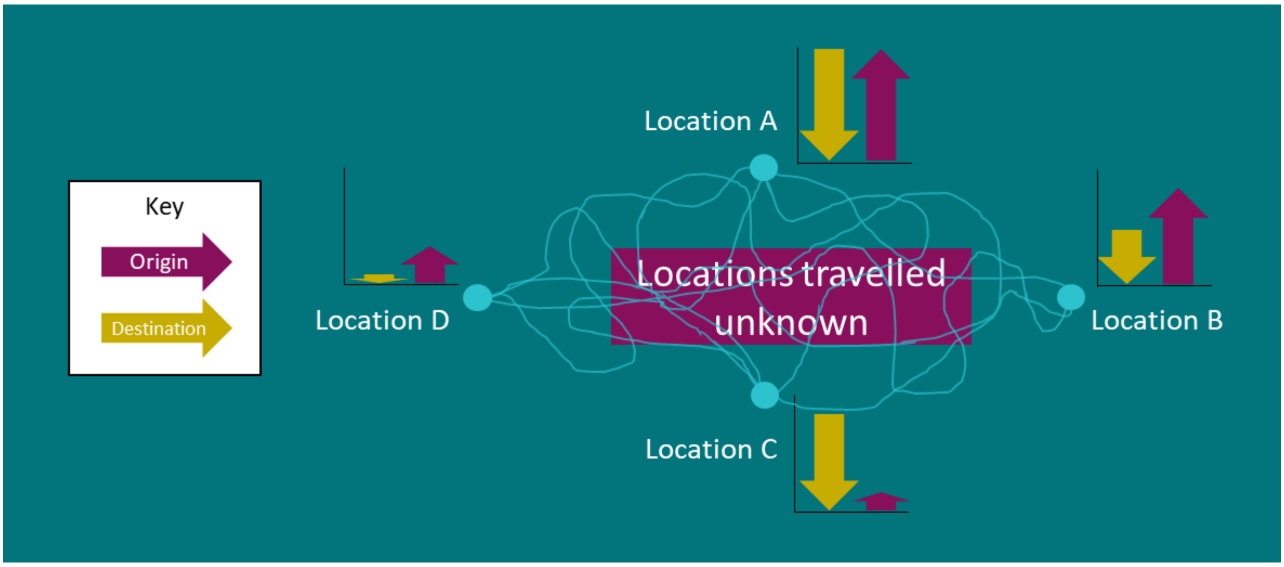
B.1.1 Data Sources

There are several data sources providing varying insights into where aged trucks are operated. Road camera data is available from state jurisdictions via NHVR, but this only provides a snapshot of activity on a particular road in the period that data is collected and analysed. There are over 170 cameras in the network, so they can be a tool to assess specific areas and to measure the impact of restrictions placed on those areas. But their distribution is aligned with major transport routes rather than being directly aligned to aged truck activity. As such this data may not provide a reliably broad indication of aged truck operations if those trucks are not on highly trafficked routes.

The National Crash Database (BITRE, 2019) gives some indication of the location of aged truck usage, based on where they are involved in accidents. After all, an aged truck can only be involved in a crash if it is physically present at that location.

The ABS Road Freight Movements (RFM) survey reports activity of trucks with data available for year up to October 2014 (ABS 2017). While these data are detailed for the origin or destination, there is no indication of which origins and destinations are linked or where the truck travels in between locations, as represented in Figure B.1 below. Also, the trip data gives no indication of what proportion of an originating load went to which destination. For example, the origin load volume from Location A cannot be correlated to any other location, just that the load's destination will be included in one of the locations, which could include Location A if it was a local load. As such the urban / regional split of this data has limited value in determining the areas in which trucks operate.

Figure B.1: Representation of ABS Road Freight Movements 2014 survey location data



The ABS SMVU provides a breakdown of VKT by truck type and location travelled split by area of operation, including capital city, other urban, outside urban and interstate (ABS 2018). This data can be used to represent the use of trucks by age and region travelled with reasonable confidence. This data set is the most useful representation of truck activity available in Australia and has been used to carry out the analysis.

