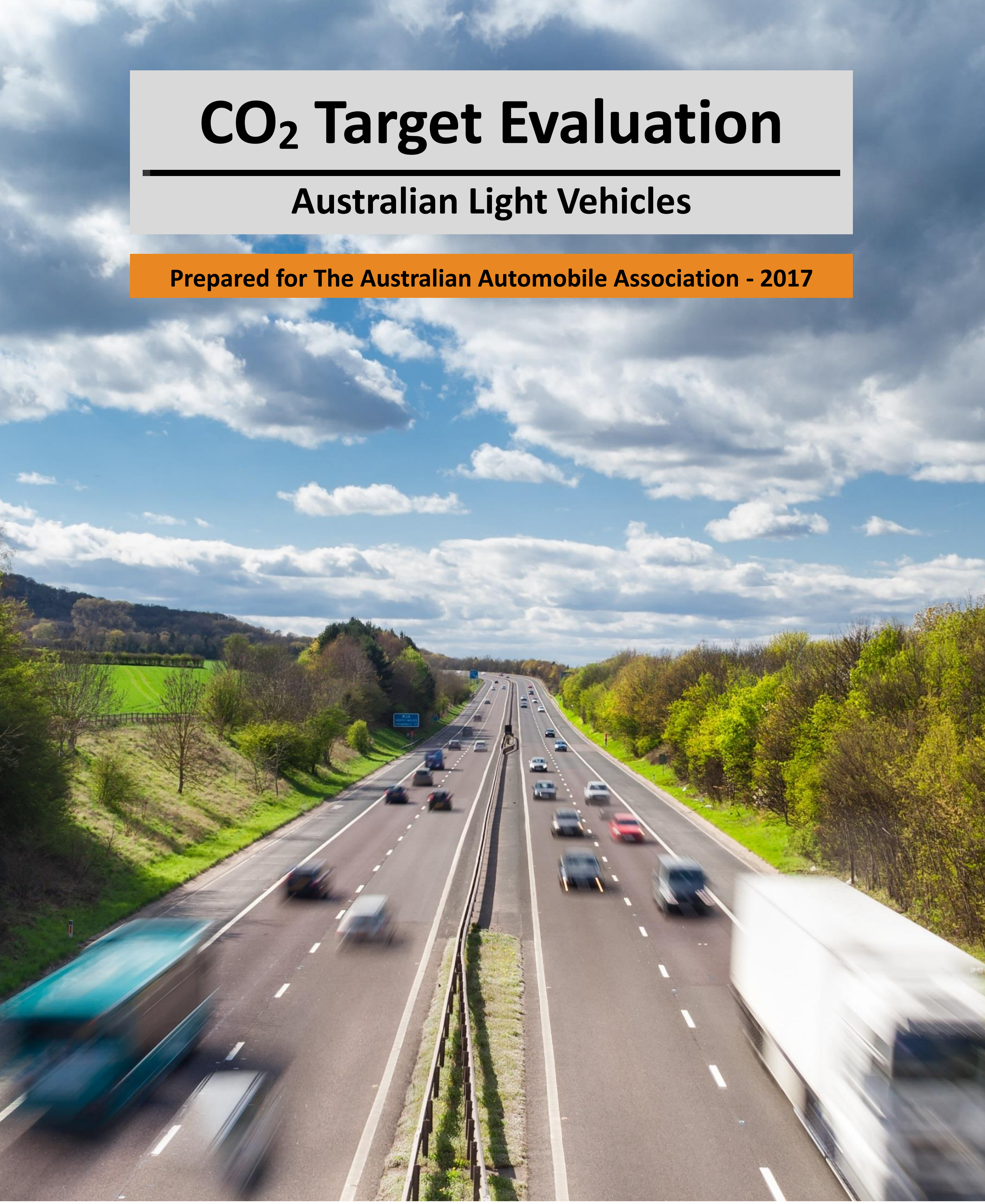


CO_2 Target Evaluation

Australian Light Vehicles

Prepared for The Australian Automobile Association - 2017

Phone: +61 3 9729 5129
Email: info@abmarc.com.au
Address: 7/51 Kalman Drive, Boronia, Victoria

www.abmarc.com.au

ABMARC

Australian Automobile Association

Disclaimer

By accepting this report from ABMARC you acknowledge and agree to the terms as set out below. This Disclaimer and denial of Liability will continue and shall apply to all dealings of whatsoever nature conducted between ABMARC and yourselves relevant to this report unless specifically varied in writing.

ABMARC has no means of knowing how the report's recommendations and or information provided to you will be applied and or used and therefore denies any liability for any losses, damages or otherwise as may be suffered by you as a result of your use of same.

Reports, recommendations made or information provided to you by ABMARC are based on extensive and careful research of information some of which may be provided by yourselves and or third parties to ABMARC. Information is constantly changing and therefore ABMARC accepts no responsibility to you for its continuing accuracy and or reliability. Our Reports are based on the best available information obtainable at the time but due to circumstances and factors out of our control could change significantly very quickly.

Care should be taken by you in ensuring that the report is appropriate for your needs and purposes and ABMARC makes no warranty that it is.

You acknowledge and agree that this Disclaimer and Denial of Liability extends to all Employees and or Contractors working for ABMARC.

You agree that any rights or remedies available to you pursuant to relevant Legislation shall be limited to the Laws of the State of Victoria and to the extent permitted by law shall be limited to such monies as paid by you for the relevant report, recommendations and or information.

© Eddie Cloud / Shutterstock.com

CO_2 Target Evaluation

Australian Light Vehicles

November 2017
For the Australian Automobile Association

ABMARC

www.abmarc.com.au

PHONE: +61 3 9729 5129
EMAIL: info@abmarc.com.au
ADDRESS: 7/51 Kalman Drive
Boronia, VIC, 3155

CONTENTS

EXECUTIVE SUMMARY

OVERVIEW

In 2016, a draft Regulation Impact Statement (RIS) on improving the efficiency of new light duty vehicles was issued by the Department of Infrastructure and Regional Development. The RIS included a series of potential CO_2 targets. On 10 July 2017, the Commonwealth Government distributed a proposed model utilising "Target A" to stakeholders for discussion. The implementation of the "Target A" model would require fleet average CO_2 emissions to be no more than 105 g/km by 2025.

Given the Australian fleet mix, which is considerably different to the European and USA fleet mixes, a number of industry and consumer organisations consider that Target A is not achievable in the nominated timeframe.

ABMARC has been commissioned by the AAA to:

- Identify and evaluate future CO_2 targets for new light duty vehicles, with associated mechanisms to enable their achievement,
- Model the impact of those targets on the composition of the vehicle fleet and
- Identify the segments that will incur any additional cost burden.

CO_2 TARGET DEVELOPMENT

Consideration was given to ensuring that the CO_2 targets developed in this work will allow consumers to continue to purchase vehicles that are affordable, and without adversely affecting vehicle choice, utility or function. Additionally, it was necessary that the targets chosen should contribute to Australia's commitment to greenhouse gas reduction through the Paris Climate Change Agreement.

After studying the annual rates of CO_2 reduction necessary in Europe and the US to achieve their targets, targets of 106 g/km for MA category vehicles and 143 g/km for the combined NA + MC category vehicles were chosen for 2030 to base a limit curve and modelling on. This represents a "business as usual" annual CO_2 reduction until 2022 (during which time manufacturers can adapt their product plans and the required legislation enacted), and then an annual CO_2 reduction rate until 2030 that is of greater magnitude than the US for MA category and similar to the US for light trucks (NA + MC). This takes into consideration the high penetration rates of advanced diesel powertrains in the NA + MC category. Selection of a CO_2 reduction rate that is aligned with global standards will ensure that vehicle models will be available for the Australian market, without requiring consumers to segment shift.

The choice of a 2030 target date allows time for the deployment and uptake of electric vehicles (or other low or zero emissions vehicles), aligns with the Paris Agreement target date and follows international precedents set for the adoption timelines of similar CO_2 standards.

Two separate CO_2 targets for 2030 have been developed; a 106 g/km target for MA category vehicles and a 143 g/km target for NA + MC category vehicles combined. The changes to the new vehicle fleet required to meet these targets are considered under two scenarios.

Both scenarios work towards the same CO_2 targets, but scenario 1 has the least administrative burden with no credits or incentives used, whereas scenario 2 uses credits. Scenario 2 is similar to that used in the US, where credits recognise that improved air-conditioning (A/C) efficiency and use of reduced global warming potential (GWP) refrigerants benefit real-world greenhouse emissions, even though the legislated laboratory emissions tests do not measure their impact on CO_2. Neither scenario utilises 'super-credits' (multiplier for zero or low emission vehicles.)

