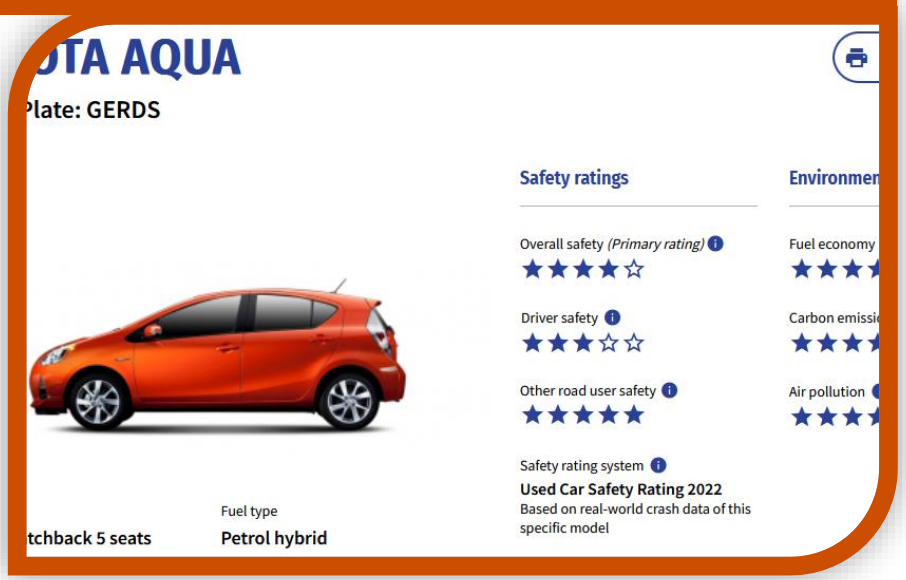
Rightcar air pollution rating system: Updated methodology



Prepared for

Waka Kotahi NZ Transport Agency

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2	1 December 2022	Jayne Metcalfe	Gerda Kuschel	Additional material on Japanese and European equivalency prepared
3	18 April 2023	Gerda Kuschel	Jayne Metcalfe	Final report combining all material and addressing peer reviewer and client feedback

Executive summary

The Rightcar website[1] is administered by Waka Kotahi NZ Transport Agency (Waka Kotahi) and is linked to the motor vehicle register. The website provides information to help consumers choose the safest, cleanest, most efficient vehicle they can afford. Rightcar utilises a rating system for vehicle safety and environmental performance, with the best performing vehicles assigned up to 6 stars in each category.

For environmental performance, vehicles are rated on fuel economy, carbon emissions and air pollution. The current Rightcar air pollution ratings utilise a simple 6 star system based on the exhaust emission standard[2] (e.g. Euro 4) of the vehicle, regardless of fuel type or engine size. Older technology vehicles (e.g. Euro 1) are rated at 1 star, with newer technology vehicles (e.g. Euro 6) granted up to 6 stars. Lower emission vehicles (e.g. hybrids and electric vehicles - EVs) are assigned between 5 and 6 stars.

While exhaust emission standards are *indicative* of the air pollution impact of vehicles under controlled test conditions, they do not accurately reflect the *actual* emissions generated by real-world driving. In addition, exhaust emissions standards do not weight the impact of the pollutants that can be emitted in varying proportions, depending on the vehicle fuel type. The recent Health and Air Pollution in New Zealand 2016 study (HAPINZ 3.0) found the effects of particulate matter ($PM_{2.5}$) and nitrogen dioxide (NO_2), which are typically higher in diesel vehicle exhaust, to be considerable even at low levels (Kuschel *et al* 2022).

This report was commissioned by Waka Kotahi to update the air pollution rating system to:

- Better represent the real-world vehicle emissions, especially those from diesel vehicles
- Reflect the likely health impact of emissions based on the HAPINZ 3.0 findings
- Future proof the ratings for the introduction of improved vehicle emission standards in New Zealand.

We developed an updated Air Pollution Star Ratings for new and used vehicles by taking manufacturers' emissions standards, matching real-world emission estimates for each vehicle type and then estimating the emissions-related health impacts. A rating (from 1 star to 6 stars) was then applied to the results, with electric vehicles getting 6 stars and other vehicles getting ranked based on the health costs of their emissions impact.

This report describes our methodology and rationale and is supported by two accompanying Excel workbooks containing all calculations and assumptions. The proposed Rightcar air pollution ratings are provided in *Rightcar_AP rating_final.xlsx* and the sensitivity analyses are in *Rightcar_AP rating_sensitivity analyses.xlsx.*

Adding these revised Air Pollution Ratings to the Rightcar website provides further choice and encouragement to consumers who want (and are able) to minimise harm to the environment and to the community through their choice of vehicle. The following table summarises the updated rating system.

[1] https://rightcar.govt.nz/

[2] Note Arabic numerals are used for Euro standards applying to light duty vehicles (e.g. Euro 5) and Roman numerals for those applying to heavy duty vehicles (e.g. Euro V).

Table ES.1: Updated air pollution star ratings assigned to the indicated exhaust emissions standard

Vehicle type	Rating (stars)	Petrol emission standard		Diesel emission standard		Other
		NZ new	Jap used	NZ new	Jap used	
Car and SUV	0	Pre-Euro 1		Euro 3 & earlier	Jap 2004 & earlier	
	1	Euro 1		Euro 4 & Euro 5	Jap 2005 to 2018	
	2	Euro 2 & Euro 3	Jap 2002 & earlier			
	3	Euro 4	Jap 2005 & 2005d	Euro 6d		
	4	Euro 5 to *Euro 7*	Jap 2009 & 2018	*Euro 7*		
	5	Hybrid/PHEV	Hybrid/PHEV			
	6					EV
Van and ute	0	Euro 1 & earlier		Euro 5 & earlier	Jap 2018 & earlier	
	1					
	2	Euro 2 & Euro 3	Jap 2002 & earlier	Euro 6d		
	3	Euro 4	Jap 2005 & 2005d	*Euro 7*		
	4	Euro 5 to *Euro 7*	Jap 2009 to 2018			
	5	Hybrid/PHEV	Hybrid/PHEV			
	6					EV

EV = electric vehicle, PHEV = plug-in hybrid vehicle, SUV = sports utility vehicle (e.g. 4WD)

Note: The ratings for Euro 7 are indicative only and have been included for completeness. They are based on the changes in the standard *limits* for PM and NO_X going from Euro 6d to Euro 7, in the absence of real-world emissions data as Euro 7 is not due to be implemented until 1 July 2025 in Europe. Euro 6 is yet to be required for vehicles entering the fleet in New Zealand so Euro 7 implementation here will be several years after Europe.

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Glossary

3P-WLTP	three phase Worldwide Harmonised Light Vehicle Test Procedure
CH_4	methane, a greenhouse gas
CO	carbon monoxide, a harmful air pollutant
CO_2	carbon dioxide, a greenhouse gas
DI	direct injection
DPF	diesel particulate filter – a PM emission control system
EGR	exhaust gas recirculation – a NO_X emission control system
EIL	Emission Impossible Ltd
EV	electric vehicle
g	gram, a unit of mass
GDI	gasoline direct injection
GHG	greenhouse gas
HAPINZ	Health and Air Pollution in New Zealand, a study of the air pollution impacts and associated social costs
heavy duty vehicle	a vehicle with a gross vehicle mass > 3.5 tonnes
km	kilometre
LCV	light commercial vehicle, a commercial vehicle with a gross vehicle mass < 3.5 tonnes
light duty vehicle	a vehicle with a gross vehicle mass < 3.5 tonnes
NEDC	New European Driving Cycle
NMHC	non-methane hydrocarbon
NO_X	oxides of nitrogen
NO_2	nitrogen dioxide, a harmful air pollutant
N_2O	nitrous oxide, a greenhouse gas (not to be confused with NO_2 which is a harmful air pollutant)
NZTA	Waka Kotahi NZ Transport Agency
PEMS	portable emission monitoring system
PFI	port fuel injection
PHEV	plug-in hybrid electric vehicle
PM	particulate matter, a harmful air pollutant
$PM_{2.5}$	particulate matter smaller than 2.5 µm in diameter
PM_{10}	particulate matter smaller than 10 µm in diameter
SCR	selective catalytic reduction – a NO_X emission control system
µm	micrometre, one millionth of a metre

VEPM	Vehicle Emissions Prediction Model, developed by Waka Kotahi to predict air emissions and fuel consumption for the New Zealand fleet
VOC	volatile organic compounds
Waka Kotahi	Waka Kotahi NZ Transport Agency
WHO	World Health Organization
WLTC	World Harmonised Light Vehicle Test Cycle
WLTP	Worldwide Harmonized Light Vehicles Test Procedure

1.0 Introduction

1.1 Purpose and scope of study

The Rightcar website[3] is administered by Waka Kotahi NZ Transport Agency (**Waka Kotahi**) and is linked to the motor vehicle register. The website provides information to help consumers choose the safest, cleanest, most efficient vehicle they can afford. Rightcar utilises a rating system for vehicle safety and environmental performance, with the best performing vehicles assigned up to 6 stars in each category. For environmental performance, vehicles are rated on fuel economy, carbon emissions and air pollution.