As with a lot of recent ABS data, both the RFM and SMVU combine light rigid trucks (3,5t-4.5t GVM) and heavy rigid trucks (>4.5t) into the single 'Rigid' category. Light and heavy rigid vehicle registration numbers are known (ABS 2019a), so the 'Rigid' data published in the RFM and SMVU has been scaled to give an estimate of VKT for heavy rigid trucks alone.

B.1.2 Metrics

The SMVU dataset provides tonne-kilometres, tonnes carried, and kilometres travelled, with each weighted per year. For the purposes of this analysis, distance is proportional to impact on the community, so kilometres was used as the functional unit for analysis. Non-freight trucks have not been included.

B.2 The Types of Freight that Aged Trucks Carry

Understanding the types of loads being carried and industries using aged trucks is important to consider the industry impact of any policy changes. There are multiple potential sources for this data that provide various levels of accuracy and confidence. The sections below summarise data options and the approach used.

B.2.1 Data Sources

Overall, the level of data and information to support these correlations is quite poor or not publicly available. Ideally, the data would include origin-destination trip data across all the freight types and sectors in the freight industry, but these kinds of analyses are typically only conducted in support of major infrastructure projects, and often not available publicly or categorised by vehicle age.

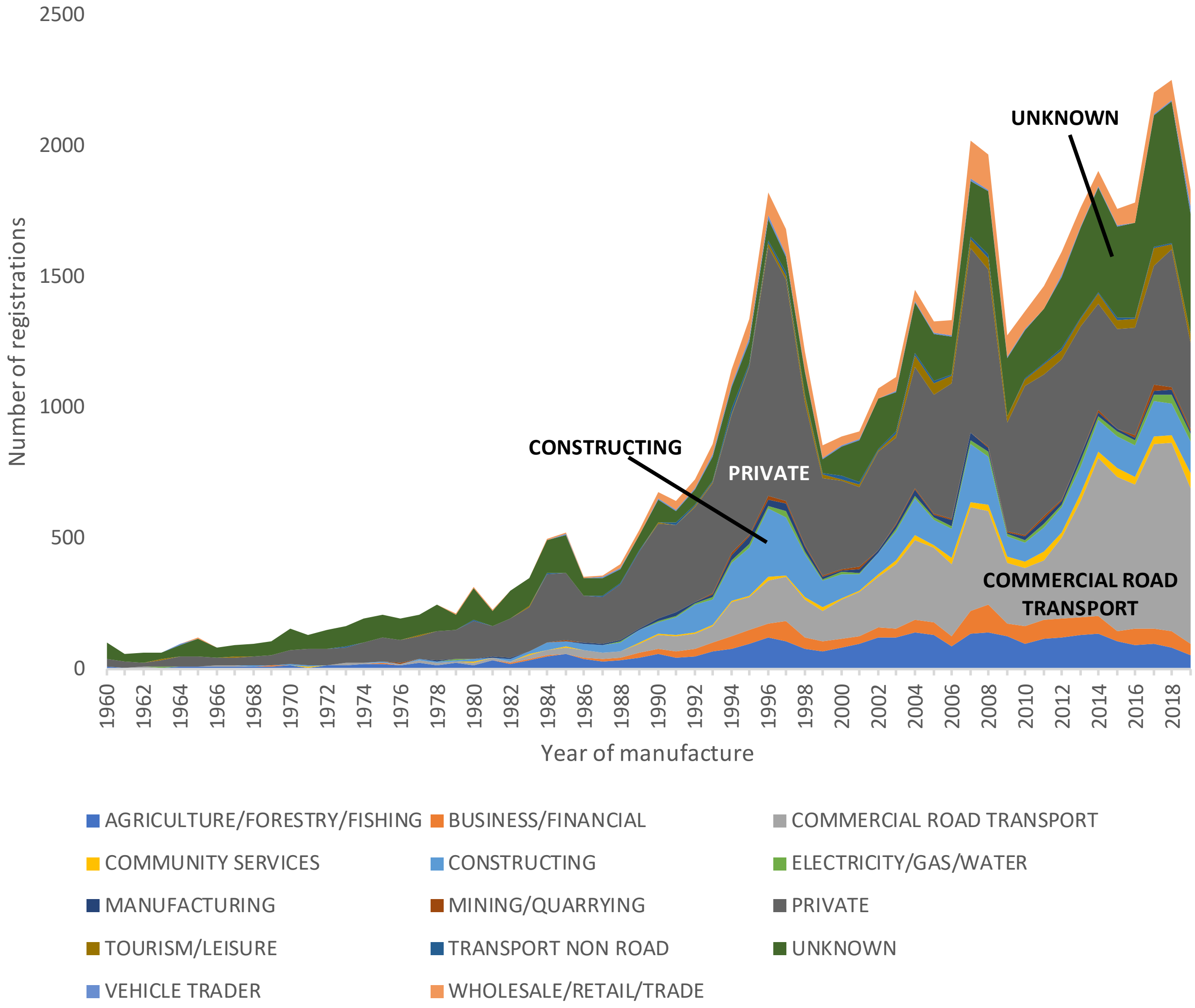
Several potential sources were consulted in the research for this phase of the project, including requests to members of the Project Working Group. These resulted in three broad levels of data utility:

- Level 1:
  - ABS registration data (Motor Vehicle Census).
  - Vehicle registration data. NEVDIS, as the holder of all vehicle registration records, maintains data fields including year of vehicle manufacture, postcode and registration address (and in some cases garaging address). Initial discussions with NEVDIS staff to obtain truck postcode registration data indicated that the research would need to proceed via an organisation that already has data agreements with NEVDIS, which would cover the resourcing required for analysis and the data fees.
  - One such agent of the NEVDIS data is the Australian Road Transport Suppliers Association (ARTSA). Postcode data for each registration is available for a fee. However, their data appears to be simply an improved and cleaned version of the NEVDIS registration data, which would provide little insight into the location of use and sector operated in.
- Level 2:
  - NHVR as the aggregator of roadside inspection data and traffic camera data, including many cameras with Automatic Number Plate Recognition (ANPR) capability (allowing a link to vehicle age via the vehicle's registration/VIN). In discussions with NHVR staff (Wigg 2019) it was noted that NHVR have access to a number of data sources that may support such analysis to identify where aged vehicles are operated. There are over 190 fixed traffic camera locations across Victoria, NSW, Queensland and SA that capture as many as 4.5 million heavy vehicle movements per month.

- Level 3:
  - ABS studies including the *Survey of Motor Vehicle Use* (ABS 2018) and the *Freight Movements Survey* (ABS 2017), covering 16,000 vehicle trips across 2014 which contains origin and destination data for freight vehicles grouped into three vehicle age categories. The incidence of aged trucks operating in urban areas was also available.

Of the data sources consulted, the registration-based data is likely to be the minimum useful level, since address and postcode may not relate to where the vehicle is used (and could be potentially misleading). An assessment of publicly available data at this level indicates that only Queensland and New Zealand publish data that is sufficiently granular to derive useful insights. Yet even for these jurisdictions, the industry segment a vehicle is used in is not well defined and subject to variation by owner and agency staff. For example, in Queensland 72% of trucks are labelled as 'commercial' and 10% as 'farming'. New Zealand has better definition in its public data, but as shown in Figure B.2, 50% of pre-1999 vehicles are still listed as either 'private' or 'unknown'.

Figure B.2: New Zealand truck registrations by sector



Source: Derived from NZTA 2019

At the middle level of data utility, data related to specific vehicle movements (such as traffic camera data) would provide real indications of truck type and location. These could be utilised to take a sample of the passing traffic of selected cameras in urban and rural areas. Alternatively, it may be possible to analyse the heavy vehicle inspector event logs for age of truck and location of event, again taking samples from geographic areas. Both sources could be used (with sufficient effort in analysis and project budget) to infer the location that aged vehicles are being operated when compared to population or VKT. This data is often owned by other parties and the release by NHVR is restricted, which is a constraint that needs to be explored further.