Scenario 2 also allows brands to transfer a CO_2 credit from one vehicle category (e.g. MA vehicles) to offset a debit in the other (e.g. NA + MC vehicles), again a method used in the US. Table 1 summarises the two scenarios and targets used to assess the impact on vehicle technology and cost.

Chosen CO_2 Targets, Credits and Incentives						
Scenario	Target Year	Vehicle Category	CO_2 Target	CO_2 Credit (Air Conditioning)	CO_2 Transfer within a brand?	Low Emission Vehicle Super Credits?
1	2030	**MA**	106 g/km	None	No	No
		NA + MC	143 g/km	None	No	No
2	2030	**MA**	106 g/km	10 g/km	Yes	No
		NA + MC	143 g/km	15 g/km	Yes	No

Table 1 – Chosen CO_2 targets, credits and incentives

MODELLING OF THE 2030 BAU FLEET

After creating a database for new light vehicles sold in 2016, attribute curves were developed to ensure that the two vehicle categories (Ma and NA + MC) were suitable for application to CO_2 targets in 2030. A mass based attribute curve was found to be most suitable in previous work (ABMARC, 2016).

Chart 1 shows the vehicles modelled in 2030 under business as usual (BAU), with each vehicle category in a different colour. The 2016 vehicle fleet is included in grey for comparison, and demonstrates the significant reductions in CO_2 that will be achieved under the BAU case from 2016 to 2030 on a model-by-model basis.

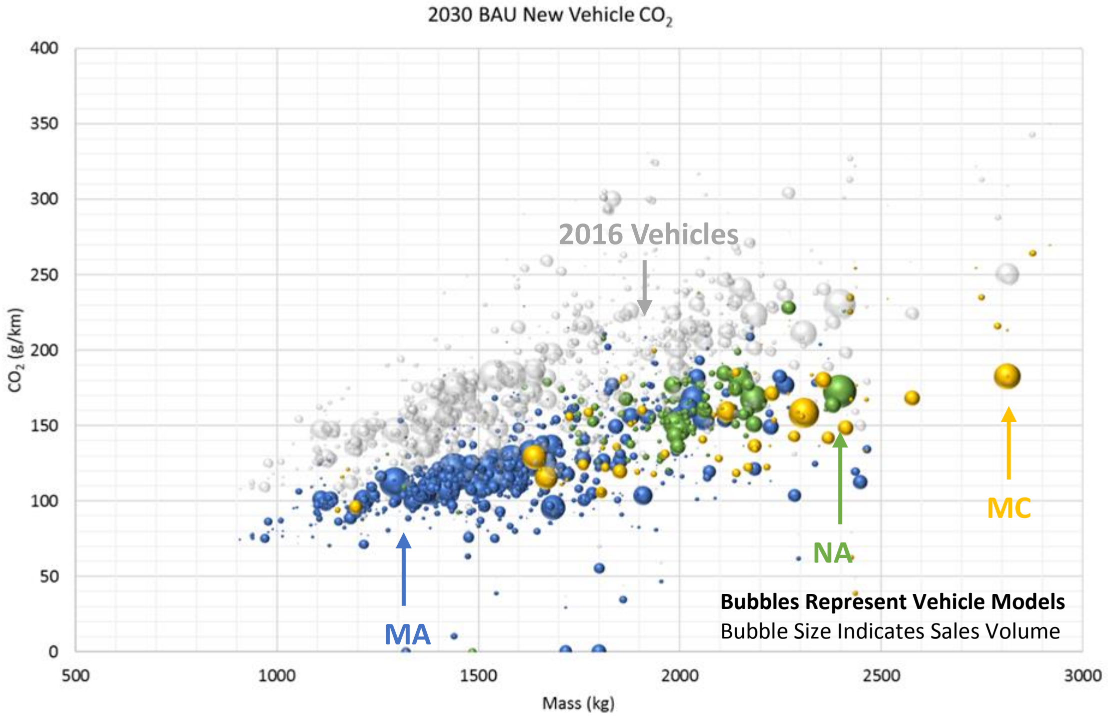


Chart 1 - BAU CO_2 forecast for all light vehicles, 2030

From the modelled 2030 BAU vehicle fleet, attribute curves were developed which then allowed the selected 2030 CO_2 targets to be translated into limit curves, against which the compliance of vehicle brands could be assessed. In this study, limit curves were applied as a percent reduction, rather than a constant offset. Chart 2 provides an example of the BAU attribute curve for MA vehicles translated into a limit curve for the 106 g/km target. The fleet average CO_2 for each of the vehicle brands in 2030 is overlaid.

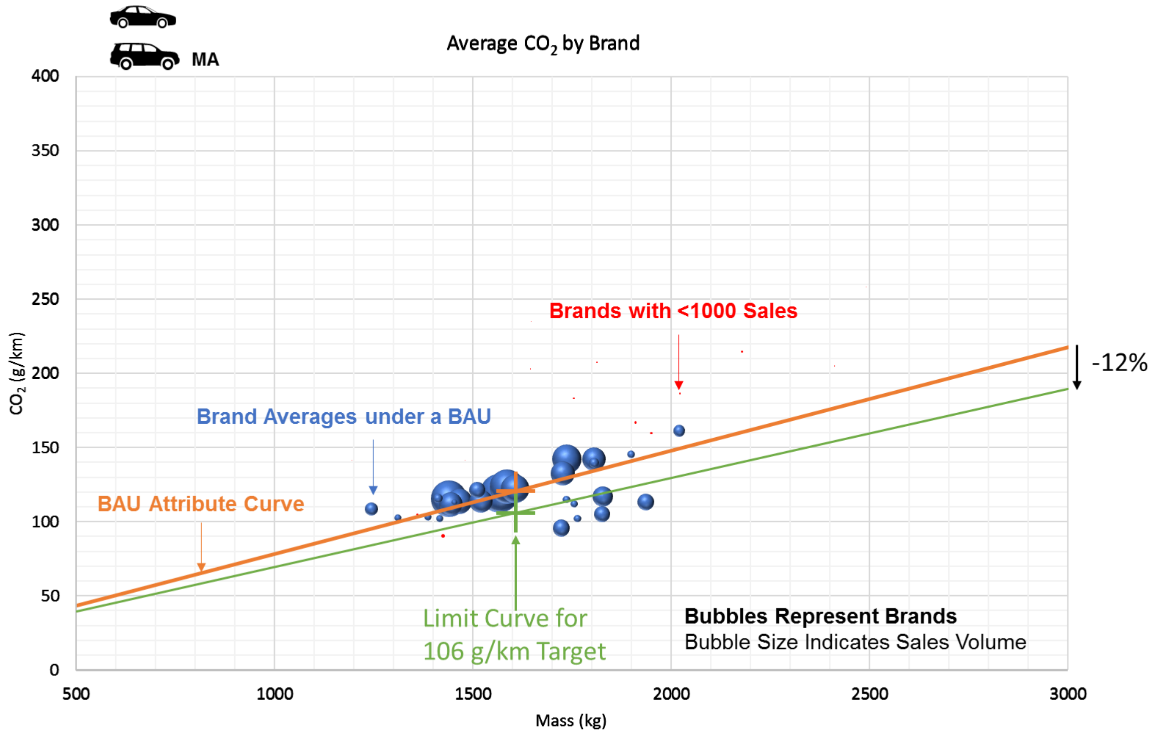


Chart 2 – Brands compared to the limit curve for MA vehicles in 2030

POWERTRAIN SUITABILITY BY VEHICLE TYPE 2030

Based on conservative BAU technology cost assumptions (selecting the upper price bound) of electrified vehicles and the fit for purpose requirements in each segment, Table 2 below provides an overview of the appropriateness of various powertrain types in 2030.

Under these assumptions, EV and PHEV MA class vehicles are unlikely to achieve widespread uptake and adoption across the entire MA class by 2030. Many models will be available in the less price sensitive segments of these markets (above $30,000), and these models will likely be purchased for their comparative performance advantages over petrol and diesel powertrains, rather than their green or operating cost credentials.

