Modelling the Australian truck fleet

Technical Appendix to *[report title]*

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Grattan Institute Working paper No. 2022-00, February 2022

This report was written by XXXXXXX. XXXXXXX provided extensive research assistance and made substantial contributions to the report.

We would like to thank the members of Grattan Institute's XXXXX Program Reference Group for their helpful comments, as well as numerous government and industry participants and officials for their input.

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This report may be cited as: XXXXXX. (2022). *Modelling the Australian truck fleet*. Grattan Institute.

ISBN: 000-0-0000000-0-0

Overview

Grattan's report ***[report name]*** includes results from a Grattan model of the Australian truck fleet. This model, referred as the 'Grattan truck model', is designed to estimate the carbon and pollutant emissions from Australian trucks over time. This appendix outlines the methodology and assumptions that underpin our model.

The assumptions include inputs to a fleet model (Chapter 1) and assumptions informing carbon and pollutant emission estimates under different policy scenarios (Chapter 2). Cost assumptions which are used as the basis for a cost benefit analysis are also outlined (Chapter 3).

The Grattan truck model is a publicly available and open source R project, and is hosted on GitHub.

Table of contents

1 Modelling the Australian truck fleet

1.1 Estimating the composition of the Australian truck fleet

We estimate the composition of the Australian truck fleet in the Grattan truck model as a combination of vehicle scrappage rates (Section 1.1.1), and vehicle sales (Section 1.1.2), for vehicles over 3.5 tonnes.

We separate vehicles into various classes, based on vehicle type, year of manufacture, and power-train. Truck types used in the model include articulated truck, rigid truck, bus and non-freight carrying vehicle categories. Where the categories 'light rigid trucks' and 'heavy rigid trucks' are specified, these are simplified into a more general 'rigid truck' category by taking a weighted average of vehicles on register in each category. All combustion engine vehicles are assumed to be diesel power-trains, and all zero emissions vehicles are assumed to have battery-electric power-trains.

1.1.1 Vehicle attrition rates

To estimate the proportion of vehicles that survive from one model year to the next, we compared the number of vehicles on register between subsequent motor vehicle censuses, by the year of vehicle manufacture. We use rates derived from data in the ABS motor vehicle censuses (MVC) between 2013 and 2020.[1]

For example, we compared how many vehicles made in 2000 were on register in the censuses between 2013 and 2020. Over time, the number of registered vehicles made in 2000 decreases as vehicles are progressively scrapped. By comparing registrations by year of manufacture across different census years, we can estimate the rate of vehicle scrappage depending on the vehicle's age and type.

We calculated annual scrappage rates for vehicles up to 50 years old as an average of rates across motor vehicle censuses between 2013 and 2020. The resulting data was used to calculate survival curves for each vehicle type. These curves show the proportion of new vehicles that are expected to survive as vehicles age. We assume that any vehicle still remaining more than 50 years after its date of manufacture is scrapped.

Scrappage rates are assumed to remain constant over time throughout the model. Figure 1.1 on the following page shows the survival curves used in the model.

1.1.2 Total vehicle sales

We estimate historical heavy vehicle sales using ABS motor vehicle census data between 2013 and 2021. For these values, we assume new sales to be the number of new vehicles on register in the MVC.[2]

Although the MVC contains detailed data of new vehicles on register from 2013 onward, data of new vehicle registrations before 2013 are unavailable. To estimate historical vehicle sales before 2013, we back-calculate from the number of vehicles on register and scrappage rates.

Survival curves provide an estimate of the proportion of vehicles surviving compared to how many were initially purchased. As the MVC includes data on vehicle registration by year of vehicle manufacture, survival curves can be used to calculate an estimate of how many vehicles, by year of manufacture, were originally sold. We use this method to estimate heavy vehicle sales by vehicle category between 1980 and 2021.

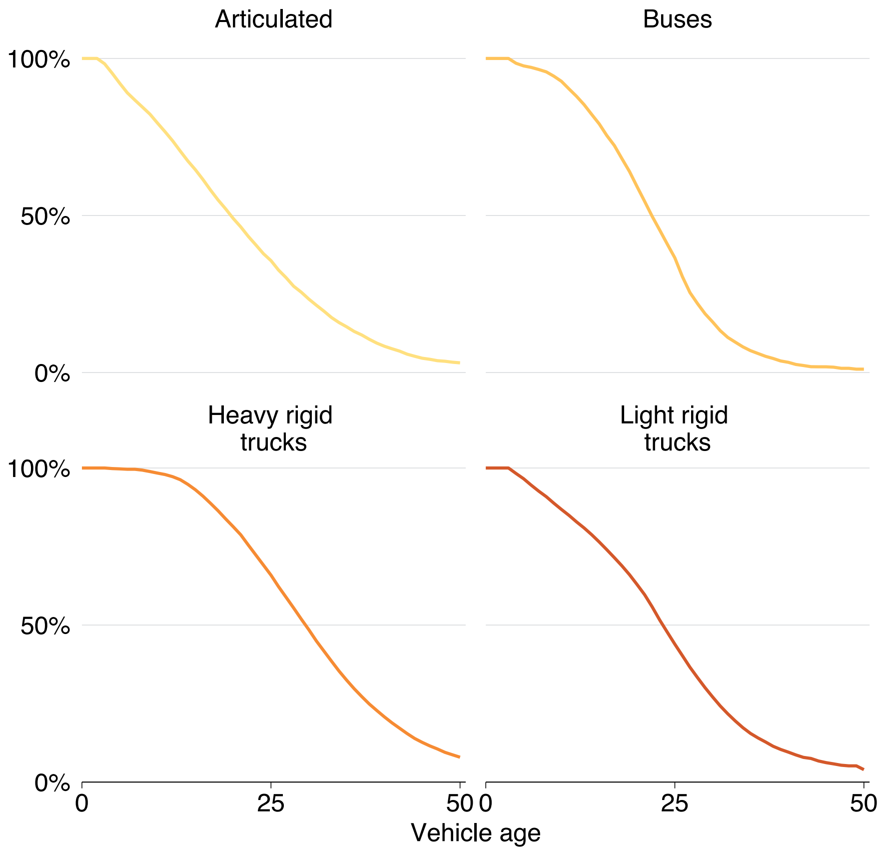
1. ABS (2021).

2. Ibid.

To estimate future vehicle sales, we assume that vehicle sales in each segment grow in line with population growth. We use population growth estimates from the 2021 Inter-Generational Report.[3] As historical sales data is very volatile, 2022 sales levels are assumed to be the average of the past 10 years of vehicle sales.

Historical and future sales estimates are included in Figure 1.3 on the next page.