The current Rightcar air pollution ratings utilise a simple 6 star system based on the exhaust emission standard[4] (e.g. Euro 4) of the vehicle, regardless of fuel type or engine size. Older technology vehicles (e.g. Euro 1) are rated at 1 star, with newer technology vehicles (e.g. Euro 6) allocated up to 6 stars. Lower emission vehicles (e.g. hybrids and electric vehicles - **EV**s) are assigned between 5 stars and 6 stars.

The air pollution health impact of vehicle emissions in New Zealand is considerable and varies substantially depending on the vehicle fuel and emission control technology. The recent Health and Air Pollution in New Zealand 2016 study (**HAPINZ 3.0**) estimated that motor vehicle emissions alone resulted in 2,247 premature deaths, nearly 9,400 hospitalisations, over 13,200 cases of childhood asthma and more than 330,000 restricted activity days[5] each year in New Zealand, at a cost of more than $10.5 billion (Kuschel *et al* 2022). HAPINZ 3.0 also found that the effects of particulate matter (**$PM_{2.5}$**) and nitrogen dioxide (**NO_2**), which are typically higher in diesel vehicle exhaust, to be appreciable even at low levels.

While exhaust emission standards are *indicative* of the air pollution impact of vehicles under controlled test conditions, they do not accurately reflect the *actual* emissions generated by real-world driving. In addition, exhaust emissions standards do not weight the impact of the pollutants that can be emitted in varying proportions, depending on the vehicle fuel type. For example, emissions from an average diesel car in New Zealand costs society (in terms of harmful emissions) around 16 times more than a new petrol car complying with the latest Euro 6 standards[6].

This report was commissioned by Waka Kotahi to update the air pollution rating system to:

- Better represent the real-world vehicle emissions, especially those from diesel vehicles
- Reflect the likely health impact of emissions based on the HAPINZ 3.0 findings
- Future proof the ratings for the introduction of improved vehicle emission standards in New Zealand.

[3] https://rightcar.govt.nz/

[4] Note Arabic numerals are used for Euro standards applying to light duty vehicles (e.g. Euro 5) and Roman numerals for those applying to heavy duty vehicles (e.g. Euro V).

[5] A restricted activity day is one in which a person due to exposure to air pollution does not feel well enough to go to work, school or undertake their normal activities.

[6] Based on social costs per km estimated in Metcalfe & Kuschel (2022).

1.2 Report structure

The report is structured as follows:

- Chapter 2 provides background on the key harmful air pollutants in motor vehicle emissions and assessing the associated public health impacts
- Chapter 3 describes the methodology followed to develop the updated air pollution star rating system
- Chapter 4 compares our proposed star rating system for air pollution with the one currently proposed by Ministry of Transport and Waka Kotahi for carbon dioxide emissions and fuel consumption
- Chapter 5 summarises our proposed air pollution rating system.

All references are listed at the end, with additional information included in appendices.

This report describes our methodology and rationale and is supported by two accompanying Excel workbooks containing all calculations and assumptions. The proposed Rightcar air pollution ratings are provided in *Rightcar_AP rating_final.xlsx* and the sensitivity analyses are in *Rightcar_AP rating_sensitivity analyses.xlsx.*

2.0 Background

2.1 Key air pollutants in motor vehicle emissions

Air emissions from vehicles are typically split into harmful air pollutants (which impact locally) and greenhouse gases including carbon dioxide (which impact globally).

Harmful air pollutants are so-called because they can cause adverse human health effects ranging from increased *morbidity* (illness, e.g. increased respiratory hospitalisations) to increased *mortality* (loss of life, i.e. premature deaths). The effects depend on the pollutant itself, the concentration and the length of time exposed – acute (short-term) or chronic (long-term).

Air pollution comprises a complex mixture of gases and particles. It is not feasible to measure or assess the effects of all the individual components of air pollution, so the assessment of health impacts is simplified by focusing on key contaminants. These key contaminants may be acting as proxies for the overall air pollution mixture (WHO 2016).

In New Zealand, the pollutants of most concern are:

- Particulate matter smaller than 10 µm (**PM_{10}**) or smaller than 2.5 µm ($PM_{2.5}$) – which arises primarily from diesel fuel combustion, brake/tyre wear and road dust. Combustion-related PM is usually in the $PM_{2.5}$ size range (known as fine particulate) whereas abrasion-related PM is usually in the $PM_{10\text{-}2.5}$ size range (known as coarse particulate).
- Nitrogen oxides (**NO_X**), in particular nitrogen dioxide (NO_2) – which is emitted primarily from diesel and petrol fuel combustion.

The recent HAPINZ 3.0 study found the effects of $PM_{2.5}$ and NO_2, which are typically higher in diesel vehicle exhaust, to be considerable in New Zealand even at low levels (Kuschel *et al* 2022).

2.2 How are emission impacts assessed?

Emissions to air, either air quality or greenhouse gas, cause an impact on society through increased medication use, lost productivity through illness, increased hospitalisations, death and extremes in climate.

The social costs of health impacts associated with transport emissions can be assessed using either detailed or screening methods.

The HAPINZ 3.0 study is the most recent detailed assessment of air pollution health impacts in New Zealand (Kuschel *et al* 2022) but assessing impacts this way is a resource-intensive exercise.

A simpler way to estimate health impacts is to use damage costs.

Damage costs value changes in air emissions so that the benefits to society of a change in policy/operation can be compared against the cost of implementing the change. They can also be used to compare a range of options to see which will yield the best overall outcome. The social costs associated with changes in harmful pollution can be calculated by combining the emissions (usually expressed in grams or tonnes of each pollutant) with unit damage costs (expressed in $ per tonne).

Table 1 shows the unit damage costs for $PM_{2.5}$ and NO_X emissions in urban areas of New Zealand. These have been derived from the results of the HAPINZ 3.0 study.

Table 1: New Zealand urban damage costs in $/tonne (June 2019 prices)

Pollutant	Costs in NZ$/tonne	Value base date (at end June)
$PM_{2.5}$	$622,786	2019
NO_X	$499,526	2019

Source: Kuschel *et al* (2022)

In this report, we applied the costs shown in Table 1 to per kilometre emission rates for different vehicle types to assess the resulting social costs.

3.0 Methodology for improved air pollution ratings

We developed air pollution ratings for light duty vehicles categorised by:

- type (car/SUV or van/ute)
- fuel (petrol, diesel, petrol hybrid, plug-in petrol hybrid and electric)
- country of origin (New Zealand new or Japanese used import)
- exhaust emission standards[7] (including European and Japanese standards)
- engine size.

The methodology for developing updated air pollution ratings followed five steps:

1. Estimate real-world $PM_{2.5}$ and NO_X emission factors for the most commonly available vehicles in New Zealand using the Waka Kotahi vehicle emissions prediction model (VEPM 6.3).
2. Calculate social costs per km for each vehicle category based on air pollution damage costs provided in HAPINZ 3.0.
3. Rank vehicle categories according to social costs, and assign stars based on these rankings.
4. Undertake sensitivity analyses
5. Estimate likely ratings for future technologies, e.g. Euro 7.