In the LCV ("ute") and MC segments, PHEVs and EVs will be limited in their uptake, not due to price, but due to fit for purpose limitations, namely:

- Reduced payload capacity
- Unacceptable towing range

2030 Powertrain Suitability by Vehicle Type					
Vehicle Type	**Petrol**	**Diesel**	**Hybrid**	**PHEV**	**EV**
Passenger	✓	△ Higher Cost Than Petrol	△ Higher Cost Than Petrol	× High Cost	× High Cost
MA SUV	✓	△ Higher Cost Than Petrol	△ Higher Cost Than Petrol	× High Cost	× High Cost
MC SUV	△ High Fuel Consumption Torque < Diesel	✓	△ Reduced Payload	× High Cost Reduced Payload	× Reduced Payload Low Towing Range
LCV Ute	△ High Fuel Consumption Torque < Diesel	✓	△ Reduced Payload	× High Cost Reduced Payload	× Reduced Payload Low Towing Range
LCV Van	△ High Fuel Consumption Torque < Diesel	✓	△ Reduced Payload	× High Cost Reduced Payload	× Reduced payload Low Towing Range

Table 2 – 2030 Powertrain Suitability by Vehicle Type

TECHNOLOGY IMPROVEMENTS REQUIRED TO MEET THE 2030 TARGETS

The fleet average CO_2 for each of the top 10 brands was compared to the limit curves to assess compliance. For both the MA and NA + MC categories, all of the top 10 brands are forecast to sit above the respective limit curves, meaning that fines are likely to be incurred unless their fleet of vehicles incorporate CO_2 reduction technologies.

In modelling, a variety of technologies were deployed to each of the top 10 brands' 2030 BAU vehicle fleet in order to enable the brands to meet the limit curves. In applying the technology changes required, vehicle fit for purpose requirements followed by a "lowest cost technology first" approach was taken. The costs associated with the technological improvements required beyond the business as usual, together with the shift in sales by powertrain type were used to assess the impact of the chosen CO_2 targets.

The zero CO_2 emissions of electric vehicles provides the most influential CO_2 reduction for the light vehicle fleet in order to achieve the target. A key assumption in this work is that the average cost of an electric vehicle (EV) in 2030 will be $5000 more than a standard petrol vehicle in that year. The risk associated with under-estimating the cost of an EV is that CO_2 targets based on the requirement to use zero-emissions cars may be unachievable if the uptake of these vehicles is significantly lower than required due to cost.

***The following is a description of charts located on pages 10 and 11*.**

MA Vehicles

Chart 4, Chart 5 and Chart 6 show the sales mix by powertrain type and brand for the BAU, Scenario 1 and Scenario 2 respectively. Under Scenario 1, significant shifts to sales of electric and hybrid technology compared to the BAU is required to meet the MA limit curve for the 106 g/km target, with a combined average of 9% of sales from electric vehicles necessary for compliance across the top 10 brands.

Scenario 2 demonstrates that the use of credits and transfer requires a much smaller shift in sales to EVs and hybrid powertrains from the BAU than in Scenario 1. Only 4% of sales from the top 10 brands must be of electric vehicles; less than half than the 9% required in Scenario 1, and much closer to the BAU forecast of 1% EV sales.

NA + MC Vehicles

Chart 6, Chart 7 and Chart 8 show the sales mix by powertrain type and brand for BAU, Scenario 1 and Scenario 2 respectively. Scenario 1 shows that without CO_2 credits or transfer, on average the top 10 brands will require approximately 8% of their sales to be of EVs, with up to 22% necessary for one of the brands. This magnitude of shift in sales from high technology diesel to electric vehicles is deemed highly unlikely considering that the use of light commercial vehicles and four-wheel drive SUVs often involves towing over long distances, operation in rugged terrain and high payload requirements.

Scenario 2 provides a more achievable pathway, with the use of credits and credit transfer reducing the requirement for EVs to less than 1% of the top 10 brand's sales of NA and MC vehicles in 2030. For the Hyundai and Volkswagen brands, a small degree of electrification of their fleets was considered possible due to their sale of smaller vans, a proportion of which could be electric for short-range delivery duties.

MA VEHICLES - BY POWERTRAIN AND BRAND

BAU

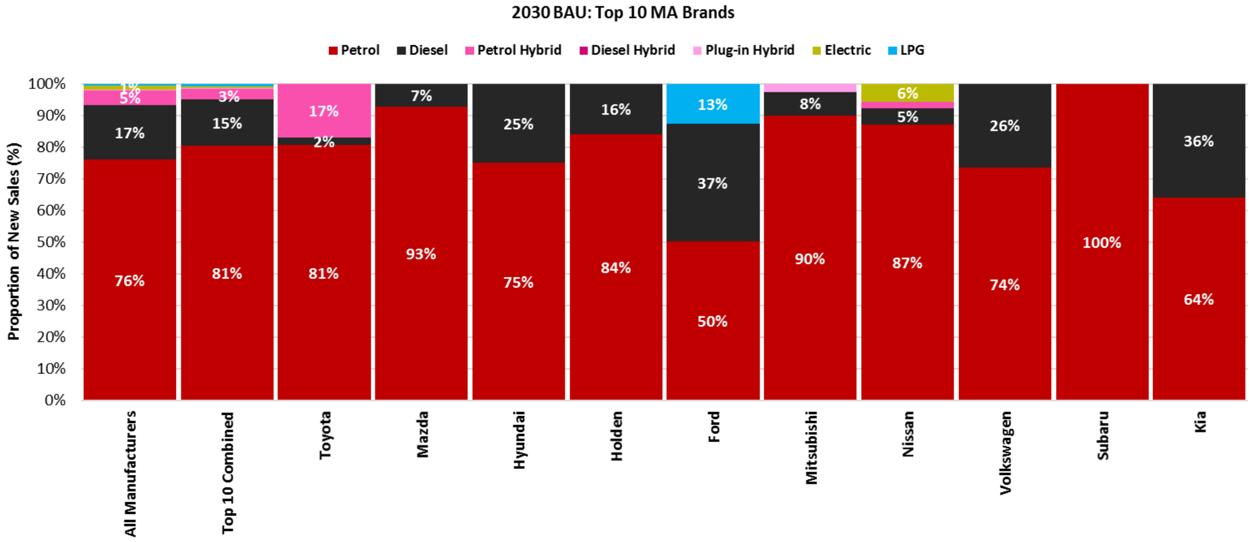


Chart 3 – Powertrain mix of the top 10 MA vehicle brands in 2030 under business as usual

Scenario 1

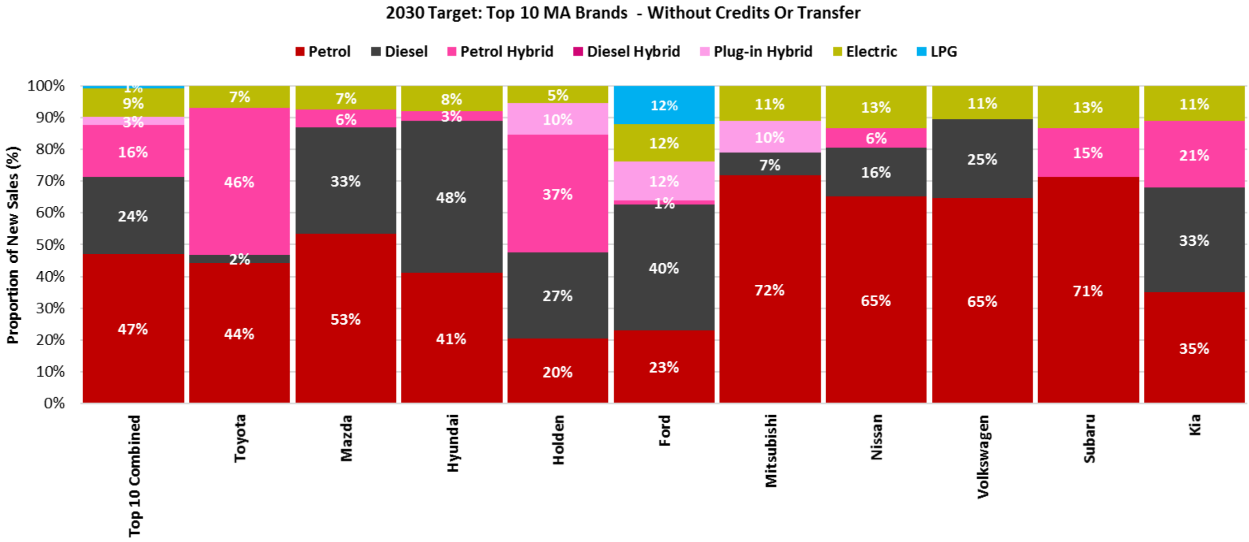


Chart 4 – Powertrain mix required for the top 10 MA vehicle brands to meet the 2030 limit curve without credits or transfer