Figure 1.1: Vehicle survival curves used in the Grattan truck model
Per cent of vehicles surviving from initial sales, by age



3. Treasury (2021).

Figure 1.2: Estimated vehicle sales used in the Grattan truck model
Number of vehicles sold

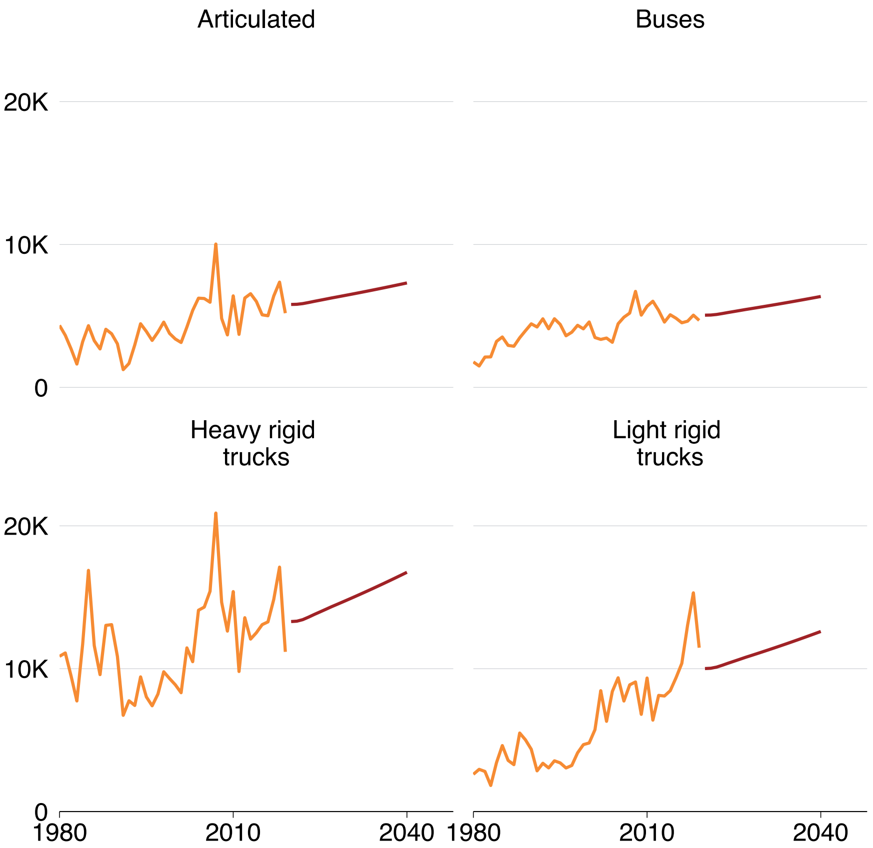
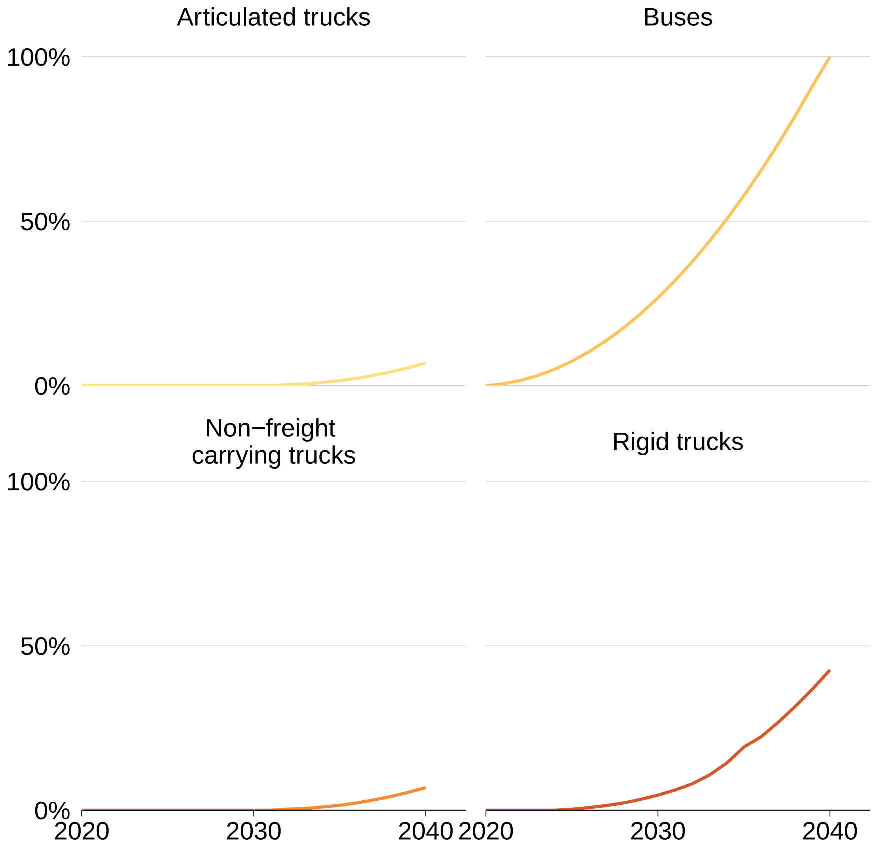


Figure 1.3: Zero-emission sales estimates used in the Grattan truck model
Proportion of new sales that are zero-emissions heavy vehicles



1.1.3 Electric and zero emission vehicle sales estimates

Although the current heavy vehicle fleet has a negligible proportion of zero emissions vehicles in 2022, this is likely to change over time. Because our modeling extends to 2040, zero emission heavy vehicles need to be included in sales estimates.

To estimate Australian zero emissions heavy vehicle uptake, a lagged estimate of European uptake forecasts was used for articulated, rigid and non-freight carrying trucks[4]. A lag of 5 years was assumed. Non-freight carrying trucks were assumed to follow the same trajectory as articulated trucks.

Buses were modeled separately. Zero emission buses are assumed to reach 25 per cent of all new bus sales by 2030, 60 per cent by 2035, and 100 per cent by 2040. The rate of bus zero emission bus uptake is likely to be driven mainly by state government decision making.

1.2 Estimating the activity of the Australian truck fleet

We estimate the activity of the Australian truck fleet by estimating how far each vehicle class with travel in each model year, and how much fuel, or electricity, each vehicle will use.

1.2.1 Vehicle kilometres travelled

As vehicles age, they tend to be driven less. For example, an average 25 year old truck will cover fewer kilometres that an average five year old vehicle each year.

Estimates of how far different vehicle types are driven each year, and how this value changes based on age, are important to estimate the activity of the heavy vehicle fleet.

4. McKinsey & Company (2017).

There is limited data available to estimate vehicle kilometres travelled (VKTs) for the Australian heavy vehicle fleet. While the ABS motor vehicle use survey includes some high level results of the kilometres travelled by different vehicles types, and by ages, these categories are broad.[5] For example, vehicle kilometres based on age are grouped into three categories only; under 5 years old, between 5 and 15 years old, and over 15 years old.

Estimating the total activity of trucks in the Australian heavy vehicle fleet requires estimates of VKTs for trucks of all ages, not just in broad categories. This is particularly important given that the estimates from this model are intended to estimate vehicle pollution; which is very dependent on the age of a vehicle.[6]

Given the lack of available data on the relationship between VKTs and age in an Australian context, we estimate VKTs (for all categories excluding buses) by combining available ABS motor vehicles use survey results with US MOVES model estimates.