These steps are described in the following sections.

3.1 Generating emission factors

To estimate real-world emissions from each vehicle category, we generated emission factors from VEPM 6.3 (Metcalfe & Peeters 2022).

VEPM predicts real-world emission factors for the New Zealand fleet under typical road, traffic, and operating conditions. New Zealand has regulations for two classes of vehicle entering the fleet for the first time – New Zealand new vehicles and used imported vehicles (typically sourced from Japan). The New Zealand new vehicles are generally certified to exhaust emissions standards from Europe (e.g. Euro 5) while used imported vehicles are generally certified to exhaust emissions standards from Japan (e.g. Jap 08). In 2021, the average age of used light vehicles entering the fleet was 9.70 years for vans/utes and 9.87 years for cars/SUVs (MoT 2022).

VEPM emission factors are constantly being updated with improved factors for new technologies, emerging issues and real-world effects. VEPM is intended to predict real-world emissions (as opposed to the limits specified in vehicle exhaust emission standards).

VEPM is an average speed model. This means that VEPM predicts different emission factors for different speeds (between 10 and 110 km/hour).

Emission factors were generated from VEPM 6.3 using an average speed of 50 km/hour with no consideration of degradation effects. Default values were used for all other settings in VEPM. A speed of 50 km/hour was chosen to be representative of typical speeds encountered in urban environments (where exposure to air pollution and the subsequent impacts are higher).

[7] Approximate year of manufacture relating to each emission standard is also specified. Year of manufacture can be used to categorise vehicles without emission standard information.

Sensitivity analyses were undertaken to investigate the impact of speed and degradation assumptions. These are discussed further in Section 3.4.

3.1.1 Japanese and European equivalency in VEPM

VEPM does not include specific Japanese emission factors, because a comprehensive Japanese emissions model is not readily available. An equivalent European emission factor is assumed in VEPM for each Japanese vehicle category, emission standard and pollutant.

For vehicles manufactured up to 2010, a detailed comparison of emission factors from European and Japanese emission models (JCAP) was undertaken to assign the closest equivalent European emission factor for each Japanese vehicle category and each pollutant. The detailed comparison is described in the technical report (EFRU 2008). The equivalencies are provided in Appendix A of this report.

Harmonisation of international emissions standards means that emissions from modern European and Japanese vehicles are broadly similar. For vehicles manufactured from 2010 onwards a simplified approach was used to assign equivalence. A comparison of Japanese and European emission standards was undertaken to identify the closest equivalent standard. For vehicles manufactured from 2010 onwards, Japanese vehicles are assigned the emission factors of the closest equivalent European emission standard (for all pollutants) based on the date of introduction of Japanese emissions standards.

3.1.2 Assumptions for Japanese used vehicles manufactured from 2010 onwards

Table 2 summarises the equivalencies that are assumed in VEPM for light duty Japanese used imported vehicles manufactured from 2010 onwards.

Table 2: Assumptions in VEPM for Japanese vehicle equivalency from 2010 onwards

Vehicle type	Fuel	Year of manufacture	Assumed equivalent emission factor
Passenger cars and SUVs	Petrol	2010-17	Euro 5
		2018-23	Euro 6 a/b/c
		2024 onwards	Euro 6d
	Diesel	2010 onwards	Euro 5
Light commercial vans and utes	Petrol	2010 onwards	Euro 5
	Diesel	2010 onwards	Euro 5

The assumptions described in Table 2 are based on simple comparison of emission standards, which is reproduced as follows. The emissions standards and test methods do not necessarily represent real-world emissions, and are not necessarily directly comparable, so this method relies on broad equivalencies only.

Japan's "*Post New Long-Term Emissions Standards*" have applied to all new light-duty vehicles since 2010. As shown in Table 3 and Table 4, these standards are broadly equivalent to Euro 5 and Euro 6 standards for petrol vehicles, and Euro 5 standards for diesel vehicles.

Table 3: Comparison of Japanese and European emission standards for year of manufacture >2009; passenger cars

Vehicle type	Emission standard	Date	Test cycle	CO g/km	NMHC g/km	NO_X g/km	PM g/km
Petrol passenger car	Euro 5	2011[a]	NEDC	1.0	0.068	0.06	0.005[b]
	Euro 6	2014[c]	NEDC	1.0	0.068	0.06	0.005[b]
	Euro 6	2018[d]	WLTC				
Petrol passenger car	Japan's Post New Long Term Stds	2009	JC08	1.15	0.05	0.05	0.005[e]
		2018	WLTC	1.15	0.1	0.05	0.005[e]
Diesel passenger car	Euro 5	2011[a]	NEDC	0.5	-	0.18	0.005[e]
	Euro 6	2014[c]	NEDC	0.5	-	0.08	0.005
	Euro 6	2018[d]	WLTC				
Diesel passenger car >1250kg	Japan's Post New Long Term Stds	2010[f]	JC08	0.63	0.024	0.08	0.005
		2019	WLTC	0.63	0.024	0.15	0.005

Source: Dieselnet.com

Note: JC08 = Japanese transient emission test cycle introduced in 2005 for light duty vehicles; WLTC = World Harmonised Light Vehicle Test Cycle; NEDC = New European Driving Cycle; CO = carbon monoxide; NMHC = non methane hydrocarbons; NOx = nitrogen oxides; PM = particulate matter.
a. 2011.01 for all models
b. applicable only to vehicles using direct injection (DI) engines
c. 2014.09
d. all vehicles from 2018.09
e. From 2009, PM values apply only to vehicles with lean-burn DI gasoline engines equipped with NOx adsorber catalysts; from 2020, PM values apply to all vehicles with DI gasoline engines, including stoichiometric DI vehicles
f. 2010.09 for all models

Table 4: Comparison of Japanese and European emission standards for year of manufacture >2009; light commercials

Vehicle type	Emission standard	Date	Test cycle	CO g/km	NMHC g/km	NO_X g/km	PM g/km
Petrol LCV > 1760kg	Euro 5	2012[a]	NEDC	2.27	0.108	0.082	0.005[b]
	Euro 6	2015[c]	NEDC	0.74	0.108	0.082	0.005[b]
	Euro 6	2018[d]	WLTC				
Petrol LCV >1700kg	Japan's Post New Long Term Stds	2009	JC08	2.55	0.05	0.07	0.007[e]
		2019	WLTC	2.55	0.15	0.07	0.007[e]
Diesel LCV > 1760kg	Euro 5	2012[a]	NEDC	0.74	-	0.28	0.005
	Euro 6	2015[b]	NEDC	0.74	-	0.125	0.005
	Euro 6	2019[f]	WLTC				
Diesel LCV >1700kg	Japan's Post New Long Term Stds	2010[e]	JC08	0.63	0.024	0.15	0.007
		2019	WLTC	0.63	0.024	0.24	0.007

Source: Dieselnet.com

Note: JC08 = Japanese transient emission test cycle introduced in 2005 for light duty vehicles; WLTC = World Harmonised Light Vehicle Test Cycle; NEDC = New European Driving Cycle; CO = carbon monoxide; NMHC = non methane hydrocarbons; NOx = nitrogen oxides; PM = particulate matter.
a. 2012.01 for all models
b. applicable only to vehicles using direct injection (DI) engines
c. 2015.09
d all vehicles from 2019.09
e. From 2009, PM values apply only to vehicles with lean-burn DI gasoline engines equipped with NOx adsorber catalysts; from 2020, PM values apply to all vehicles with DI gasoline engines, including stoichiometric DI vehicles
f. all vehicles from 2020.09

The Worldwide Harmonized Light Vehicles Test Procedure (**WLTP**) has been used for all vehicles from 2018 in Europe, and from 2019 in Japan. From 2018, European test requirements have also included in service conformity testing based on in-use vehicle **PEMS** (portable emissions monitoring system) testing. Japan plans to begin implementing in service conformity testing in October 2022, and to fully implement requirements by October 2024[8].