Scenario 2

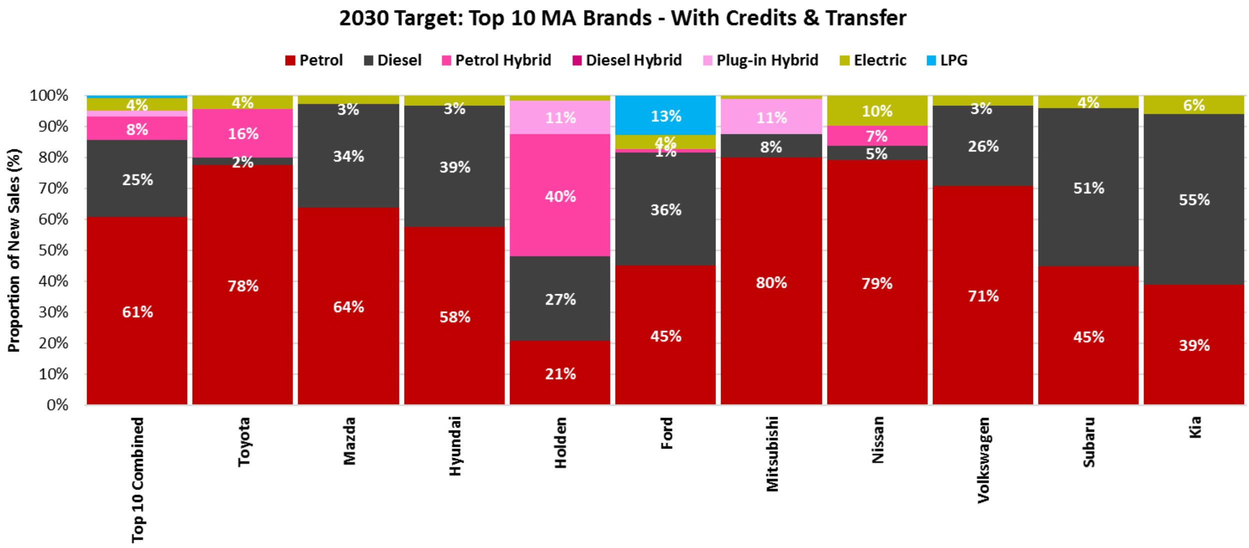


Chart 5 - Powertrain mix required for the top 10 MA vehicle brands to meet the 2030 limit curve using credits and transfer

NA + MC VEHICLES - BY POWERTRAIN AND BRAND

BAU

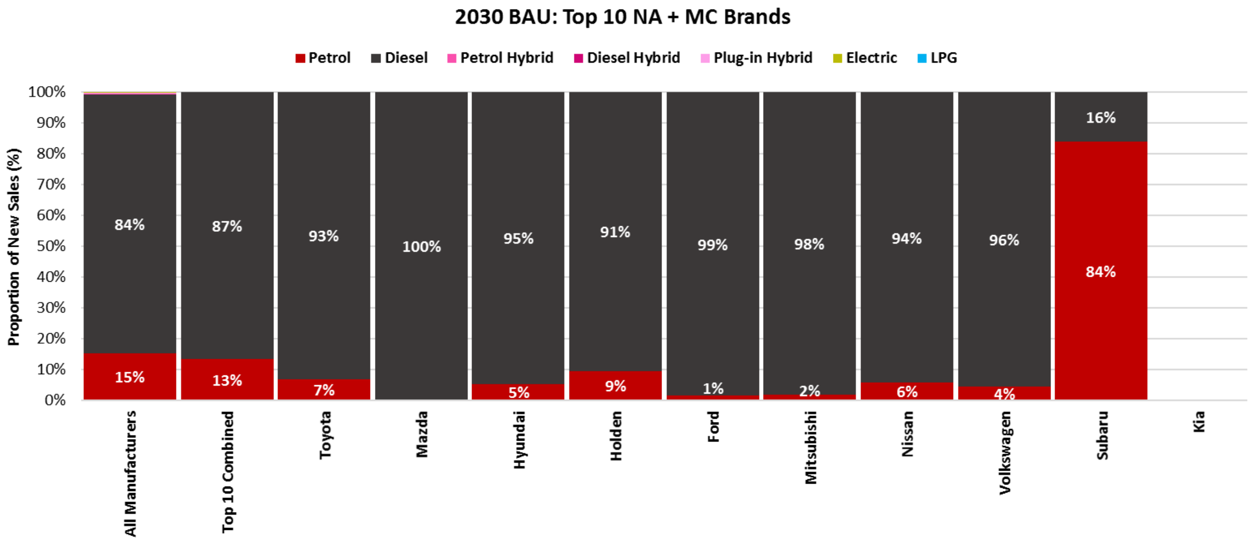


Chart 6 - Powertrain mix for the top 10 NA + MC vehicle brands in 2030 under business as usual

Scenario 1

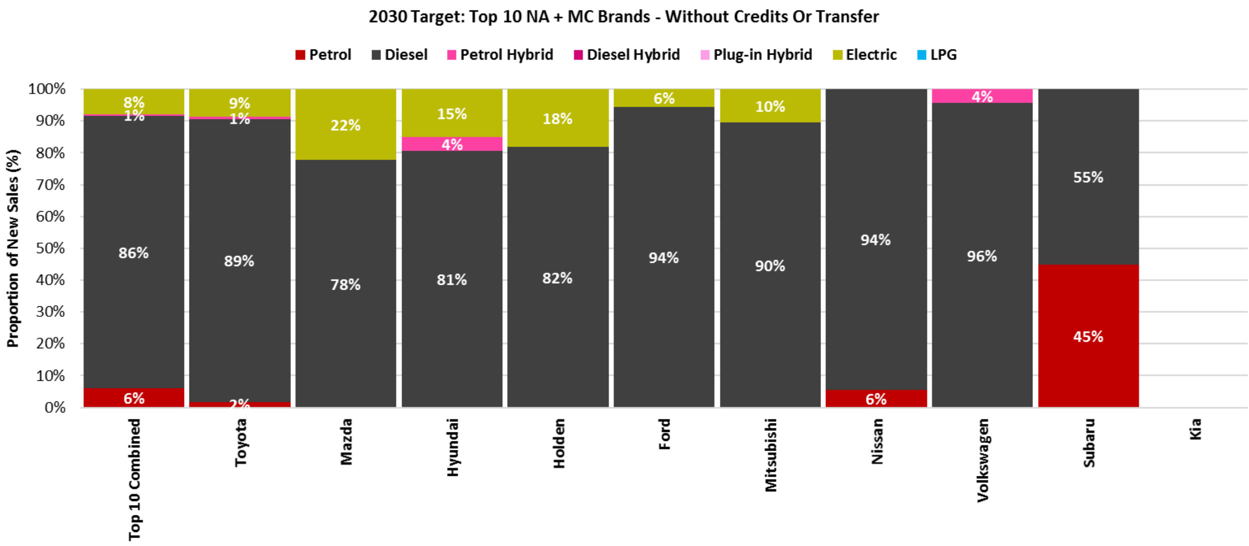


Chart 7 - Powertrain mix required for the top 10 NA + MC vehicle brands to meet the 2030 limit curve without credits or transfer