The MOVES model contains VMT (vehicle miles travelled) estimates by vehicle age and type, described as mathematical functions.[7] We mapped the VMT functions to known Australian data for articulated, rigid, and non-freight carrying trucks. This included minor dilations and translations of the MOVES functions, to ensure consistency with Australian data in the ABS Survey of Motor Vehicle Use (SMVU).

For articulated trucks, the MOVES data is a polynomial function that is only appropriate for trucks aged between 0 and 16 years old. We assume VKTs for articulated trucks older than 16 years follow a linear

5. ABS (2020).
6. The amount of pollution a vehicle emits is dependent on what pollutant control technologies the vehicle has. As regulations of pollutant control technologies has changed over time, vehicle age can be used as a proxy.
7. EPA (2009).

relationship, calibrated to provide consistent estimates with what is available from the ABS motor vehicle use census data.

Because there is no MOVES data available for buses, bus VKTs were assumed to follow a piecewise linear relationship. Buses were assumed to travel a constant distance for the first 10 years of operation, before declining linearly between ages of 10 and 30. They are assumed to cease operation at 30 years of operation. This assumption is consistent with the attrition curves for buses.

VKTs for all vehicles aged which are 0 years of age (sold during the year in question) are also adjusted. Because vehicles are likely to be sold at roughly an even rate across a year, the average VKT of a new (age 0) vehicle is assumed to be half of that otherwise estimated.

The resulting VKT curves are included in figure Figure 1.4

1.2.2 Vehicle activity estimates

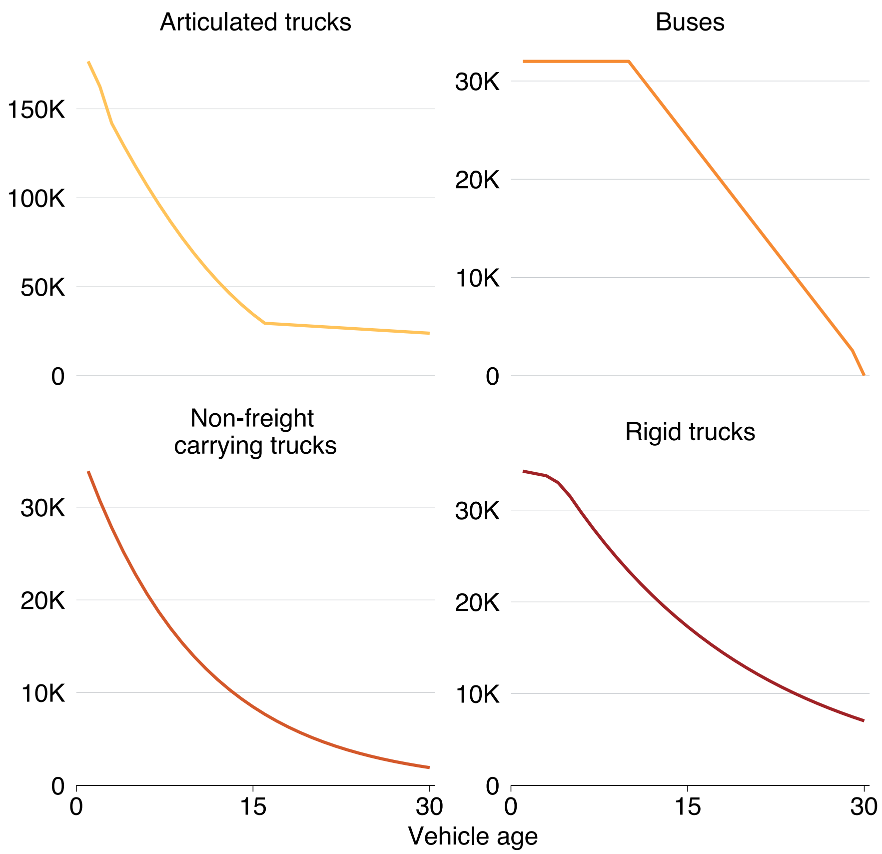
The overall activity of the heavy vehicle fleet is determined by how many vehicles there are, and how far each vehicle travels. As Section 1.1.2 on page 5 explains, we assume that future vehicle sales grow in line with population growth, similarly to historical trends.

However, because of the way vehicle scrappage rates, sales estimates, vehicle age and VKTs interact, there is a shortfall that exists between growth in new vehicles sales, and growth in the acitivity of the overall fleet. Although the assumed sales trajectories are in line with population growth, total vehicle kilometres travelled by the fleet tend to grow at a slower rate.

In the Grattan truck model, this issue is considered in two ways. Both methods result in total fleet activity that broadly follows BITRE forecasts of growth in road freight activity.[8]

Figure 1.4: Estimated vehicle kilometres travelled (VKT) in the Grattan truck model

Annual kilometres travelled, by vehicle age and category



8. BITRE (2019).

Under the 'base case' in the model, this shortfall is accounted for by adjusting the activity of the total fleet over time; increasing the VKTs of each vehicle by a given amount to achieve the desired overall growth. In this case, three scenarios are assumed for growth in fleet activity - a central estimate, lower, and upper bound. The central estimate assumes that future fleet activity grows at a rate of 35 per cent of GDP. For the lower bound scenario, we assume that fleet activity grows at 10 per cent of GDP rates, and we assume that freight activity grows at 60 per cent of the rate of forecast GDP growth in the upper bound scenario. Data for GDP forecast growth was taken from the 2021 Inter-Generational Report.[9]

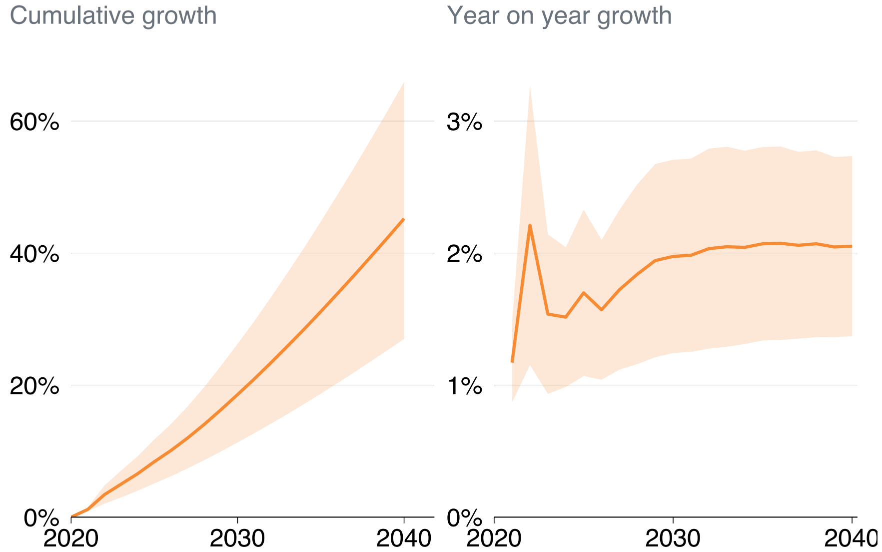
To make sure this method is robust, a second approach is also undertaken for sensitivity analysis. Instead of assuming that vehicles of all ages travel further to make up the shortfall in activity growth, we assume that new sales volumes are larger than expected under the base case.