3.2 Calculating social costs of vehicle emissions

The social costs associated with emissions of $PM_{2.5}$ and NO_X were estimated using the New Zealand urban damage costs, as shown in Table 1, based on the findings of HAPINZ 3.0 (Kuschel e*t al* 2022).

3.3 Assigning star ratings

Air pollution star ratings were assigned based on relative social costs ($/km) estimated for each vehicle category.

The distribution of vehicle emissions (and associated social costs) follows a *decay* rather than linear curve (as seen in Figure 1). Our analysis found that the relative social costs (ranked from highest to lowest) naturally fell into distinct clusters that could then be assigned to the star ratings shown.

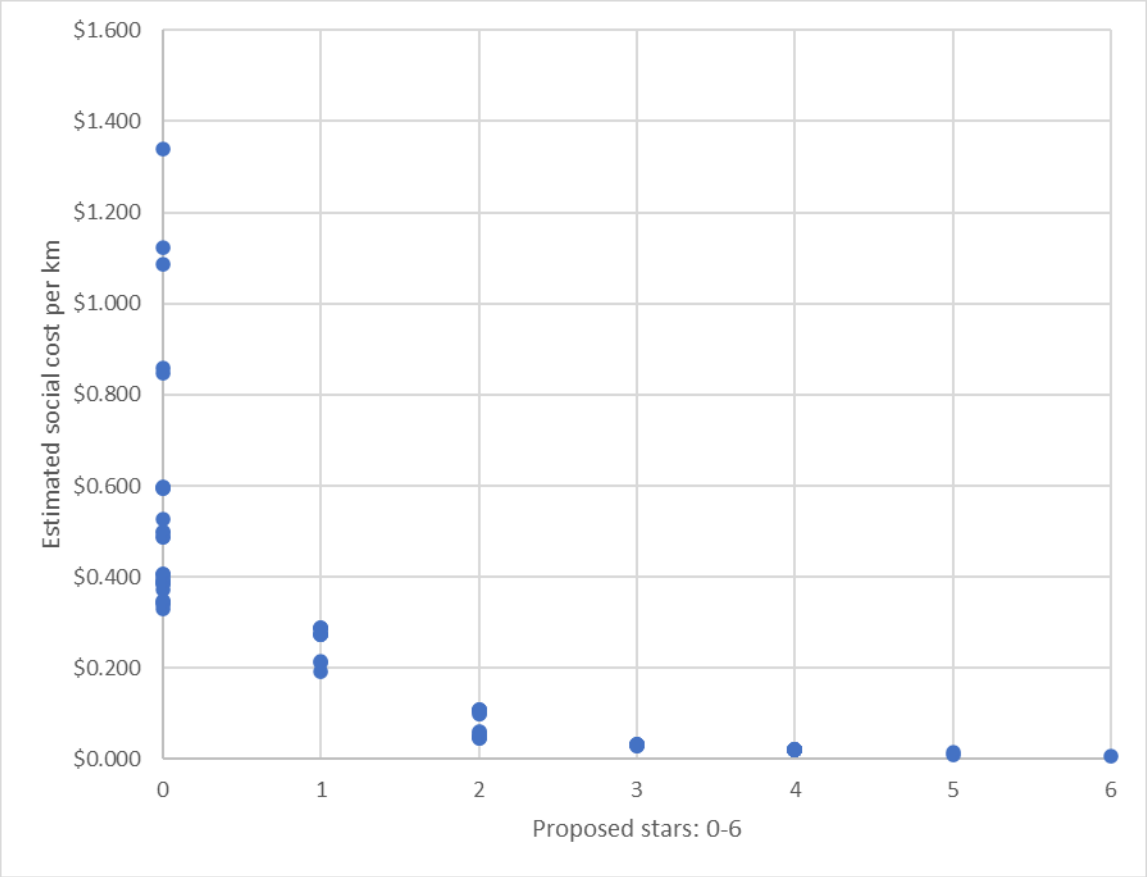

Figure 1: Estimated social cost ($/km) versus proposed star ratings for all vehicles assessed

[8] https://unece.org/DAM/trans/doc/2018/wp29grpe/GRPE-76-18e.pdf

While all vehicle categories with 3 stars to 6 stars have very low emissions relative to older, high emission vehicle types, these still show clear separation for the different star ratings when looked at in detail (shown in Figure 2).

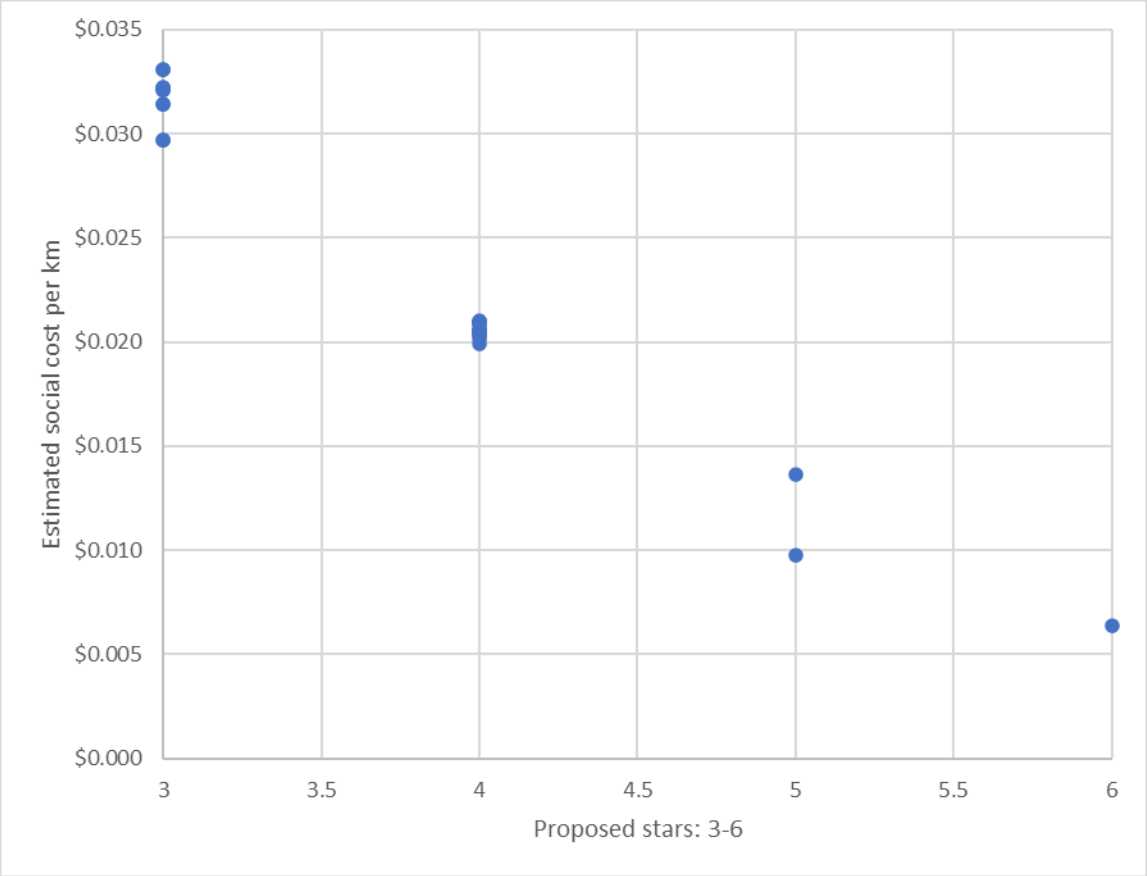

Figure 2: Estimated social cost ($/km) versus proposed star ratings for only the 3 to 6 star vehicles assessed

In general terms, the ratings apply to the following vehicle categories:

- 6 stars: Electric vehicles (which have brake and tyre wear emissions only)
- 5 stars: Petrol hybrid and petrol plug-in hybrid vehicles
- 4 stars: Euro 5 and Euro 6 petrol vehicles (and Japanese equivalent)
- 3 stars: Euro 6d diesel cars and Euro 4 petrol vehicles (and Japanese equivalent)
- 2 stars: Euro 6d diesel light commercial vehicles and Euro 3 or Euro 2 petrol vehicles (and Japanese equivalent)
- 1 star: Euro 5 or Euro 4 diesel cars, Euro 1 petrol cars (and Japanese equivalents)
- 0 star: Most diesel light commercial vehicles, older diesel cars and older petrol vehicles

Figure 3 provides an indication of the proportion of the light fleet travel which would be assigned each star rating, based on estimated vehicle kilometres travelled in 2022 for each category in VEPM 6.3[9]. This shows that relatively few vehicles will be assigned 0 or 1 star.