Scenario 2

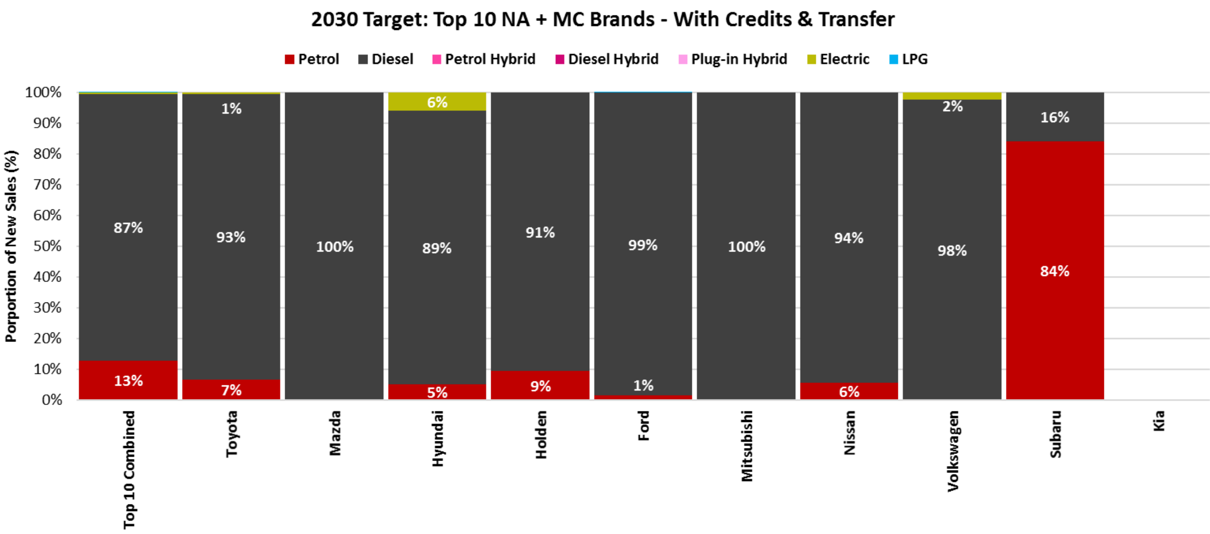


Chart 8 - Powertrain mix required for the top 10 NA +MC vehicle brands to meet the 2030 limit curve using credits and transfer

SEGMENTS INCURRING ADDITIONAL COST BURDEN TO ACHIEVE TARGET

The technology adoption and cost burden will not be evenly shared across all vehicle types and segments when complying with the targets. Analysis of buying behaviour and fit for purpose requirements reveals that within both the MA and NA + MC categories there will be subsections that will be required to accept and purchase higher cost fuel saving technologies at high rates as the other segments will not (due to cost or fit for purpose requirements).

In the MA category, analysis of 2016 data demonstrates that there is a very low rate of adoption of alternative powertrain technologies (<1%) in vehicles with a base purchase price less than $30,000. This is due to the price sensitive nature of this segment. Therefore, higher cost alternative technologies in 2030 can be assumed to be purchased only by buyers of cars with a base price greater than $30,000, which contributes only 46% of the total segment.

In Scenario 1, 68% of buyers of cars in the MA category who purchase a vehicle >$30,000 will be required to spend $2,000 or more and 20% will be required to spend $5,000 more in order for manufacturers to comply with the target. In Scenario 2, 38% of buyers of cars in the MA category who purchase a vehicle >$30,000 will be required to spend $2,000 or more and 9% will be required to spend $5,000 more in order for manufacturers to comply with the target. This is summarised in Table 3.

Proportion of vehicles required to increase costs to meet the limit curve				
MA Vehicles	Scenario 1		Scenario 2	
Cost Above BAU	>$2,000	$5,000 (Electric)	>$2,000	$5,000 (Electric)
All vehicles	31%	9%	17%	4%
Vehicles >$30k	68%	20%	38%	9%

Table 3 – Proportion of MA vehicles with increased costs to meet the limit curve

In the NA + MC category, analysis of vehicle technology to 2030 and operator fit for purpose requirements reveals that there is very limited opportunity to deploy electrified powertrains (EV and PHEV) due to the payload and towing needs in this segment. Analysis of 2016 sales data illustrates the NA + MC category already has very high adoption rates of efficient diesel engine vehicles with comparatively low CO_2. In this category, the burden of electrified technology adoption to achieve any CO_2 standard will most likely fall to vans and a limited number of MC class vehicles.

In Scenario 1, whilst only 14% of average sales will be required to spend greater than $2,000 to achieve the target, this will fall to 80% of van buyers and 3% of MC buyers in order for manufacturers to comply with the target. Of these, 45% of van buyers will be required to spend an additional $5,000 and 2% of MC buyers.

In Scenario 2, whilst only 1% of average sales will be required to spend greater than $2,000 to achieve the target, this will fall to 5% of van buyers in order for manufacturers to comply with the target. Of these, 3% of van buyers will be required to spend an additional $5,000. This is summarised in Table 4.

Proportion of vehicles required to increase costs to meet the limit curve				
NA + MC Vehicles	Scenario 1		Scenario 2	
Cost Above BAU	>$2,000	$5,000 (Electric)	>$2,000	$5,000 (Electric)
All	14%	8%	1%	0%
Vans (80% Share)	80%	45%	5%	3%
MC (20% Share)	3%	2%	0%	0%

Table 4 - Proportion of NA + MC vehicles with increased costs to meet the limit curve

A risk is that under Scenario 1, buyers intending to purchase a van may be dissuaded by the $5,000 premium modelled for an electric vehicle and decide to purchase a utility vehicle instead. As utility vehicles generally emit higher CO_2 than vans, this would make it more challenging to meet the CO_2 target for these vehicles. Under

Scenario 2, as a much lower proportion of vans would need to be electric, the risk of failing to meet the 143 g/km target is significantly reduced.

It is noted that under scenario 2, when utilising the transfer of CO_2 credits from the MA vehicle category to offset debits in the NA + MC category, that zero emissions vehicles (incurring an additional cost of $5,000) are required to be 4% of total MA sales, or 9% of MA vehicles priced over $30,000. In total, 38% of consumers in the MA category spending $30,000 or more on a car, will be required to spend an additional $2000 in order for MA and NA + MC category vehicles to meet their respective targets. The acceptance of the cost burden on such a large proportion of this group of vehicle buyers may prove to be difficult to accomplish.

CONCLUSION

From the modelling work conducted in this report, the following conclusions can be made:

- When compared to the 105 g/km 2025 target ("Target A"), the selected 2030 targets provide a more achievable framework for the introduction of more fuel-efficient, low emissions vehicles, whilst retaining a challenging target and preserving consumer choice in vehicle type.
- Based on analysis of the top 10 brands, the use of CO_2 credits and credit transfer within a brand significantly aids compliance with the selected 2030 targets, reducing the required number of EVs from 9% to 4% for MA vehicles, and from 8% to less than 1% for the NA + MC category.
- Even with the use of credits and transfer of credits within a brand, it will be challenging for manufacturers to meet the selected 2030 targets, particularly in the NA + MC category due to the limited suitability of electric powertrains for these vehicles.
- Further work is recommended to ensure the viability of a 143 g/km target for NA + MC vehicles, especially if credits and incentives were not allowed to aid compliance with this target.
- The cost burden to achieve the targets will not be evenly distributed among vehicle sales, but primarily borne by:
  - MA category vehicles with a base price over $30,000.
  - NA category vans.
- Under Scenario 1 (no credits or credit transfers), for the MA category, although it appears that 9% of the top 10 brand's sales will need to be EVs, if this were only applied to the vehicles >$30k then the figure would be more like 20%. In the NA + MC category, 45% of van buyers would be required to spend an additional $5000 to purchase an EV in order for manufacturers to achieve their target.

LIST OF FIGURES, CHARTS & TABLES

LIST OF FIGURES

LIST OF CHARTS

LIST OF TABLES

ACRONYMS

AAA	Australian Automobile Association
A/C	Air Conditioning
ACEA	European Automobile Manufacturers' Association
ADR	Australian Design Rule
AS	Australian Standards
ASTM	American Society for Testing and Materials
Avg	Average
BAU	Business As Usual
BSFC	Brake Specific Fuel Consumption
CAN	Controller Area Network
CARB	California Air Resources Board
CF	Conformity Factor
CI	Compression-Ignition Engine (Diesel)
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DPF	Diesel Particulate Filter
EC	European Council
ECU	Engine Control Unit
EEV	Enhanced Environmentally Friendly Vehicle
EGR	Exhaust Gas Recirculation
EGT	Exhaust Gas Temperature
EPA (US)	Environmental Protection Agency
EPA (AUS)	Environment Protection Authority
EU	European Union
EV	Electric Vehicle
FID	Flame Ionization Detector
GCM	Gross Combination Mass
GFM	Gravimetric Filter Module
GPS	Global Positioning System
GVM	Gross Vehicle Mass
GWP	Global Warming Potential
HD	Heavy Duty
HDV	Heavy Duty Vehicle
ICE	Internal Combustion Engine
ISO	International Organization for Standardization
JRC	Joint Research Centre
LCV	Light Commercial Vehicle
LDV	Light Duty Vehicle
LPG	Liquefied Petroleum Gas
MAP	Manifold Absolute Pressure
MAW	Moving Average Window
MIL	Malfunction Indicator Lamp
N/A	Not Applicable
NDIR	Non-Dispersive Infrared
NEDC	New European Drive Cycle
NDUV	Non-Dispersive Ultra-Violet
NEDC	New European Drive Cycle
NMHC	Non-Methane Hydrocarbons
NRMM	Non-Road Mobile Machinery
NO	Nitric Oxide
NO_X	Oxides of Nitrogen
NO_2	Nitrogen Dioxide
NTE	Not To Exceed
NSW	New South Wales
OBD	On-board Diagnostic
OEM	Original Equipment Manufacturer
PC	Passenger Car
PEMS	Portable Emissions Measurement System
PI	Positive Ignition Engine (Petrol)
PID	Vehicle Data Parameter Identifier
PM	Particulate Matter
PPM	Parts Per Million
RDE	Real Driving Emissions
RPM	Revolutions per Minute
RVCS	Road Vehicle Certification System
SAE	Society of Automotive Engineers
SUV	Sports Utility Vehicle
Temp.	Temperature
THC	Total Hydrocarbons
UN	United Nations
UN ECE	United Nations – Economic Commission for Europe
UV	Ultra Violet
VIC	Victoria
WLTC	Worldwide Harmonized Light-duty Test Cycle
WLTP	Worldwide Harmonized Light-duty Vehicles Testing Procedure