The difference in the two methods is mainly in how many vehicles are included in the modelled fleet, how far each vehicle travels, and the distribution of VKTs among vehicles of different ages. Comparatively, the base case method assumes that there are fewer vehicles in the fleet, but each vehicles travel further, and older vehicles have a slightly larger share of overall VKTs. The method used for sensitivity testing assumes that the total fleet is larger, but each vehicle travels fewer kilometres each year. It also assumes new vehicle make up a bigger share of annual VKTs.

The overall growth in vehicle kilometres travelled by the heavy vehicle fleet under the base case is included in Figure 1.5. Although the activity adjustments do have an impact on these results, the overall trajectory is primarily driven by growth in new vehicle sales over time.

Figure 1.5: Estimated freight growth in the Grattan truck model

Per cent growth in total freight kilometres travelled (base case scenario)



Notes: Includes growth from increased vehicle sales and change in vehicle activity. Confidence intervals represent upper and lower bound estimates of vehicle activity growth.

9. Treasury (2021).

1.2.3 Fuel consumption of combustion engine vehicles

Fuel consumption in the road freight sector depends on many variables. For example, different trucks with different engines, payloads or driving conditions consume fuel at different rates. Newer trucks are likely to have more efficient engines than old trucks.

We estimate fuel consumption of heavy vehicles based on data from the ABS SMVU. For articulated trucks sold before 2020, we assume trucks within each ABS age band (<5, 0-15, >15) consume fuel at the average fuel rate included in the SMVU. For rigid trucks, we assume vehicles sold before 2000 have a constant rate of fuel consumption. Between 2000 and 2020, we assume fuel consumption rates follow a linear relationship determined form the SMVU, where fuel consumption rates decrease for newer vehicles.[10]

We adopt a similar approach for buses, and assume a constant value for buses made before 2005. We assume fuel consumption rates decrease linearly for vehicles sold between 2005 and 2020. For non-freight carrying trucks sold before 2020, we assume a constant rate of fuel consumption.

In all vehicle categories, we assume that fuel consumption declines by 0.5 per cent year-on-year for new vehicles sold after 2020. This follows assumptions made in the national emissions projections.[11]

1.2.4 Electricity consumption of zero-emission vehicles

All zero emission heavy vehicles included in the model are assumed to be battery-electric vehicles. Vehicle energy consumption is assumed to follow upper bound estimates from the ICCT in 2020.[12] Between 2020 and 2030, it is assumed that energy consumption declines by 2.8 per cent per year from the baseline 2022 value, in line with ICCT forecasts for Europe.[13] Energy consumption figures are assumed to remain steady beyond 2030.

10. ABS (2020).
11. DISER (2021).
12. ICCT (2020).

Table 1.1: Estimated energy consumption of electric heavy vehicles in the Grattan truck model
Energy consumption, kWh/km, by year of vehicle sale

Vehicle type	2020	2025	2030
Articulated trucks	1.9	1.63	1.37
Rigid trucks	1.2	1.03	0.86
Buses	1.02	0.88	0.73
Non-freight carrying vehicles	0.98	0.85	0.71

Notes: ICCT (2020). Values for buses and non-freight carrying vehicles are calculated from rigid truck energy consumption estimates, by scaling in line with current fuel consumption estimates.

1.3 Carbon and tailpipe pollutants from the Australian truck fleet

The Grattan truck model produces estimates of the carbon and tailpipe emissions from the Australian truck fleet. For carbon emissions, these estimates are a function of the assumptions described previously, and are based on fuel and electricity use. For tailpipe pollutants, different emissions factors are assumed for each vehicle class in the model to derive overall estimates.

1.3.1 Estimating carbon emissions

We estimate carbon emissions from the heavy vehicle fleet through fuel and electricity use.

13. ICCT (2021a).

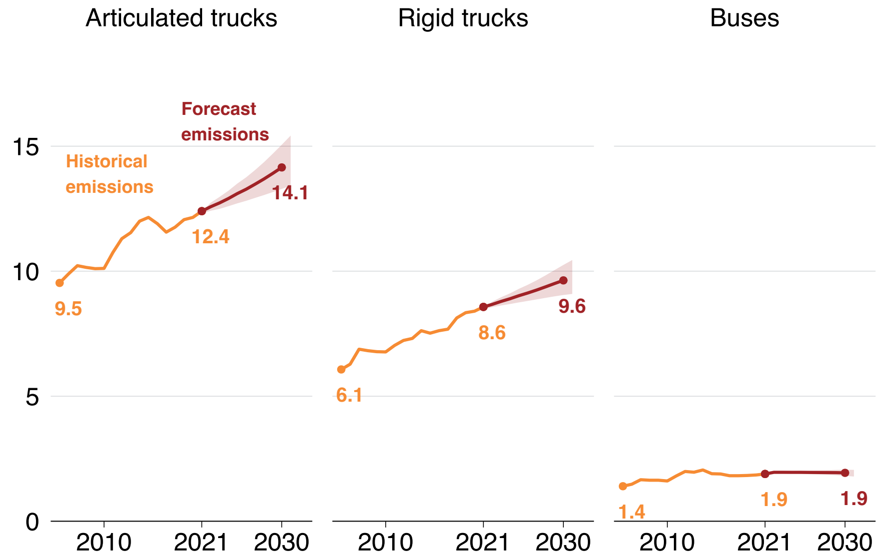
For combustion engine vehicles, we use a conversion ratio between fuel consumption and carbon dioxide production using data from the National Greenhouse Accounts.[14]

For electric vehicles, carbon emission estimates are based on estimated electricity use, and the carbon intensity of the electricity grid. We assume all vehicles are charged using energy from the electricity grid. Estimates for the carbon intensity of the grid between 2020 and 2040 follow the AEMO 'step change' scenario for the national electricity market (NEM).[15] For residual values calculated beyond 2040, it is assumed the grid linearly decarbonises to zero emissions by 2050, and stays at zero emissions beyond 2050.

Forecast carbon emissions under a business as usual (BAU) scenario are included in Figure 1.6.

Figure 1.6: Business as usual emissions forecasts from the Grattan truck model

Historical and forecast carbon dioxide emissions from heavy vehicles



Notes: Confidence intervals represent upper and lower bound estimates of vehicle activity growth. Forecast emissions are from the grattan truck model. Historical emissions are from DISER..

Source: DISER (2021).

14. Department of Industry, Science, Energy and Resources (2021, p. 14).
15. AEMO (2021).

1.3.2 Estimating pollutant emissions

As well as carbon dioxide, heavy vehicles produce numerous other pollutants. Many of these pollutants are be damaging to human health. We estimate heavy vehicle pollutant emissions exhaust pollutants, non-exhaust pollutants, and secondary pollutants for key pollutant categories, including nitrogen oxides (NOx), particulate matter (PM10 and PM2.5), sulfur oxides (SOx) and volatile organic compounds (VOCs).