[9] The proportion of *vehicle kilometres travelled* assigned to each vehicle category is not the same as the proportion of *vehicles* in each category because newer vehicles tend to travel further.

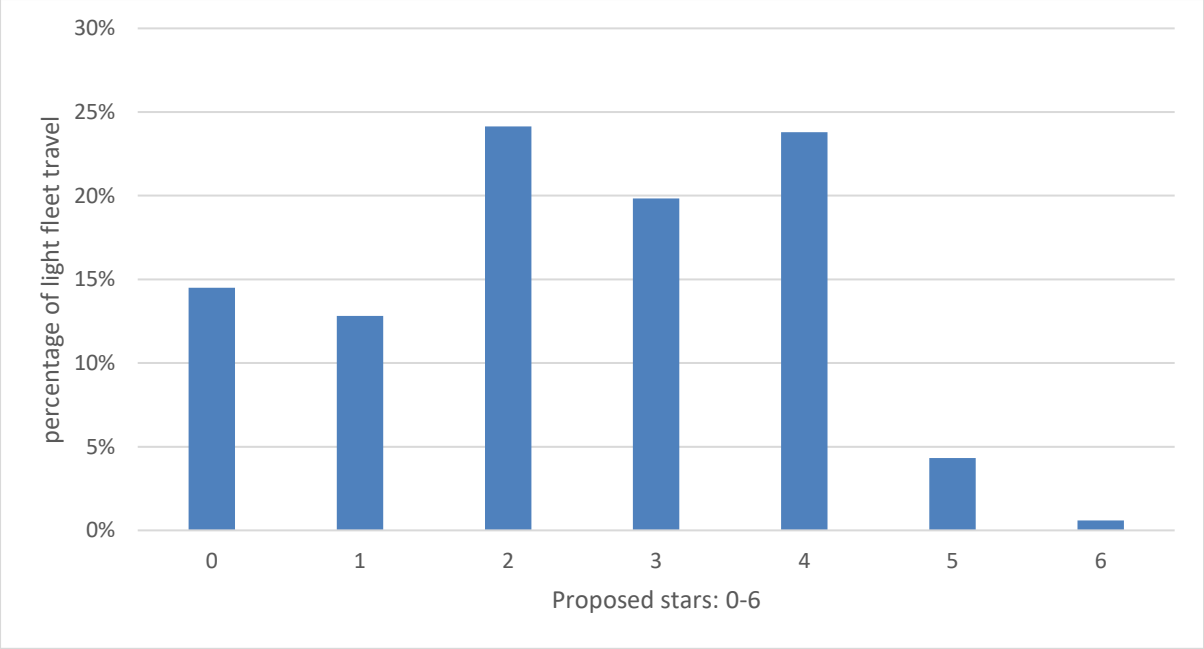

Figure 3: Estimated percentage of light fleet travel by vehicles in each star category assuming the VEPM 6.3 fleet in 2022

Details of the vehicle categories assigned to each star category are provided in the accompanying Excel workbook - *Rightcar_AP rating_final.xlsx.*

3.4 Undertaking sensitivity analyses

We also assessed whether the rankings were sensitive to assumptions about speed and degradation. The sensitivity analyses are provided in a separate Excel workbook - *Rightcar_AP rating_sensitivity analyses.xlsx*.

3.4.1 Speed

Emission factors were estimated at 20 km/hour and 100 km/hour.

For nearly all vehicle categories, we confirmed that the vehicle would still be assigned the same star rating (as for 50 km/hour) based on the 20km/hour or 100km/hour emission factors. The only exceptions were:

- The petrol hybrid vehicle (5 star) category has a $0.001/km higher social cost compared with some (4 star) petrol cars at 100 km/hour. However, we considered it appropriate for these vehicles to be assigned to the 3 star category based on their lower social costs at lower speeds[10].

- Euro 4 and Japanese 05 light commercial petrol vehicles (assigned to the 3 star category) have a $0.001/km higher estimated social cost compared with some (2 star) petrol cars at 100 km/hour. However, we considered it appropriate for these vehicles to be assigned to the 3 star category based on their lower social costs at lower speeds[11].

[10] For example, at 50 km/hour the estimated social cost is $0.006/km lower than the best 4 star category vehicle.

[11] For example, at 50 km/hour the estimated social cost is $0.014/km lower than the best 2 star category vehicle.

3.4.2 Degradation

To test the impact of degradation, emission factors were generated with the degradation option in VEPM set to "*yes*" and the distribution of the results (outlined in section 3.2) was re-assessed.

Accounting for degradation changed the relative social costs ranking of some vehicles, particularly new vehicles with assumed low mileage. However, we confirmed that all vehicles would be assigned to the same star category with or without consideration of degradation, with only one exception. The social costs for Euro 6d diesel cars (initially rated as 3 stars) matched costs for some vehicles assigned 4 stars, if degradation was included for all vehicles.

However, we do not recommend including degradation in the ratings at this stage because:

- The degradation impacts in VEPM 6.3 for new vehicles are estimated from limited actual data and are likely to be updated in the near future (Metcalfe & Peeters 2022).
- Mileage would need to be incorporated into the ratings as an additional parameter, which would unnecessarily complicate the system.

Note: We have recommended text for the Rightcar website which states that the ratings tell you how much pollution your vehicle emitted when it was first manufactured, i.e. brand new.

3.4.3 Conclusions

The sensitivity analyses confirm that the air pollution star ratings are not materially affected by assumptions about speed and degradation.

3.5 Estimating likely ratings for future technologies

In our approach, we assigned air pollution ratings to vehicle categories present in appreciable numbers in the New Zealand fleet. However, there are certain vehicle types that are currently absent from our fleet that are likely to appear in future, in particular:

- Petrol hybrid/PHEV vans and utes
- Electric vans and utes
- Petrol and diesel Euro 7 light vehicles.

For completeness, we included air pollution rating estimates for these future technology vehicles, based on the following assumptions:

- Petrol hybrid/PHEV vans and utes were assumed to have the same rating as petrol hybrid/PHEV cars and SUVs, i.e. 5 stars.
- Electric vans and utes were assumed to have the same rating as electric cars and SUVs, i.e. 6 stars.
- In the case of Euro 7 light vehicles, we estimated the likely rating based on the changes in the standard *limits* for PM and NO_X going from Euro 6d to Euro 7, in the absence of *real-world* emissions data. Euro 7 is not due to be implemented in Europe until 1 July 2025. Given Euro 6 is yet to be required for vehicles entering the fleet in New Zealand, Euro 7 implementation here will be several years after Europe. Consequently, the ratings we have developed for Euro 7 light vehicles are indicative only.

4.0 Comparison with proposed CO_2/fuel consumption ratings

Ministry of Transport and Waka Kotahi have developed a proposed star rating system for carbon dioxide (CO_2) emissions and fuel consumption to align with Clean Car policies. We reviewed their proposed rating system to ensure consistency with our proposed star rating system for air pollution.

4.1 Official versus real-world emissions

The proposed CO_2 ratings are derived on *official type-approval* emissions values, based on emissions tests undertaken in accordance with the three phase Worldwide Harmonised Light Vehicle Test Procedure (3P-WLTP). Where WLTP values are not available, the available type-approval results (e.g. NEDC values) are converted to the WLTP equivalent.

The proposed approach for CO_2 and fuel consumption differs from our proposed approach for air pollution, which is based on *estimated real-world* emissions from VEPM.

It is widely recognised that there is a gap between official test results and real-world emissions. Although the recent switch from the New European Driving Cycle (NEDC) to the Worldwide Harmonised Light Vehicles Test Procedure (WLTP) will likely reduce the gap between official and real-world fuel consumption and CO_2 emissions values, there are indications that a substantial divergence could remain in the future.