Of course, this camera and inspection data will relate only to the specific roads where the cameras operate; and only for the period sampled. Types of vehicle or body configuration detail may also be insufficient to derive useful insight into the freight segment serviced. For example, a tanker trailer might be used for cement, waste oil, petrol distribution, or milk transport – each sector involving very different markets, profitability and operator profile.

At the upper level of utility, the ABS Road Freight Movement in Australia study (ABS 2017) also contains load commodity data for freight vehicles and is grouped into three vehicle age categories. As well as location of aged trucks, the sectors they operate in could potentially be implied from this study.

It was decided that the Level 3 ABS data would be used in the detailed analyses for the report – particularly modelling health costs and vehicle locations. A major benefit and factor in that decision was that data categories in these studies (e.g. vehicle age, VKT per age group, and vehicle definitions) would then be consistent across multiple data sources, since other ABS datasets were used in the full modelling.

Appendix C Heavy Vehicle Fuel Consumption

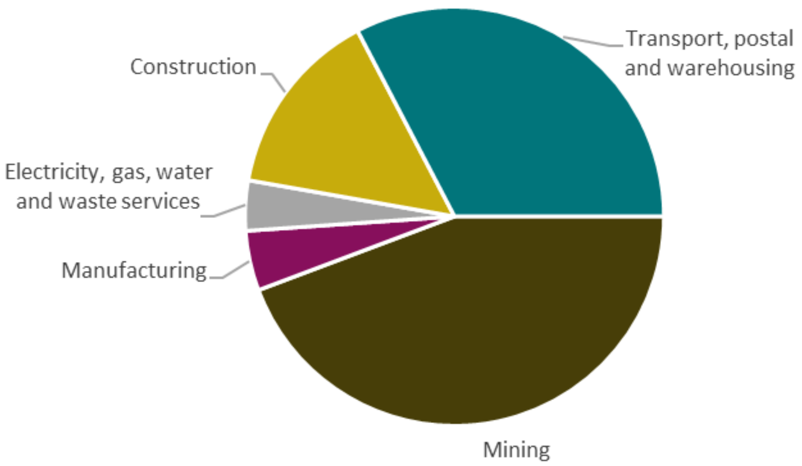
C.1 Road Freight Contribution to Australian Diesel Usage

The consumption of diesel fuel in Australia occurs in a number of different industries. Figure C.1 highlights that road transport is just a subset of the second highest consuming sector, and freight trucks (the subject of this report) are a smaller subset of transport.

The other sectors represented, including the largest consumer of diesel, which is mining, are often referred to as Non-Road Diesel Engines and Equipment (NRDEE). NRDEE emissions are not regulated. Considering the table in Appendix A showing trucks are limited to Euro V levels of emissions, means that NRDEE sectors (more than two-thirds of all diesel-related emissions) are allowed to emit the same criteria pollutants at more than 10-20 times the levels of new trucks. This is important when considering any future regulation increases on *new* trucks, as they represent at most one third of one third of all diesel emissions.

However, the target cohort of this report (trucks at Euro 0 levels) is emitting at or near the levels allowed in other NRDEE sectors. As discussed in the report elsewhere, the main consideration of how this translates to an impact is proximity to population. In the case of trucks, this is often similar to or higher than the other NRDEE sectors, apart from perhaps construction.

Figure C.1: Diesel consumption in Australia



Source: ABS 2019b

C.2 Fuel Consumption of Aged Trucks

The statement commonly arises that older trucks have worse (higher) fuel consumption than newer trucks. However, there does not seem to be conclusive data to support this in the literature.

As an example, Lam et al. (2019) appear to assume that a 1-2% improvement in engine efficiency leads directly to an improvement in truck fuel efficiency, not taking into account that modern trucks have become heavier (tare weight) due to more stringent safety and emissions. According to TIC (TIC 2019a), a post-2008 truck is 300 to 600 kg heavier than a pre-2003 truck. Not only will the increased vehicle mass increase a trucks' fuel consumption, but when freight is weight constrained, a modern truck would have lower productivity, carrying less freight on each trip.