GLOSSARY OF TERMS

Euro 1 – 6: European emission standards define the acceptable limits for exhaust emissions of new vehicles sold in EU member states.

Electrified: refers to vehicles with a full or partially electric drive train. This includes hybrid vehicles.

Gaseous Emissions: Engine emissions in gaseous form, includes oxides of nitrogen, carbon monoxide, carbon dioxide and total hydrocarbons.

Homologation: The formal process of approving and accepting a new vehicle type for sale in a country.

Mass in Running Order: Vehicle tare mass, plus the fuel mass (with fuel 10L below full) and the 75kg to account for the weight of a driver.

MA Category Vehicle: A passenger vehicle, not being an off-road passenger vehicle or forward-control passenger vehicle, having up to 9 seats, including that of the driver.

MC Category Vehicle: A passenger vehicle having up to 9 seats, including that of the driver and being designed with special features for off-road operation.

NA Category Vehicle: A light goods vehicle designed primarily for carrying goods, with gross vehicle mass not exceeding 3.5 tonnes

ABBREVIATIONS

°C	Degrees Celsius
g	Gram
mg/km	Milligrams per Kilometre
g/km	Grams per Kilometre
g/s	Grams per Second
h	Hour
kg/L	Kilograms per Litre
L/100km	Litres per 100 Kilometres
km	Kilometre
kW	Kilowatt
L	Litre
m	Metre
mm	Millimetre
min	Minute
Nm	Newton Metre
Pa	Pascal
ppm	Parts per Million
RPM	Revolutions per Minute
s	Seconds

BACKGROUND

OVERVIEW

PROJECT BRIEF

ABMARC has been commissioned by the AAA to develop or identify:

- Future CO_2 targets for new light duty vehicles;
- A timescale within which these would be applied; and
- A potential framework that considers credits and credit transfers that would facilitate their achievement in practice.
- Any challenges in meeting the 2025 “Target A”

Two separate targets are to be determined:
1. MA category vehicle target
2. Combined NA + MC category target

Consideration was given to the following objectives:

- To ensure that the CO_2 targets developed allow consumers to continue to purchase vehicles that are affordable, without adversely affecting vehicle choice, utility or function.
- To develop CO_2 targets that allow the new vehicle fleet to contribute to Australia’s commitment to greenhouse gas reduction through the Paris Agreement.

APPROACH USED FOR NEW CO_2 TARGETS

In the development of alternative CO_2 targets, limit curves and a timeframe to implement, forecasting has been based on 2016 vehicle data, and an evidence-based approach, leveraging global experience and detailed vehicle purpose requirements, has been taken.

The methods used by various Governments globally, such as credits, credit transfers and super-credits, were examined to determine which might assist in meeting an Australian vehicle CO_2 target, whilst ensuring vehicle choice. Some methods relating to CO_2 or fuel efficiency policies have been found to be beneficial in achieving compliance in overseas jurisdictions. Any schemes or methods that were determined to be impractical when applied in the Australian context or that might have an adverse outcome in the target year were discounted.

Vehicle technologies required to be deployed to meet targets will have a cost associated with them. In developing the technology matrix to achieve targets, vehicle fit for purpose requirements followed by “lowest cost technology first” approach has been taken.

The following provides a high-level overview of the steps taken to complete the work for each target segment.

1. Develop the 2016 vehicle database and attribute curve
2. Analyse vehicle and consumer trends across; technology, pricing, powertrain, fit for purpose requirements
3. Select Australian fleet average CO_2 limits based on analysis of legislated global CO_2 reduction trends and consider Australia’s capacity to achieve them
4. Forecast 2030 sales and technology mix and the vehicle attribute curve under a BAU scenario
5. Establish the limit curve based on 2030 fleet average target and attribute curve
6. Based on the 2030 limit curve:
    a. Scenario 1: with no credits, transfers or incentives determine the technology required to achieve the target by top 10 manufacturer
    b. Scenario 2: with credits and transfers determine the technology required to achieve the target by top 10 manufacturer
7. Assess the cost and impact to the relevant market segments

The remainder of this section is an extension of ABMARC's previous work prepared for the Department of Infrastructure and Regional Development in 2016. The 2016 work required ABMARC to develop a limit curve for a target of 105 g/km CO_2 for all light vehicles in 2025. The inclusion in this report of additional analysis of the 105 g/km 2025 target is to provide background to the AAAs request to develop alternative targets and mechanisms to achieve.

POTENTIAL PENALTIES TO MEET A 105 G/KM TARGET IN 2025

In 2016, ABMARC used 2015 new light vehicle sales data to model the new vehicle fleet in 2025 and produced a mass versus CO_2 limit value curve required to meet a 105 g/km CO_2 target for all light vehicles. Analysis of the 2025 data allowed the likely fleet average CO_2 for each of the top 10 brands to be compared to this limit curve. From this, the possible penalties to be incurred by each of the top 10 brands for non-compliance with the 105 g/km limit curve was estimated (with penalties applying for the 2025 year only).

The penalties are based on the following assumptions:

- A CO_2 policy for Target A would not be formally enacted until 2022, with a 2025 target date.
- From 2018 until 2022, each brand's average CO_2 will decrease at a business as usual trajectory as manufacturers are likely to have already planned their products to be introduced in this timeframe.
- From 2022 until 2025, each brand's average CO_2 will have an annual reduction of 4.7%, equivalent to the average of the reductions necessary to meet the US car and light truck targets over this timeframe.
- Sales of vehicles increase by 2.3% per annum from 2015 to 2025, with the market share of brands in 2025 remaining unchanged.
- Penalties are forecast for 2025 only, and do not consider any requirements for brands to comply with a phased introduction of the target over the preceding three years.
- 'Super-credits' were not applied in the analysis. The application of 'super-credits' could reduce each brand's average CO_2 through the use of sales multipliers for ultra-low emissions vehicles.
- The calculated penalties equate to each brand's forecast sales in 2025, multiplied by a fine of $100 for each g/km that their respective average CO_2 is above the limit curve.

The fleet average CO_2 of the brands shown in Chart 9 is therefore the prediction of what is likely to occur if, from 2022, manufacturers were required to work towards the 105 g/km target by 2025, and during this timeframe drew vehicles from their global product base. 2022 is the start date for manufacturers as product plans for the interim years (2019-2021) will have already been developed.