Emission models such as VEPM do not provide CO_2 or fuel consumption estimates that are suitable for consumers because vehicles are grouped into broad categories. There will be substantial differences in vehicle fuel consumption within these categories.

Databases of real-world fuel-consumption estimates for individual vehicle makes and models of vehicles have been developed internationally[12]. However, real-world fuel consumption estimates are not currently available for the diverse range of vehicles in the New Zealand fleet. The proposed star rating system for fuel consumption, which is based on 3P-WLTP type-approval tests, is currently the best available option.

4.2 Assigning star ratings

The proposed CO_2 rating system assigns stars on a *linear* basis between 0 and 300 gCO_2/km, with non-zero emission vehicles having their rating capped at 5.5 stars. Electric vehicles are allocated 6 stars and all vehicles emitting 300 gCO_2/km or more assigned a rating of zero stars. Fuel consumption star ratings will be calculated to be equivalent to the CO_2 star rating (using conversion factors designated in the Clean Car Standard).

Calculation of stars based on CO_2 emissions has been proposed because it is objective (as opposed to the current system which is somewhat arbitrary).

By comparison, our proposed air pollution star rating system is based on an assessment of the relative social costs of vehicle emissions, according to the vehicle type, fuel and emissions standard. A formula to directly assign air pollution ratings is not considered practical at this stage.

[12] For example the ICCT Find a car (mile21.eu)

5.0 Summary and recommendations

We developed an updated Air Pollution Star Ratings for new and used vehicles by taking manufacturers' emissions standards, matching real-world emission estimates for each vehicle type and then estimating the emissions-related health impacts. A rating (from 1 star to 6 stars) was then applied to the results, with electric vehicles getting 6 stars and other vehicles getting ranked based on the health costs of their emissions impact.

Table 5 summarises the updated air pollution rating system.

Table 5: Updated air pollution star ratings assigned to the indicated exhaust emissions standard

Vehicle type	Rating (stars)	Petrol emission standard		Diesel emission standard		Other
		NZ new	Jap used	NZ new	Jap used	
Car and SUV	0	Pre-Euro 1		Euro 3 & earlier	Jap 2004 & earlier	
	1	Euro 1		Euro 4 & Euro 5	Jap 2005 to 2018	
	2	Euro 2 & Euro 3	Jap 2002 & earlier			
	3	Euro 4	Jap 2005 & 2005d	Euro 6d		
	4	Euro 5 to *Euro 7*	Jap 2009 & 2018	*Euro 7*		
	5	Hybrid/PHEV	Hybrid/PHEV			
	6					EV
Van and ute	0	Euro 1 & earlier		Euro 5 & earlier	Jap 2018 & earlier	
	1					
	2	Euro 2 & Euro 3	Jap 2002 & earlier	Euro 6d		
	3	Euro 4	Jap 2005 & 2005d	*Euro 7*		
	4	Euro 5 to *Euro 7*	Jap 2009 to 2018			
	5	Hybrid/PHEV	Hybrid/PHEV			
	6					EV

EV = electric vehicle, PHEV = plug-in hybrid vehicle, SUV = sports utility vehicle (e.g. 4WD)

Note: The ratings for Euro 7 are indicative only and have been included for completeness. They are based on the changes in the standard *limits* for PM and NO_X going from Euro 6d to Euro 7, in the absence of real-world emissions data as Euro 7 is not due to be implemented until 1 July 2025 in Europe. Euro 6 is yet to be required for vehicles entering the fleet in New Zealand so Euro 7 implementation here will be several years after Europe.

Adding these revised Air Pollution Ratings to the Rightcar website provides further choice and encouragement to consumers who want (and are able) to minimise harm to the environment and to the community through their choice of vehicle.

In terms of implementation, vehicles can be allocated star ratings according to the emissions standards shown in Table 5, assuming this information is available from the motor vehicle register. For vehicles with missing emissions standards codes, year of manufacture can be used to identify the likely emission standards and the appropriate star rating. For details, refer to the accompanying Excel workbook - *Rightcar_AP rating_final.xlsx.*

A set of responses has also been drafted to assist with answering frequently asked questions – both general and technical/industry specific – when the new rating system is launched. These are available in Appendix B.

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Appendix A: Japanese European equivalence table

This appendix tabulates the assumed Japanese European equivalencies utilised in our assessment (see Table 6 overleaf).

Notes:

- Up to 2010, the "*Japan Standard*" column relates to emission categories in the JCAP Japanese emission model, based on year of manufacture, as described in the VEPM development report (EFRU 2008).
- From 2010, the "*Japan Standard"* refers to the closest equivalent European standard that is assumed based on comparison of emission standards and test requirements (Metcalfe & Peeters 2022)
- For methane (**CH_4**) and nitrous oxide (**N_2O**), equivalencies are the same as volatile organic compounds (**VOC**) and NO_X respectively.
- The "*tech*" column shows the technology sub-category, which is specified in the EMEP/EEA emission factors. These are:
    - **PFI**: port fuel injection
    - **GDI**: gasoline direct injection
    - **DPF**: diesel particulate filter – a PM emission control system
    - **EGR**: exhaust gas recirculation – a NO_X emission control system
    - **SCR**: selective catalytic reduction – a NO_X emission control system

The proposed Rightcar air pollution ratings are provided in an Excel workbook - *Rightcar_AP rating_final.xlsx*.

The sheets "*Petrol Japan codes*" and "*Diesel Japan codes*" show which individual emission codes are assigned to which **overarching Japanese emission standard** (e.g. Japan 09 petrol). This information was provided by Ministry of Transport.

Star ratings are assigned to the **overarching Japanese emission standard** in the "*Ratings*" worksheet. These are assigned based on social costs, which are calculated based on estimated emissions of NO_X and PM per km. The emission rates are derived from the Waka Kotahi Vehicle Emission Prediction Model (VEPM).