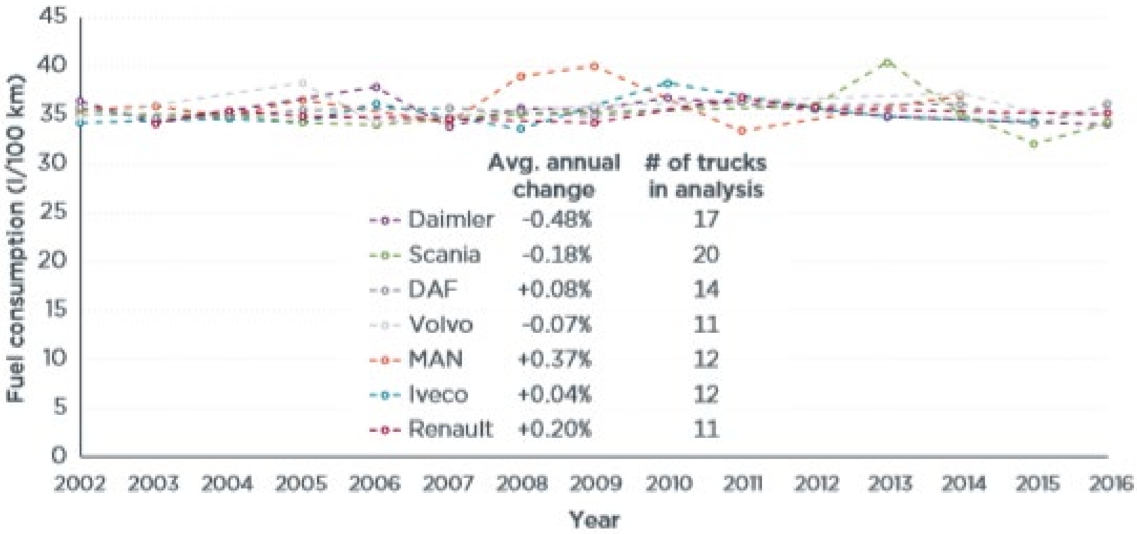
Similarly, the ACEA suggests European trucks have become significantly more fuel efficient over the years. Its claims include (ACEA 2016b):

- 60% reduction in fuel consumption since 1965
- 20% improvement expected between 2005 and 2020 (~1.3%/year)

As of 2016, the driving force for these fuel economy improvements has been market forces (ACEA 2016b).

However, contradicting those views, ICCT data shown in Figure C.2, indicates that the fuel consumption of the largest trucks (semi-trailers) has remained relatively static over the decade to 2016 (ICCT 2018a). ICCT suggests that the static vehicle fuel consumption could be due to engine efficiency improvements being offset by the stricter pollution controls required.

Figure C.2: Static semi-trailer fuel consumption in Europe.



Source: ICCT 2018a

It should be noted that these statistics are for European trucks only, not the mixture of European, US, Japanese and Australian built trucks common in Australia. However, there is no reason to assume that all these benefits have rolled across to Australian trucks. In fact, there are obstacles which may have prevented technologies commonplace in Europe/US being adopted in Australia (e.g. aerodynamic equipment limited by Australian truck widths) (TIC 2019a). It is reasonable to assume that over time, some but not all of these improvements in fuel economy have trickled into the Australian truck market.

The US already has, and Europe is planning to introduce, regulatory CO2 mandates for heavy trucks in the near future, which will help continue this trend (ICCT 2018b). Without adopting Euro VI in Australia, we may benefit a little or a lot from these changes overseas.

No data was found on the complex problem of how an individual vehicle’s fuel consumption is expected to change with age. It is reasonable to assume an initial improvement due to reducing friction, before this is overwhelmed later in life by age related issues such as compression loss and poor maintenance.

Given their long life, repowering or refurbishing truck engines is commonplace. It could be assumed that a refurbished engine’s performance is close to that of a new one.