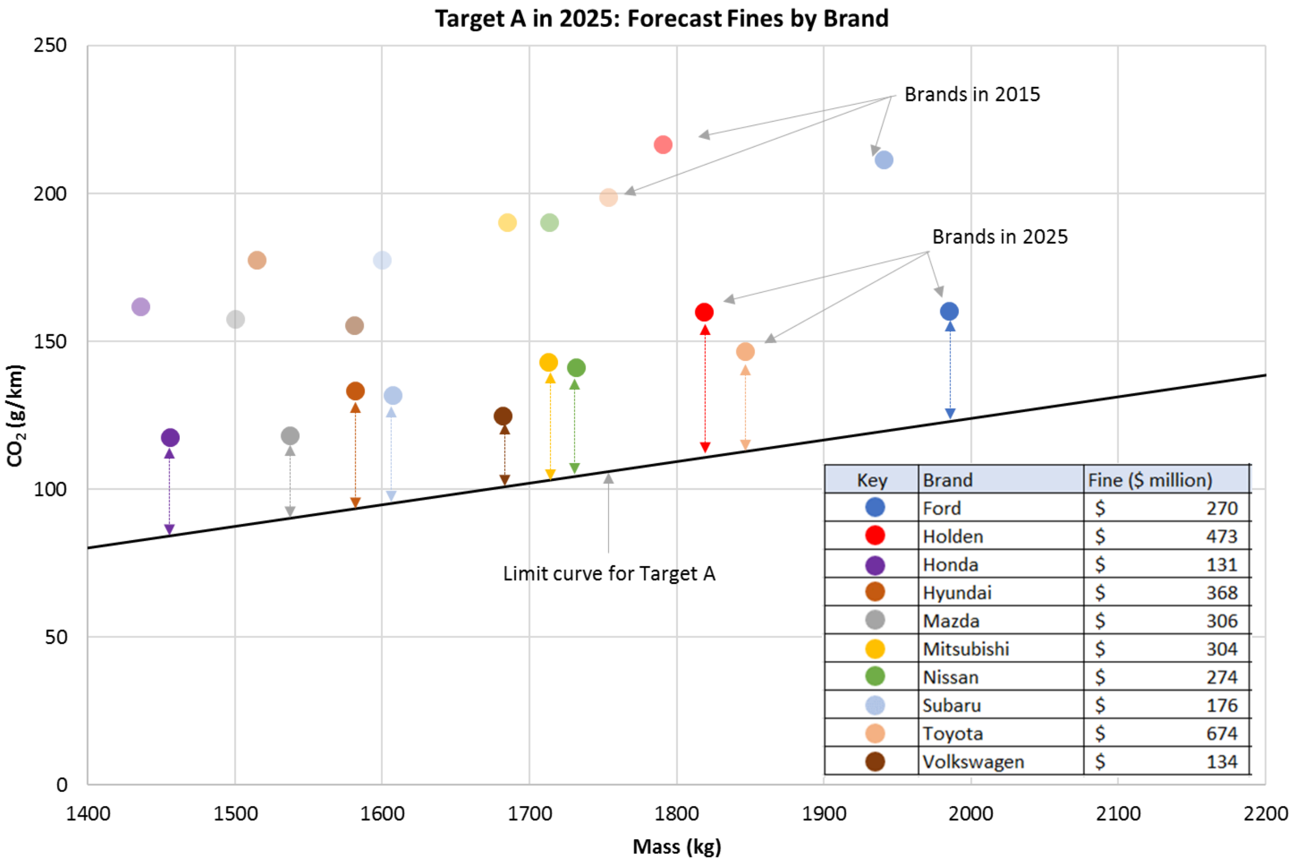


Chart 9 – Potential fines if Target A is applied in 2025

Due to the very short timeframe, stringent CO_2 target and lack of suitable global models within each segment at prices Australian consumers are willing (or able) to pay, it is forecast that none of the top 10 brands would be able to comply with the limit curve for a 105 g/km target in 2025 without the use of the super credits for the supply of ultra-low emission vehicles.

This would result in fines of up to $674 million for individual brands in 2025 alone, with none of the top 10 brands incurring a fine of less than $130 million. The size of each fine is heavily influenced by the number of vehicles a manufacturer is forecast to sell.

ABILITY TO MEET TARGET A IN 2025

One way to achieve Target A in 2025 without requiring a change in powertrain type is to consider which vehicles are predicted to meet the limit curve for the 105 g/km target. Chart 10 shows that only a small proportion of the new light vehicles forecast for 2025 will be able to meet the limit curve for Target A.

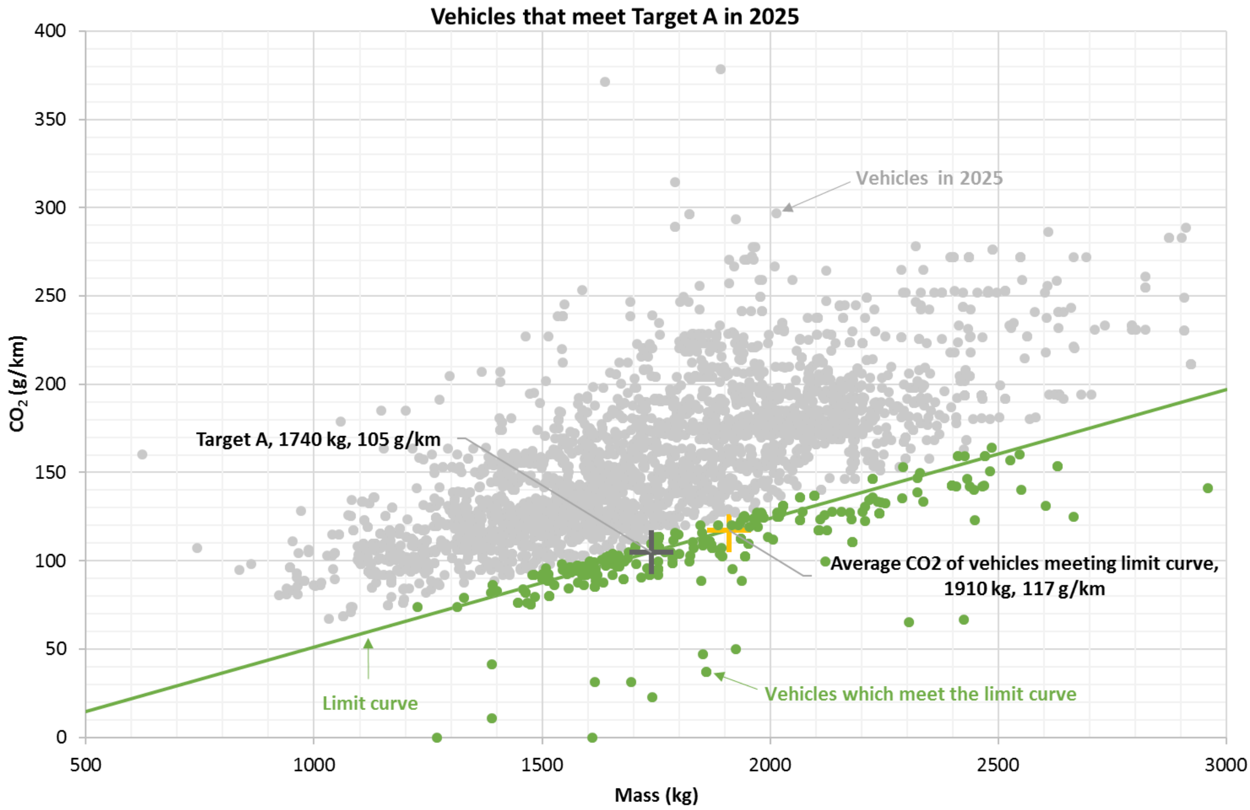


Chart 10 – Vehicles that are able to meet Target A in 2025

The average CO_2 of all these vehicles is 117 g/km, however, their 1910 kg average mass means that they comply with the Target A limit curve. This highlights the fact that if the 105 g/km target were modified to account for the increased mass associated with increased sales of heavier vehicles, the target under this scenario would be 117 g/km.

To demonstrate the significant shift in the sales of vehicles that is required to achieve Target A, Chart 11 shows that under business as usual (BAU), 47% of sales are forecast to be from SUVs, with 35% from PC and 18% from LCVs. The vehicles which, when combined, are able to meet Target A represent only 8% of the total fleet sales, meaning that consumer choice would be severely limited by the adoption of a Target A.