For exhaust emissions, such as diesel particulates, we calculate pollutant emissions based on fuel consumption. 'Emissions factors' for various pollutants and vehicle types (reported as gram of pollutant per litre of fuel burned) are used for this calculation. Pollutant emissions factors were provided by BITRE[16], categorised by vehicle age, vehicle type, and fuel type. For exhaust particulates, we assume that 92 per cent of PM10[17] by mass are PM2.5[18] and the remaining 8 per cent fraction is PM2.5-10.[19]

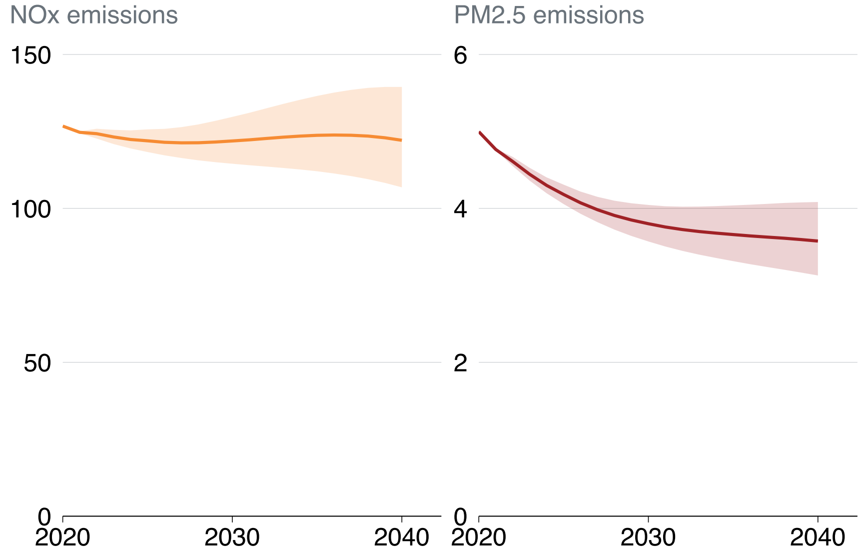
For non-exhaust emissions, such as tyre and brake wear, we calculate emissions based on vehicle kilometres travelled. We use US EPA MOVES model values for tyre and brake wear per kilometre.[20] Particulate matter from road wear and re-entrained road dust is not included in our analysis.

We estimate secondary PM2.5 pollution from SOx and NOx using offset conversion factors. An offset factor of 1:100 is assumed for NOx, and 1:40 for SOx – meaning that for each gram of NOx formed, 0.01g of secondary PM2.5 is assumed to form, and for 1g of SOx emissions, 0.025 grams of PM2.5 is formed. This approach is consistent with US NACAA (National Association of Clean Air Agencies) methodology for estimating secondary pollutant emissions. The ratios assumed are ratios used for the west coast of the US.[21] As secondary pollution is very sensitive to a range of environmental and atmospheric conditions, while these estimates indicative, they are relatively uncertain.

Estimates of business as usual pollution are included in Figure 1.7.

Figure 1.7: Business as usual pollutant forecasts from the Grattan truck model

Annual emissions from Australian heavy vehicles (000' tonnes)



Notes: Confidence intervals represent upper and lower bound estimates of vehicle activity growth. Particulate emissions from re-entrained road dust and road wear are not included.

16. Pers comm
17. Particulate matter smaller than 10um in aerodynamic diameter.
18. Particulate matter smaller than 2.5um in aerdynamic diameter.
19. EPA (2014a).
20. EPA (2014b, pp. 16, 24).
21. NACAA (2011, p. 18).

1.4 Pollutant health costs

We estimate the health cost from pollution using a damage cost approach. This approach assigns a cost to pollutant emissions based on mass, for example, as a cost per tonne of pollutant emitted. Damage costs are typically calculated from more detailed impact pathway approaches.

Multiplying the emissions from the heavy vehicle fleet by damage cost estimates generates a forecast of total health costs under various policy scenarios. We use damage costs provided by BITRE[22]. These estimates are developed from impact pathway modeling conducted by Jacob Marsden Ass. (2016), which was part of a broader review into fuel quality and vehicle emissions.[23]

While health costs are inherently uncertain, these costs are comparable with the range of other costs estimated in the literature.[24]

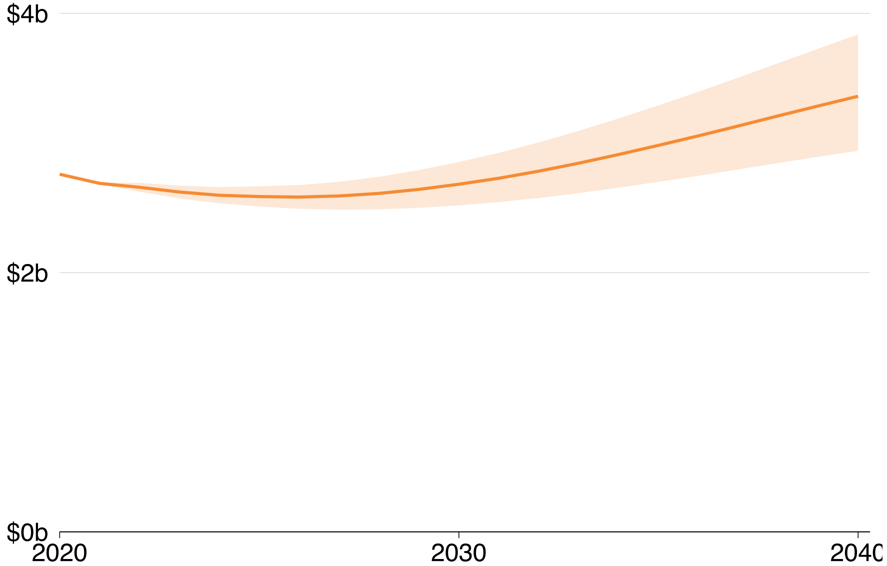
Pollutant emissions are particularly harmful to human health in densely populated, urban areas, because more people are exposed to the pollution. To account for this, damage costs are separated into rural and urban costs to account for the differences in population exposure. We calculate the share of pollution in urban and rural areas by assigning a proportion of vehicle kilometres travelled to each, based on data from the ABC SMVU. This share is assumed to be constant with vehicle age and over time.

For zero-emission trucks, we also estimate health costs for pollutants from large scale power generation. We use the Australian Academy of Technological Sciences and Engineering (ATSE) externality estimates for health costs for different types of generation. The make-up of total costs is weighted by the power generation share in the NEM.[25] Costs are assumed to decrease in line with emissions intensity.

Figure 1.8 shows the estimated health costs under a business as usual scenario.

Figure 1.8: Business as usual health cost forecasts from the Grattan truck model

Estimated health costs from vehicle pollution



Notes: Confidence intervals represent upper and lower bound estimates of vehicle activity growth.