Appendix D Methodology and References for Calculating Health Costs

Table D.1 lists the main data sources used to inform the modelling of pollution-related health costs in Section 4.1 of the report. The input data for this model was derived from a wide variety of sources, but all data is only a snapshot in time. In particular, the ABS publishes data periodically: although the motor vehicle census is carried out every year, the SMVU is only conducted every other year and the RFM survey has only been carried out once, in 2014. All these studies aggregate trucks into three age groups: <5 years old, 5-15 years, and >15 years.

Table D.1: Main data sources for modelling

Proportioning	Km driven	Emissions intensity	Unit costs
ABS 2018 ABS 2020	USEPA 2004, USCB 2002, NEPC 1999, ABS 2020	DITRDC 2020b ATA 2018	DIRD 2016 ABS 2020

The latest available data was used for modelling and the age of the trucks at the time of the survey was considered. The data sources used in each stage of the modelling are outlined below.

Proportioning

The current Australian fleet was split into 20 main segments, representing Heavy Rigid and Articulated vehicles, Urban and Non-Urban km travelled, and the five different age classes. This was done using a variety of ABS data, including SMVU and census data (ABS 2018, ABS 2020).

The change in vehicle numbers of each age class predicted to be on the road in 2019 and future years was estimated from current and past census data (ABS 2020).

Km Driven

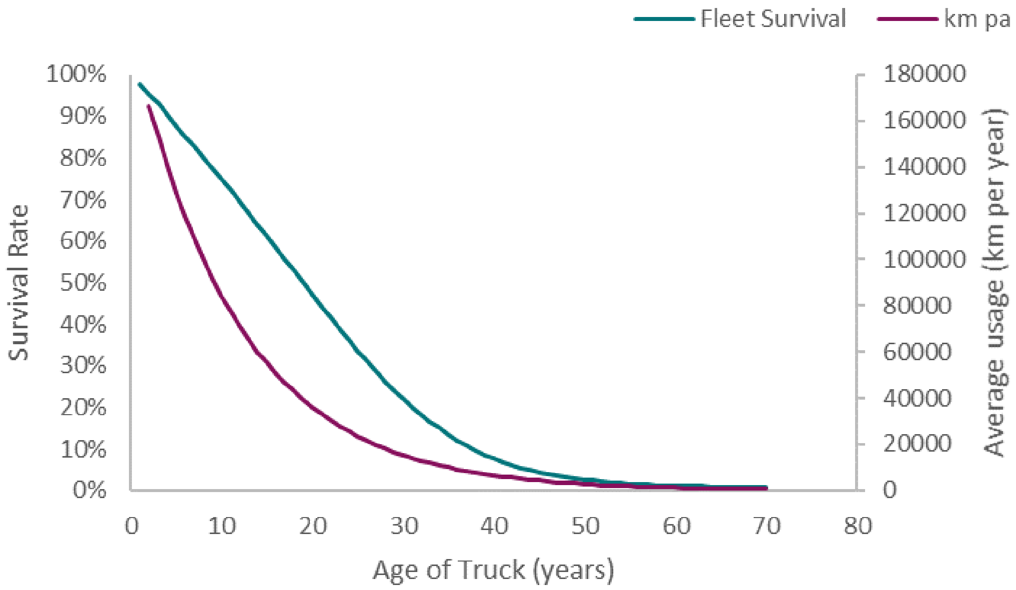
One of the challenges in modelling the aged truck fleet is finding a realistic annual mileage for older vehicles. As vehicles age, they are typically used less and less until they are eventually deregistered and scrapped. The obvious data that is most commonly used from the ABS only provides annual mileage data in three age categories (<5 years, 5-15 years, and >15 years old), as used in some of the analysis in previous sections. These age categories were not deemed sufficiently representative for the emissions calculation, because they span trucks that are very different in age (a 15-year-old truck, the average age of the fleet, would be running far higher annual mileages than a truck double that age, with the median survival time of the fleet in Australia around 27 years).

These differences matter, because they span two or even three emissions regulation periods for which a different emissions factor must be used (as shown in the figure below), and that factor does not vary linearly in the same way as the change in mileage.