Table 6: Japanese European assumed equivalencies

Category	Fuel Type	Segment	Japan Standard	CO Standard	CO Tech	VOC Standard	VOC Tech	NOx Standard	NOx Tech	PM Standard	PM Tech	EC Standard	EC Tech
CAR	Petrol	Small	Pre 1973, J73	PRE ECE	-	PRE ECE	-	PRE ECE	-	PRE ECE	-	PRE ECE	-
CAR	Petrol	Medium	Pre 1973, J73	PRE ECE	-	PRE ECE	-	PRE ECE	-	PRE ECE	-	PRE ECE	-
CAR	Petrol	Large-SUV-Executive	Pre 1973, J73	PRE ECE	-	PRE ECE	-	PRE ECE	-	PRE ECE	-	PRE ECE	-
CAR	Petrol	Small	J75, J76	Euro 1	-	Euro 1	-	PRE ECE	-	Euro 1	-	Euro 1	-
CAR	Petrol	Medium	J75, J76	Euro 1	-	Euro 1	-	PRE ECE	-	Euro 1	-	Euro 1	-
CAR	Petrol	Large-SUV-Executive	J75, J76	Euro 1	-	Euro 1	-	PRE ECE	-	Euro 1	-	Euro 1	-
CAR	Petrol	Small	J78	Euro 1	-	Euro 1	-	Euro 1	-	Euro 1	-	Euro 1	-
CAR	Petrol	Medium	J78	Euro 1	-	Euro 1	-	Euro 1	-	Euro 1	-	Euro 1	-
CAR	Petrol	Large-SUV-Executive	J78	Euro 1	-	Euro 1	-	Euro 1	-	Euro 1	-	Euro 1	-
CAR	Petrol	Small	J78, J88	Euro 1	-	Euro 2	-	Euro 2	-	Euro 2	-	Euro 2	-
CAR	Petrol	Medium	J78, J88	Euro 1	-	Euro 2	-	Euro 2	-	Euro 2	-	Euro 2	-
CAR	Petrol	Large-SUV-Executive	J78, J88	Euro 1	-	Euro 2	-	Euro 2	-	Euro 2	-	Euro 2	-
CAR	Petrol	Small	J00	Euro 3	PFI	Euro 3	PFI	Euro 3	PFI	Euro 3	PFI	Euro 3	PFI
CAR	Petrol	Medium	J00	Euro 3	PFI	Euro 3	PFI	Euro 3	PFI	Euro 3	PFI	Euro 3	PFI
CAR	Petrol	Large-SUV-Executive	J00	Euro 3	PFI	Euro 3	PFI	Euro 3	PFI	Euro 3	PFI	Euro 3	PFI
CAR	Petrol	Small	J05	Euro 4	PFI	Euro 4	PFI	Euro 4	PFI	Euro 4	PFI	Euro 4	PFI
CAR	Petrol	Medium	J05	Euro 4	PFI	Euro 4	PFI	Euro 4	PFI	Euro 4	PFI	Euro 4	PFI
CAR	Petrol	Large-SUV-Executive	J05	Euro 4	PFI	Euro 4	PFI	Euro 4	PFI	Euro 4	PFI	Euro 4	PFI
CAR	Petrol	Small	Euro 5	Euro 5	PFI	Euro 5	PFI	Euro 5	PFI	Euro 5	PFI	Euro 5	PFI
CAR	Petrol	Medium	Euro 5	Euro 5	PFI	Euro 5	PFI	Euro 5	PFI	Euro 5	PFI	Euro 5	PFI
CAR	Petrol	Large-SUV-Executive	Euro 5	Euro 5	PFI	Euro 5	PFI	Euro 5	PFI	Euro 5	PFI	Euro 5	PFI
CAR	Petrol	Small	Euro 6 a/b/c	Euro 6 a/b/c	PFI	Euro 6 a/b/c	PFI	Euro 6 a/b/c	PFI	Euro 6 a/b/c	PFI	Euro 6 a/b/c	PFI
CAR	Petrol	Medium	Euro 6 a/b/c	Euro 6 a/b/c	PFI	Euro 6 a/b/c	PFI	Euro 6 a/b/c	PFI	Euro 6 a/b/c	PFI	Euro 6 a/b/c	PFI
CAR	Petrol	Large-SUV-Executive	Euro 6 a/b/c	Euro 6 a/b/c	PFI	Euro 6 a/b/c	PFI	Euro 6 a/b/c	PFI	Euro 6 a/b/c	PFI	Euro 6 a/b/c	PFI
CAR	Petrol	Small	Euro 6 d	Euro 6 d	PFI	Euro 6 d	PFI	Euro 6 d	PFI	Euro 6 d	PFI	Euro 6 d	PFI
CAR	Petrol	Medium	Euro 6 d	Euro 6 d	PFI	Euro 6 d	PFI	Euro 6 d	PFI	Euro 6 d	PFI	Euro 6 d	PFI
CAR	Petrol	Large-SUV-Executive	Euro 6 d	Euro 6 d	PFI	Euro 6 d	PFI	Euro 6 d	PFI	Euro 6 d	PFI	Euro 6 d	PFI
CAR	Diesel	Medium	Pre 1986	Conventional	-	Conventional	-	Euro 1	-	Conventional	-	Conventional	-
CAR	Diesel	Large-SUV-Executive	Pre 1986	Conventional	-	Conventional	-	Euro 1	-	Conventional	-	Conventional	-
CAR	Diesel	Medium	J86	Euro 1	-	Euro 2	-	Euro 1	-	Conventional	-	Euro 1	-
CAR	Diesel	Large-SUV-Executive	J86	Euro 1	-	Euro 2	-	Euro 1	-	Conventional	-	Euro 1	-
CAR	Diesel	Medium	J92, J94	Euro 1	-	Euro 2	-	Euro 3	DPF	Conventional	-	Euro 1	-
CAR	Diesel	Large-SUV-Executive	J92, J94	Euro 1	-	Euro 2	-	Euro 3	DPF	Conventional	-	Euro 1	-
CAR	Diesel	Medium	J98	Euro 1	-	Euro 2	-	Euro 3	DPF	Euro 1	-	Euro 1	-
CAR	Diesel	Large-SUV-Executive	J98	Euro 1	-	Euro 2	-	Euro 3	DPF	Euro 1	-	Euro 1	-
CAR	Diesel	Medium	J02	Euro 1	-	Euro 2	-	Euro 3	DPF	Euro 3	DPF	Euro 1	-
CAR	Diesel	Large-SUV-Executive	J02	Euro 1	-	Euro 2	-	Euro 3	DPF	Euro 3	DPF	Euro 1	-
CAR	Diesel	Medium	J05	Euro 3	DPF	Euro 4	DPF	Euro 4	DPF	Euro 4	DPF	Euro 3	DPF
CAR	Diesel	Large-SUV-Executive	J05	Euro 3	DPF	Euro 4	DPF	Euro 4	DPF	Euro 4	DPF	Euro 3	DPF

Category	Fuel Type	Segment	Japan Standard	CO Standard	CO Tech	VOC Standard	VOC Tech	NOx Standard	NOx Tech	PM Standard	PM Tech	EC Standard	EC Tech
CAR	Diesel	Medium	Euro 5	Euro 5	DPF	Euro 5	DPF	Euro 5	DPF	Euro 5	DPF	Euro 5	DPF
CAR	Diesel	Large-SUV-Executive	Euro 5	Euro 5	DPF	Euro 5	DPF	Euro 5	DPF	Euro 5	DPF	Euro 5	DPF
LCV	Petrol	N1-III	J73, J75, J79	Conventional	-	Conventional	-	Conventional	-	Conventional	-	Conventional	-
LCV	Petrol	N1-III	J79, J81	Euro 1	-	Conventional	-	Euro 1	-	Conventional	-	Conventional	-
LCV	Petrol	N1-III	J88	Euro 1	-	Euro 1	-	Euro 2	-	Euro 1	-	Euro 1	-
LCV	Petrol	N1-III	J01	Euro 3	PFI	Euro 3	PFI	Euro 3	PFI	Euro 3	PFI	Euro 3	PFI
LCV	Petrol	N1-III	J05	Euro 4	PFI	Euro 4	PFI	Euro 4	PFI	Euro 4	PFI	Euro 4	PFI
LCV	Petrol	N1-III	Euro 5	Euro 5	PFI	Euro 5	PFI	Euro 5	PFI	Euro 5	PFI	Euro 5	PFI
LCV	Diesel	N1-III	Pre 1974, J74	Conventional	-	Euro 1	-	Conventional	-	Euro 1	-	Conventional	-
LCV	Diesel	N1-III	J77, J79	Conventional	-	Euro 1	-	Euro 1	-	Euro 1	-	Conventional	-
LCV	Diesel	N1-III	J82, J83, J87	Conventional	-	Euro 1	-	Euro 3	DPF	Euro 1	-	Conventional	-
LCV	Diesel	N1-III	J88	Euro 1	-	Euro 3	DPF	Euro 3	DPF	Euro 1	-	Euro 1	-
LCV	Diesel	N1-III	J93	Euro 1	-	Euro 3	DPF	Euro 3	DPF	Euro 3	DPF	Euro 1	-
LCV	Diesel	N1-III	J97, J03	Euro 1	-	Euro 3	DPF	Euro 4	DPF	Euro 3	DPF	Euro 1	-
LCV	Diesel	N1-III	J05	Euro 3	DPF	Euro 4	DPF	Euro 4	DPF	Euro 4	DPF	Euro 3	DPF
LCV	Diesel	N1-III	Euro 5	Euro 5	DPF	Euro 5	DPF	Euro 5	DPF	Euro 5	DPF	Euro 5	DPF

Appendix B: Frequently asked questions

This appendix summarises responses drafted to assist with answering frequently asked questions – both general and technical/industry specific.

B.1 General FAQs

Q. Are the Air Pollution Ratings for cars a new initiative?

Air Pollution Ratings, based solely on manufacturers' information, have been available for new cars previously.

Q. What methodology and contributing factors are used to estimate the updated ratings?

The updated Air Pollution Star Ratings for new and used vehicles have been developed by taking manufacturers' emissions ratings, matching real-world emission estimates for each vehicle type and then estimating the emissions-related health impacts.