22. Pers comm.
23. Jacob Marsden Associates (2016).
24. For example in the US: Gilmore et al (2018)
25. Technological Sciences and Engineering (2009); and Australian Energy Regulator (2022).

2 Policy scenarios modelled

2.1 Policies to reduce carbon emissions

The ***report name*** includes estimates of carbon emissions, pollution, and health costs under various policy intervention scenarios. The Grattan truck model is used as the basis for assessing potential outcomes under these policy scenarios compared to a business as usual scenario. This section explains the results of policy scenarios tested, and any further assumptions used in the modelling.

2.1.1 Technology standards

We used the Grattan truck model to estimate the effect of implementing technology standards[26] would have on carbon emissions from the Australian heavy vehicle fleet.

Based on international evidence, we assume carbon emissions reductions of 3 per cent per year would be met through engine standards, and of 1.5 per cent per year would be met through tyre standards.[27] Both are assumed relative to a 2022-era Euro V baseline vehicle, and assumed to be in place from 2024 to 2030.

We assume targets would cover rigid and articulated trucks, and that manufacturers would meet, but not overshoot, the targets each year.

2.1.2 Zero emission targets

Targets for the sale of zero emissions trucks are becoming common globally. We modelled the expected effect of zero-emission targets on carbon emissions from the heavy vehicle fleet.

The assumed target trajectories are shown in Figure 2.1 on the following page. Targets are assumed to be enforced from 2024, and are applied to articulated and rigid trucks only. We assume all zero emissions vehicles are electric vehicles. Figure 2.2 on the next page shows the expected carbon emissions under technology standard and zero emission target scenarios.

26. Details regarding vehicle technology standards are included in the ***report name***.
27. ICCT (2017); ICCT (2016); ICCT (2021b); and ICCT (2018).

Figure 2.1: Proposed zero-emissions sales targets for articulated and rigid trucks
Zero emission sales targets as a proportion of new sales

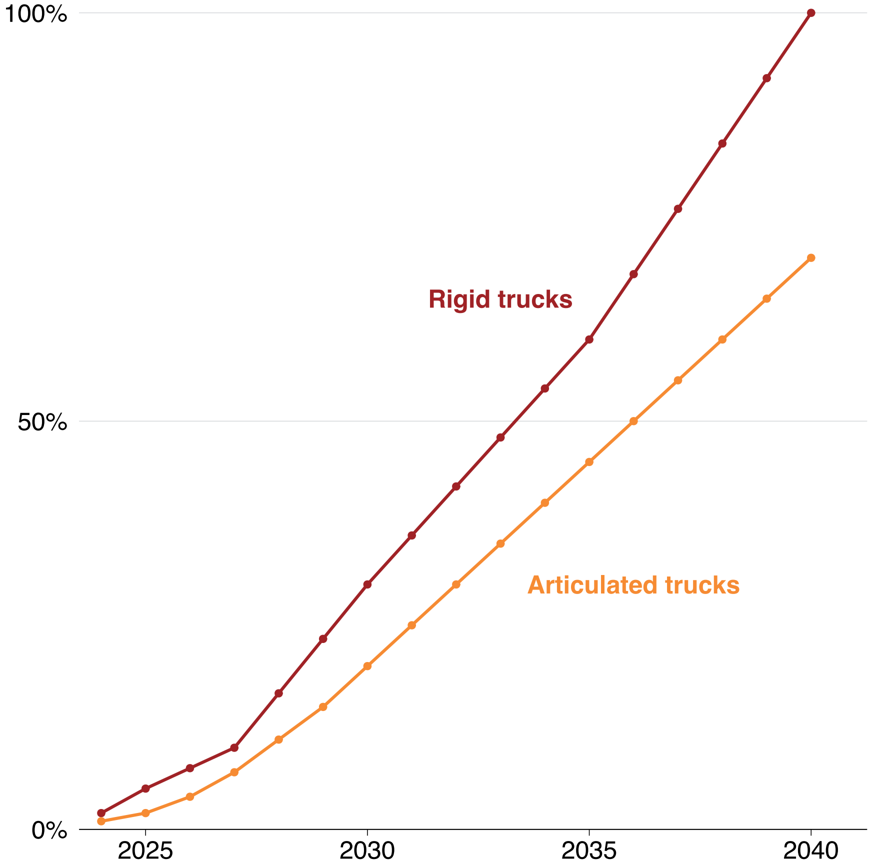
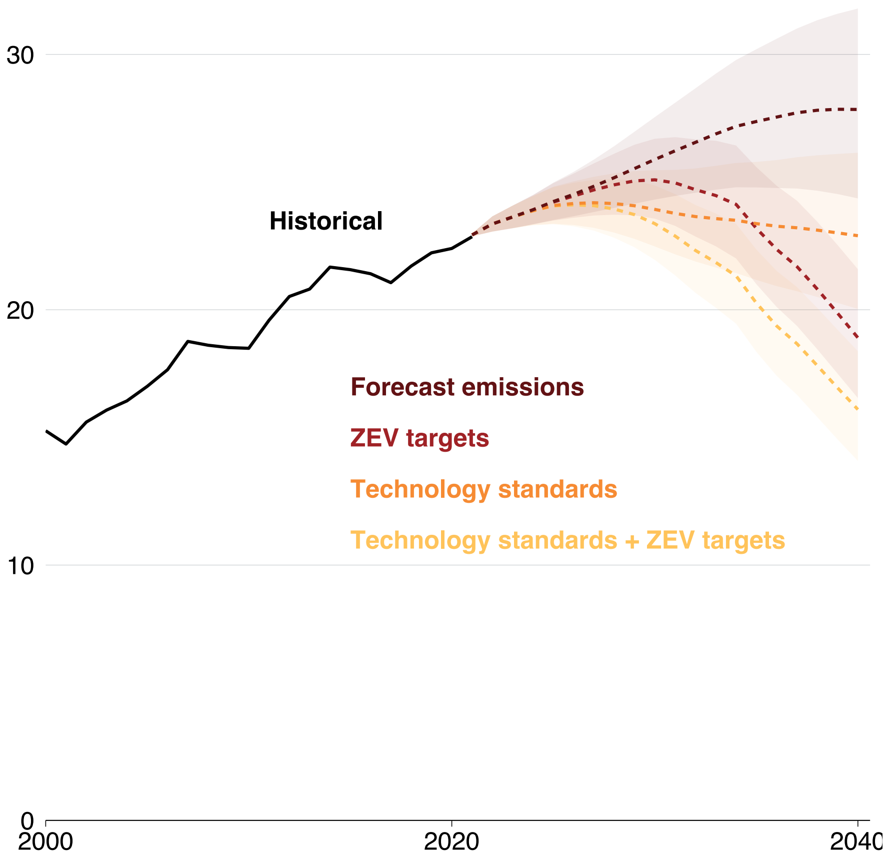


Figure 2.2: Grattan truck model estimates of carbon dioxide emissions under the proposed policy scenarios
Estimated annual carbon dioxide emissions (Mt)



Notes: Confidence intervals represent upper and lower bound estimates of vehicle activity growth.