A further literature review did not identify any recent or reliable estimates of the mileage decay effect for Australian trucks. To address this information gap, a new mileage decay profile of freight trucks was developed as part of this project, covering the typical Australian truck life span. To develop the mileage profile, a national age profile also had to be developed for Australian freight trucks (using real registration data from ABS). Figure D.1 shows an example of the profiles created for this modelling, with declining use of individual trucks (km p.a.) as well as the declining number of trucks (Fleet Survival) as they age.

The limited data available from the ABS was used to scale this profile, ensuring an appropriate representation of today's Australian fleet (ABS 2020).

Figure D.1: Usage of articulated trucks as they age



Emissions Intensity

The emissions intensity of trucks was derived from a variety of Australian and international papers measuring the emissions of older trucks under real world and laboratory conditions. ADR80/03 certification limits and ATA estimates of Australian real-world fuel consumption were used to correct these values to represent Australian on-road per-km emissions (ATA 2018). This was done separately for heavy rigid trucks and articulated trucks, taking into account Australia's unique mix of vehicle combinations, e.g. B-Doubles (ABS 2017, ABS 2018, ABS 2019a).

Unit Cost of Emissions

The health cost of exhaust pollutants was taken from the 2016 DIRD *Vehicle Emissions Standards for Cleaner Air, draft regulation impact statement* (DIRD 2016) and updated to 2019 prices according to the consumer price index (ABS 2020). Table D.2 shows the final costs used.

Table D.2: Health costs of heavy vehicle emissions ($/tonne)

	CO	HC/VOC	NOx	PM10
Urban	5	2,114	3,700	264,261
Non-Urban	0.5	211	1,234	59,195

Source: Derived from DIRD 2016, ABS 2020

Modelling Scenarios

Combining the vehicle usage decay profile with the other factors in the formula shown in Figure 4.2 established a BAU case for aged vehicle emissions and associated health costs. The BAU used the current fleet as a foundation and natural turnover rates. The BAU was compared with two scenarios removing the pre-1996 trucks from the road to determine the difference in health costs under the different scenarios (since all aged trucks must be replaced by some other kind of truck).

In modelling the scenarios, it was important to remember that the fleet is made up of individual truck operators undertaking their individual tasks. On average, current operators of pre-1996 vehicles use their trucks much less than operators of newer vehicles for a variety of reasons. If operators of pre-1996 trucks were forced to replace their truck, there is no reason to believe they would use the truck any differently to the older truck. Therefore, two “limit” scenarios were developed to represent a high or low emissions benefit. The scenarios were as follows:

- BAU
- Scenario 1: New-for-old – direct replacement of pre-96 vehicles with new Euro V vehicles
- Scenario 2: Trickle-down – removal of pre-96 vehicles via replacement with the next closest (oldest) suitable vehicle remaining in the market for normal aged truck usage.

These scenarios were developed as examples of alternative replacement scenarios to maintain the overall truck fleet at today’s level if Euro 0 trucks were not in the fleet today. They are not intended to show the effect of any particular intervention and were used for modelling purposes only. A few caveats and notes:

- The modelling assumes the number of trucks on the road stays constant. In reality, removing pre-1996 heavy trucks will provide a dilemma for their previous operators, as newer trucks require a higher capital investment that current business models may not support. Some of these operators would likely opt for hiring/contracting a truck when they need it instead of purchasing, effectively reducing the total fleet size. (The fleet has continued to grow over time)
- It was assumed that, regardless of age, an urban km in an old truck was replaced with an urban km in its replacement newer truck, and similar for non-urban (i.e. freight task remains as per the current market).
- The previously noted issue of older trucks probably carrying lighter loads was not explicitly included in the modelling. Insufficient data was available to quantify how significant that effect might be, but it may slightly reduce emissions from the older trucks. At the same time, there is some uncertainty about aged truck fuel consumption, which some claim is higher and therefore potentially increases emissions. These effects tend to offset each other to some degree, so the net effect may be relatively small.
- It was assumed that all vehicles were certified to the minimum emissions standard at their date of purchase, and that the Euro VI emission standard is not yet introduced to Australia for the term of the modelling.

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