A rating (from 1 star to 6 stars) is applied to the results. Electric vehicles score 6 stars and other vehicles get fewer stars, depending on the health costs of their emissions impact. The health costs are based on the latest Health and Air Pollution in New Zealand (HAPINZ 3.0) study.

Q. Why are these ratings being updated?

The Air Pollution Star Ratings are being updated to reflect new information we now have on the effect of vehicle emissions (and other sources of air pollution) on the health of New Zealanders.

The HAPINZ 3.0 study – which found much greater health effects of vehicle emissions than previously thought, especially due to nitrogen dioxide (NO_2). The significant health impacts of these emissions provided impetus to raise the profile and importance of Air Pollution Star Ratings and the new findings enabled used vehicles to also be rated using the same system.

Q. What research underpins these ratings?

The HAPINZ 3.0 study built on previous work first conducted for 2001 (HAPINZ 1.0) and then updated for 2006 (HAPINZ 2.0). However, in HAPINZ 3.0 researchers were able, for the first time, to assess the impacts not only of fine particles ($PM_{2.5}$) but also NO_2 (which is particularly important for vehicle emissions).

The HAPINZ 3.0 study used air quality monitoring, population, and health data to establish the impact of air pollution on the health of New Zealanders.

Q. Why are we using findings from a study based on 2016 data?

HAPINZ 3.0 used a base year of 2016 because that was the most recent year for a complete set of suitable air quality, population and health data when the study got underway.

Air quality data typically become available within one to two years of the end of a calendar year, but health data on hospitalisations and deaths can lag by three or more years.

Q. What did HAPINZ 3.0 find?

The HAPINZ 3.0 study found that in 2016 alone, vehicle emissions contributed to:

- more than 2,200 premature deaths in New Zealand
- over 13,000 cases of asthma in our children
- and costs to the economy of more than $10.5 billion.

Given the implications of the findings, the study underwent rigorous peer-review by three international air quality experts. The peer reviewers concluded that the study findings were robust and that the magnitude of the NO_2 effects relating to vehicle emissions were genuine.

Q. Who funded and conducted this research?

The HAPINZ 3.0 study was jointly funded by the Ministry for the Environment, Waka Kotahi NZ Transport Agency, Te Manatū Waka Ministry of Transport, and Manatū Hauora Ministry of Health. Regional Councils were represented in the research steering group and supplied air quality data.

The study was undertaken over three years by a team of New Zealand researchers in air quality, health, economics and messaging.

Q. What is the relationship between greenhouse gas emissions and vehicle air pollution and why should we be concerned about reducing both?

- Diesel and petrol combustion contributes to both greenhouse gas emissions (GHG) emissions and air pollution. GHG emissions from vehicles include primarily carbon dioxide (CO_2) and some nitrous oxide (N_2O). Air pollution from the same source includes fine particles ($PM_{2.5}$) and nitrogen dioxide (NO_2).
- When we deliver better transport choices for everyone in Aotearoa New Zealand, we can reduce both greenhouse and harmful emissions and contribute to more vibrant, resilient and prosperous places to live, work and visit.
- Emissions from the use of fossil fuels are contributing to the global climate change. Rising sea levels, more frequent flooding, coastal and inland erosion, and drought are just some of the impacts we are already seeing.
- The collective action we take now to reduce our vehicle emissions reduces the future impacts of climate change and leads to cleaner air, healthier communities, and a more sustainable economy.
- Reducing emissions is a domestic legislative requirement and an international obligation.
- In New Zealand, motor vehicles are responsible for most of the harm (approximately two thirds) caused by human-made air pollution.
- Motor vehicles dominate the health impacts associated with nitrogen dioxide (NO_2) and are also responsible for 17 percent of the health impacts of fine particles ($PM_{2.5}$) in the air we breathe.
- In 2016 alone, vehicle emissions contributed to:
    - more than 2,200 premature deaths in New Zealand
    - over 13,000 cases of asthma in our children
    - and costs to the economy of more than $10.5 billion.

B.2 Technical and Industry specific FAQs

Q. Do these ratings mandate action by car retailers?

No. These Air Pollution Star Ratings are primarily for information only.

Q. Why are the Air Pollution Star Ratings different to the Carbon Emissions Star Ratings for some vehicles?

The two rating systems represent different environmental impacts.

The Carbon Emissions Star Ratings indicate the amount of greenhouse gas emissions (**GHG**) released by a vehicle based on its fuel consumption. GHG emissions have a global impact and contribute to climate change. The primary GHG is carbon dioxide (**CO_2**). The amount of greenhouse gases emitted depends on the vehicle fuel type, engine size and its efficiency.

The Air Pollution Star Ratings are a measure of the health effects from air pollution released by a vehicle based on its emissions performance. Air pollution has a local impact and causes adverse health effects in people exposed. The primary air pollutant in vehicle exhausts is nitrogen dioxide (**NO_2**) but there is also a contribution from fine particles (**$PM_{2.5}$**). The amount of harmful air pollution emitted depends also on the fuel type and engine size but is strongly influenced by the emission control equipment installed on the vehicle (e.g. whether it has a catalytic converter or particle filter).

Q. Why have some vehicles' Air Pollution ratings decreased but their Carbon emissions remained the same?

New research from the HAPINZ 3.0 study has revealed significant detrimental health impacts from nitrogen dioxide (NO_2), a primary air pollution by-product of fuel combustion. This is now considered in the calculation of air pollution ratings. So, while a vehicle may perform well in terms of its carbon emissions, it may not perform well with NO_2 containing exhaust.

Q. Why do diesel vehicles get a lower Air Pollution rating than petrol vehicles even if they meet the same exhaust emissions standard (i.e they both meet Euro 5)?

Petrol and diesel engines emit pollutants in different amounts due to differences in the fuel and the engine technology. Diesel vehicles typically release more nitrogen dioxide (**NO_2**) and fine particles (**$PM_{2.5}$**) than petrol vehicles of the same size, even if emission control equipment (e.g. catalytic converters and particle filters) is installed.

The exhaust emissions standards (e.g. Euro 5) set **maximum** allowable limits for individual pollutants in grammes per kilometre and are usually the same regardless of fuel type. However, when driven in real-world conditions, some vehicles (e.g. petrol vehicles) meet the maximum limits more easily than others so their **actual** emissions are much lower.

The updated Air Pollution Star Ratings for new and used vehicles were developed by taking manufacturers' emissions ratings (i.e. the exhaust emissions standards) and then matching real-world emission estimates for each vehicle type to get the actual emissions for each vehicle based on typical driving. These emissions were then multiplied by damage costs (health costs per tonne) taken from the HAPINZ 3.0 study results.

Given the largest damage costs are for NO_2 and $PM_{2.5}$, the health costs for diesel vehicles are typically worse than those for petrol vehicles and so these diesels typically get fewer stars for air pollution.

Q. Will a lower Air Pollution Star Rating affect whether the vehicle can get a clean car discount?

No. The Air Pollution Star Ratings have no effect on the clean car discount or clean car standard.

Q. What can I do to reduce my air pollution effects if I want to buy a trade vehicle?

Air pollution impacts are affected by the size of the vehicle (engine size and vehicle mass) and its fuel type.

If you want to reduce your air pollution impacts the question to ask or decisions to make include:

- What is the smallest vehicle I need to do the job? Can I get away with a smaller engine version?
- Does it need to be able to tow trailers? Most hybrid vehicles are not suitable for towing so you if you need to do this then you will have to go with either a fossil fuel (petrol or diesel) or an electric model (if available).
- If towing isn't a requirement, the best vehicle fuel type for reducing air pollution is electric, followed by petrol-hybrid, followed by petrol and then finally diesel. However, your ability to opt for the lowest emitting option will depend on whether these fuel types are available for the model/requirements you are looking at as well as your available budget (some fuel types have a premium).

Overall, electric vehicles will give you the best ratings for both air pollution and carbon emissions.

Note: It is worth considering more than just the purchase price for your new vehicle as the running costs for some options (e.g. electric) are much lower so over time they may be more economic when looking at whole of vehicle life costs.