2.2 A policy to reduce pollutants from new vehicles

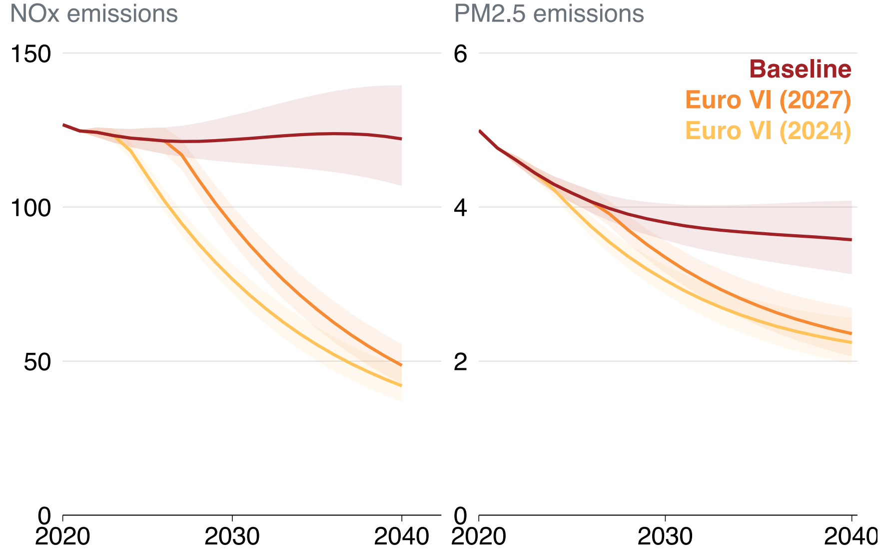
Euro VI pollutant standards for heavy vehicles are common globally and have been proposed in Australia. The following charts illustrate the estimated affect of Euro VI regulations on pollutant emissions from the heavy vehicle fleet.

We assume that a Euro VI vehicle produces 80 per cent less NOx emissions and 66 per cent less PM emissions compared to an equivalent Euro V vehicle. These values are consistent with the pollution reductions required by vehicle testing to meet Euro VI standards compared to Euro V.[28] In practice, actual NOx and PM reductions are likely to exceed these estimates.

Estimates of vehicle pollution (Figure 2.3) and health costs are included (Figure 2.4 on the next page).

Figure 2.3: Grattan truck model estimates of pollutant emissions under proposed policy scenarios

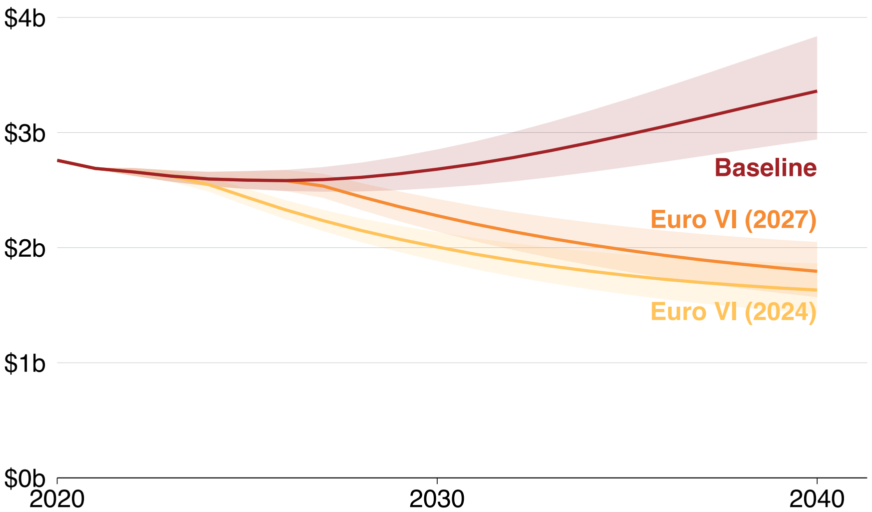
Annual emissions from Australian heavy vehicles (000' tonnes)



Notes: Confidence intervals represent upper and lower bound estimates of vehicle activity growth.

28. These values are the upper limits of the transient and stationary test cycles: DITRDC (2020)

Figure 2.4: Grattan truck model estimates of pollutant health costs under proposed policy scenarios
Estimated annual health cost from heavy vehicle pollution



Notes: Confidence intervals represent upper and lower bound estimates of vehicle activity growth.

3 Zero emissions targets: cost benefit analysis

We used the Grattan truck model as the basis for a cost benefit analysis (CBA) of a zero-emission target. This cost benefit analysis compares the costs and benefits of zero emissions vehicle targets for heavy vehicle sales, compared to a business as usual scenario.

We assume zero-emission targets only apply to rigid and articulated trucks.

The framework for the CBA includes the costs and benefits quantified is included in Table 3.1.

Although there may be other benefits (and costs), such as safety improvements, these are not quantified in the modelling because they are general believed to be small. Similarly, there is some recent evidence concerning the effects of air pollution on productivity and economic activity.[29] Where they have been quantified, these effects have been found to be substantial, and would increase the estimates benefits of reductions to pollution substantially. however, as the evidence is in early stages and limited studies are available to support conclusions, this effect has not been included in our analysis.

The evaluation period for the CBA is from 2022 to 2040, with residual values beyond 2040 included in the analysis. Discount rates of 7 per cent and 4 per cent are applied.

3.1 Cost assumptions used in the Grattan truck model

Diesel and electricity prices

We assume that diesel and electricity prices remain constant over the evaluation period. We use assumptions from the Australian trucking Association, and assume diesel costs $1.33/L[30] and electricity costs $0.15/kWh for truck operators.[31]

Table 3.1: Costs and benefits quantified in the CBA

Benefits	Costs
Reduced running costs	Additional upfront vehicle costs
Reduced maintenance costs	Additional charging infrastructure costs
Avoided health costs	Time and weight penalties
Avoided carbon emissions	

Upfront vehicle costs

The additional upfront cost of a zero emissions vehicle is assumed to be the difference between the cost of an electric vehicle and diesel vehicle. We use CSIRO values to estimate additional upfront costs of zero emission heavy vehicles compared to diesel alternatives using the ‘long range’ vehicle cost estimates for electric vehicles.[32]

As CSIRO only provides data at five yearly intervals, we estimate costs of all years through by linearly interpolating the data.

29. Dechezleprêtre et al (2020).

30. This price does not include the fuel excise tax because the vast majority of heavy vehicles receive a rebate on fuel excise tax.
31. EVC & ATA (2021, p. 8).
32. Graham and Havas (2021, p. 24).

Charging infrastructure costs

We assume that charging infrastructure costs follow ICCT estimates (Table 3.2).[33] Cost are estimated per zero emissions vehicle sold. We assume that 'low volume' cost estimates apply between sales volumes of 0 – 100 vehicles, medium volume cost estimates apply between sales of 1 – 1,000 vehicles, and high volume costs apply for sales volumes 10,000+.

Table 3.2: Charging infrastructure costs used in the Grattan truck model

Vehicle type	Volume	Cost per vehicle
Articulated trucks	Low volume	$255,600
Articulated trucks	Medium volume	$160,460
Articulated trucks	High volume	$99,400
Rigid trucks	Low volume	$116,440
Rigid trucks	Medium volume	$56,800
Rigid trucks	High volume	$38,340

Notes: Rigid truck cost estimates are also assumed to apply to buses and non-freight carrying vehicles.

Maintenance and Adblue costs

We use maintenance costs values from the Australian Transport Assessment and Planning (ATAP).[34] We use assumptions made by the ICCT and assume electric vehicle maintenance costs are 30% lower than for diesel vehicle costs.[35]

Oil and lubricant costs are assumed to follow ICCT estimates for diesel vehicles.[36]

33. ICCT (2019).
34. Australian Transport Assessment and Planning (2013).
35. ICCT (2019).
36. Ibid.

Adblue is assumed to cost $0.55/L, and adblue consumption rates are assumed to be 5 per cent of fuel consumption rates where used.[37]

Time and weight penalties for electric vehicles

As electric heavy vehicles tend to have large, heavy batteries, they typically weigh more than their diesel equivalent. This reduces the payload that can be carried by the vehicle. To account for this, we assume that 3 per cent more electric vehicles are required to perform the same freight task as diesel vehicles.

Electric vehicles also must be charged, which can take longer than refuelling a diesel vehicle. To account for this time penalty, we assume that an additional 1.5 per cent more electric vehicles are required to perform the same freight task as diesel equivalents.

Both assumptions are estimates from the ICCT, and apply to all costs – including the requirement for more chargers to support the additional vehicles.[38]

Noise pollution cost estimates

We use noise pollution cost estimated from Austroads "Updating Environmental Externalities Unit Values" paper.[39] We adjust values reported as $/1000t-km to values per kilometre travelled, using an average load of 5.86 tones for Rigid trucks and 25.82 tonnes for Articulated trucks, estimated from the SMVU. We use this method for both urban and rural values, and estimated the proportion of VKTs spent in urban and rural areas using SMVU data. We assume the noise of an electric vehicle is 90 lower than the noise of a diesel vehicle. Noise cost estimates are included in Table 3.3 on the following page.

37. Yara (2022).
38. ICCT (2019).
39. Austroads (2014, pp. 49, 50).

Table 3.3: Diesel vehicle noise pollution costs used in the Grattan truck model

Vehicle type	Region	Cost per '000 km
Articulated trucks	Urban	$219
Articulated trucks	Regional	$22
Rigid trucks	Urban	$49
Rigid trucks	Regional	$5
Buses	Urban	$47
Buses	Regional	$5

Notes: Non-freight carrying trucks are assumed to have the same costs as rigid trucks.

Source: Austroads (2014).

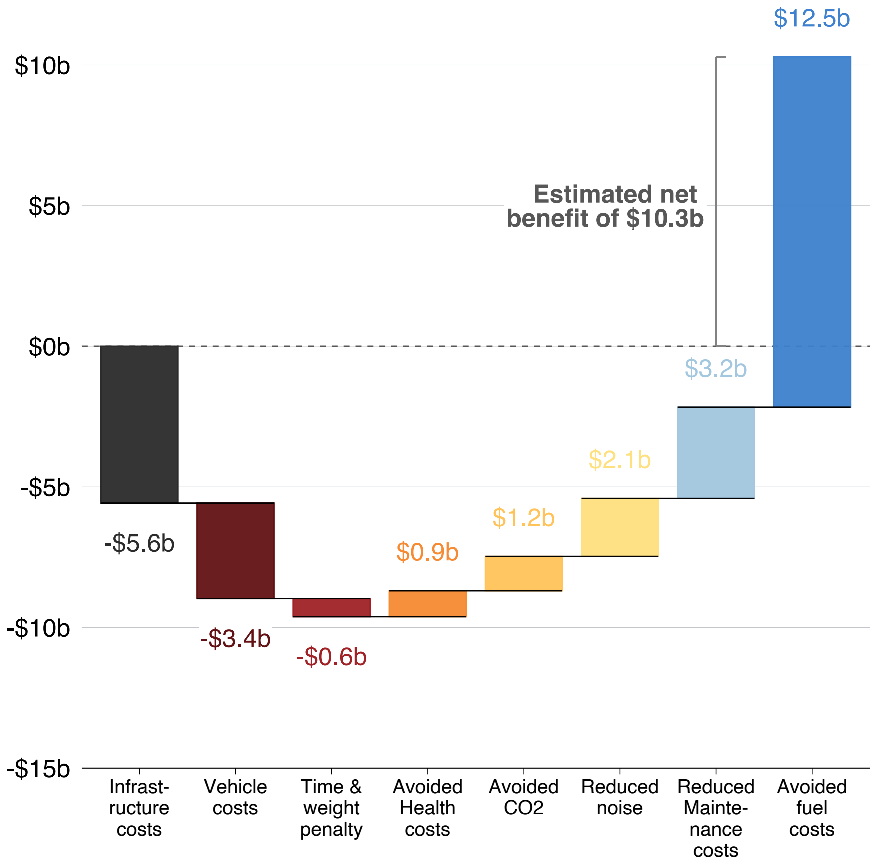
Social cost of carbon estimates

Where a social cost of carbon is included, we follow past practices by the Department of Infrastructure and Regional Development and assume a cost of $35/tonne.[40] This estimate was used by the department based on the United States Office of Management and Budget approach used for regulatory impact analyses. As noted by the department, this is a conservative estimate of the social cost of carbon.

3.2 CBA results

Figure 3.1: Grattan truck model estimates of the costs and benefits from zero-emission heavy vehicle targets

Costs and benefits of ZE-HDV targets under baseline scenario



Notes: A discount rate of 7% is used.

40. DIRD (2016, pp. 73–74).

Table 3.4: Sensitivity testing of CBA results [needs updating]

Scenario	Discount rate	Net benefit	BCR
Baseline	7%	$6.9b	1.63
Baseline	4%	$15.2b	2.00
Upper bound freight growth	7%	$9.4b	1.85
Upper bound freight growth	4%	$19.7	2.29
Lower bound freight growth	7%	$4.7b	1.43
Lower bound freight growth	4%	$11.3	1.75
High diesel cost	7%	$8.3b	1.76
High diesel cost	4%	$17.6	2.16
High electricity cost	7%	$4.7	1.43
High electricity cost	4%	$11.5	2.00
Low diesel cost	7%	$5.5b	1.50
Low diesel cost	4%	$12.8b	1.84
Low electricity cost	7%	$9.1b	1.84
Low electricity cost	4%	$18.9b	2.26

Notes: High diesel cost is assumed to be $1.43/L. Low diesel cost is assumed to be $1.23/L. High electricity cost is assumed to be $0.20/kWh. Low electricity cost is assumed to be $0.10/kWh.

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