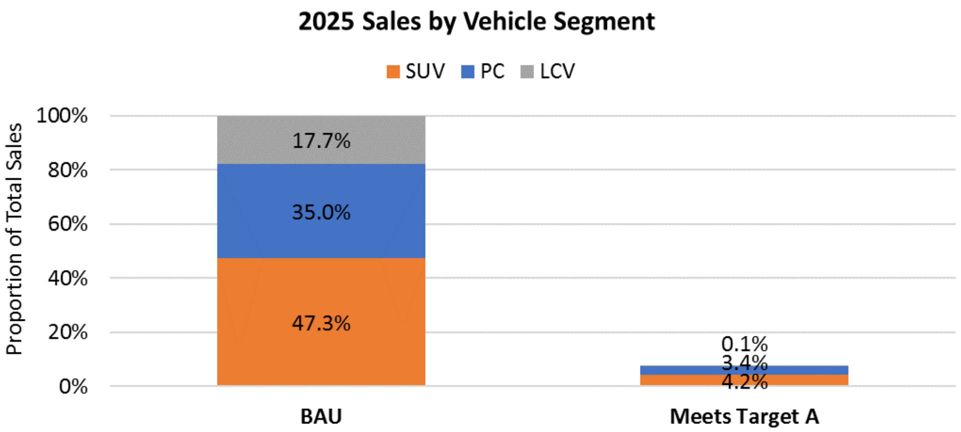


Chart 11 – 2025 Sales by Vehicle Segment

It may be considered that the introduction of global vehicles with lower CO_2 not currently imported into Australia will ensure compliance with a 105 g/km target. However, it is important to note that for MA vehicles, those with substantially lower CO_2 tend to be smaller vehicles with lower power, passenger volume and luggage space. If Australian consumers prefer the improved utility of larger vehicles (with higher associated CO_2), a high uptake of vehicles with low CO_2 is unlikely to occur as it would require a shift to smaller vehicles. For NA and MC vehicles, the technologies used in Australian vehicles are already highly developed, with diesel being the most common powertrain and so the most likely option for reducing CO_2 is the shifting to electrified powertrains which are less suitable for these vehicles.

2016 NEW VEHICLE CO_2 ANALYSIS

The CO_2 emissions of individual vehicle models sold in Australia in 2016 were analysed using vehicle technical data sourced from Redbook (redbook.com.au) and sales data from VFacts. This enabled analysis of the 2016 new light duty vehicle fleet using the most recent complete calendar year sales data. Chart 12 provides a summary of the CO_2 emissions of every vehicle model sold in Australia in 2016 and its relationship to mass. Each bubble signifies a vehicle model, and the size of the bubble is proportional to its annual sales. The data is segregated by using a different colour for each vehicle category: MA which includes passenger cars and most SUVs, MC which comprises off-road passenger vehicles and/or SUVs, and NA which comprises light commercial vehicles. MC category SUVs were determined using data available in the Commonwealth Government's Road Vehicle Certification System (RVCS).

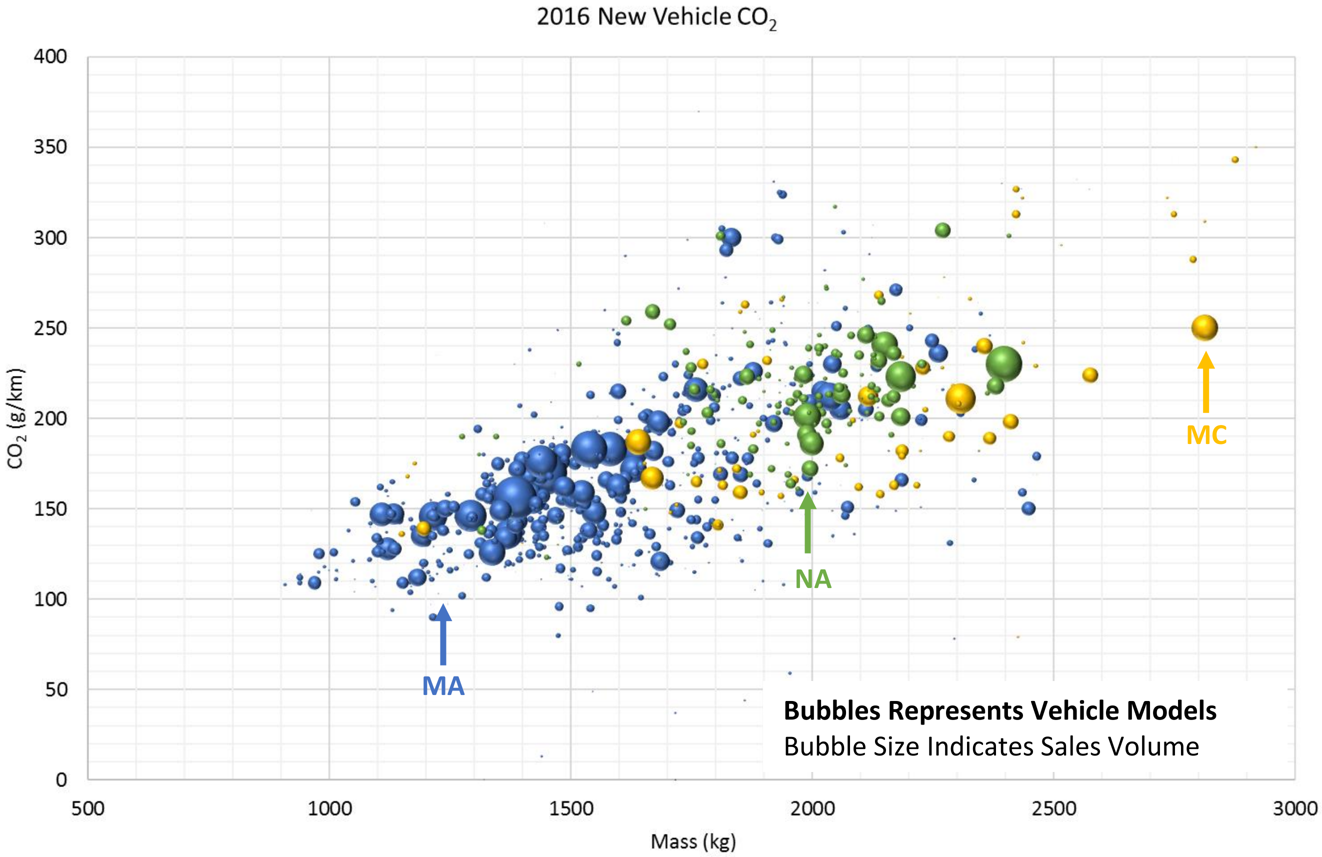


Chart 12 – 2016 vehicle CO_2 for all light duty vehicles

Vehicle CO_2 data is plotted against vehicle mass, where the mass is strictly mass in running order (refer Glossary). Kerb mass was used for vehicles with an unknown tare mass, and a default 120 kg was added to the tare mass of cab chassis LCVs to represent the average mass of an aluminium tray. The CO_2 data relates to the manufacturer's declared emissions according to NEDC laboratory testing.

It can be observed that for a given vehicle mass, there are many vehicle models across a wide range of CO_2 emissions. When only vehicles with high sales are considered, there is a much clearer relationship between the mass of a vehicle and the CO_2 that it produces. It is this sales-weighted approach that forms the basis of the CO_2 analysis conducted.

Vehicle mass, rather than vehicle footprint (the attribute used in the USA), has been chosen as the attribute upon which to assess CO_2. Vehicle mass was chosen as it was previously found to have a much stronger relationship for vehicles sold in Australia and readily enables the addition of new safety features and other vehicle technologies (ABMARC, 2016).

It can be seen in Chart 12, that when considering the correlation between mass and CO_2 for all categories of light vehicles, there is a slightly different relationship for each vehicle category (MA, NA + MC). It is this relationship at the vehicle segment level that defines a CO_2 limit curve intended to achieve a CO_2 target; each vehicle manufacturer's average CO_2 from its annual vehicle sales must conform to the limit curve. Therefore, it is imperative that in establishing a relationship between vehicle mass and CO_2, vehicle categories are used that demonstrate a strong relationship between both parameters or else there is a risk that manufacturers will not be able to produce vehicles that enable them satisfy the limit curve, leading to the possibility of fines for non-compliance.

Another important consideration is that a limit curve should be established such that it does not reduce consumer choice or require segment shifting to achieve the target. Basing the limit curve on the attributes of a country's vehicle fleet, and ensuring that the limit curve does not require a rate of reduction in fleet average CO_2 that is higher than comparative global standards, will ensure that segment shifting (consumers purchasing smaller vehicles) or high rates of incentivisation will not be required.

MA CATEGORY VEHICLES

The attribute curve representing the relationship between mass and CO_2 for MA category vehicles in 2016 is shown in Chart 13 below. The attribute curve represents the line of best fit drawn through the sales-weighted average mass versus CO_2 data, ensuring that it passes through the point corresponding to the average mass and CO_2, marked with a "+". As the attribute curve reflects the relationship between vehicle mass and CO_2, all vehicles are included. All models, including from brands with annual sales less than 1000 vehicles, have been included in the data.

As the attribute curve describes the average relationship between mass and CO_2 there are vehicles significantly above and below the line, however these tend to be models with low sales volumes.

The dashed line shows the sales-weighted CO_2 at 50 kg increments. It is this sales weighted result that the attribute curve is then produced from.

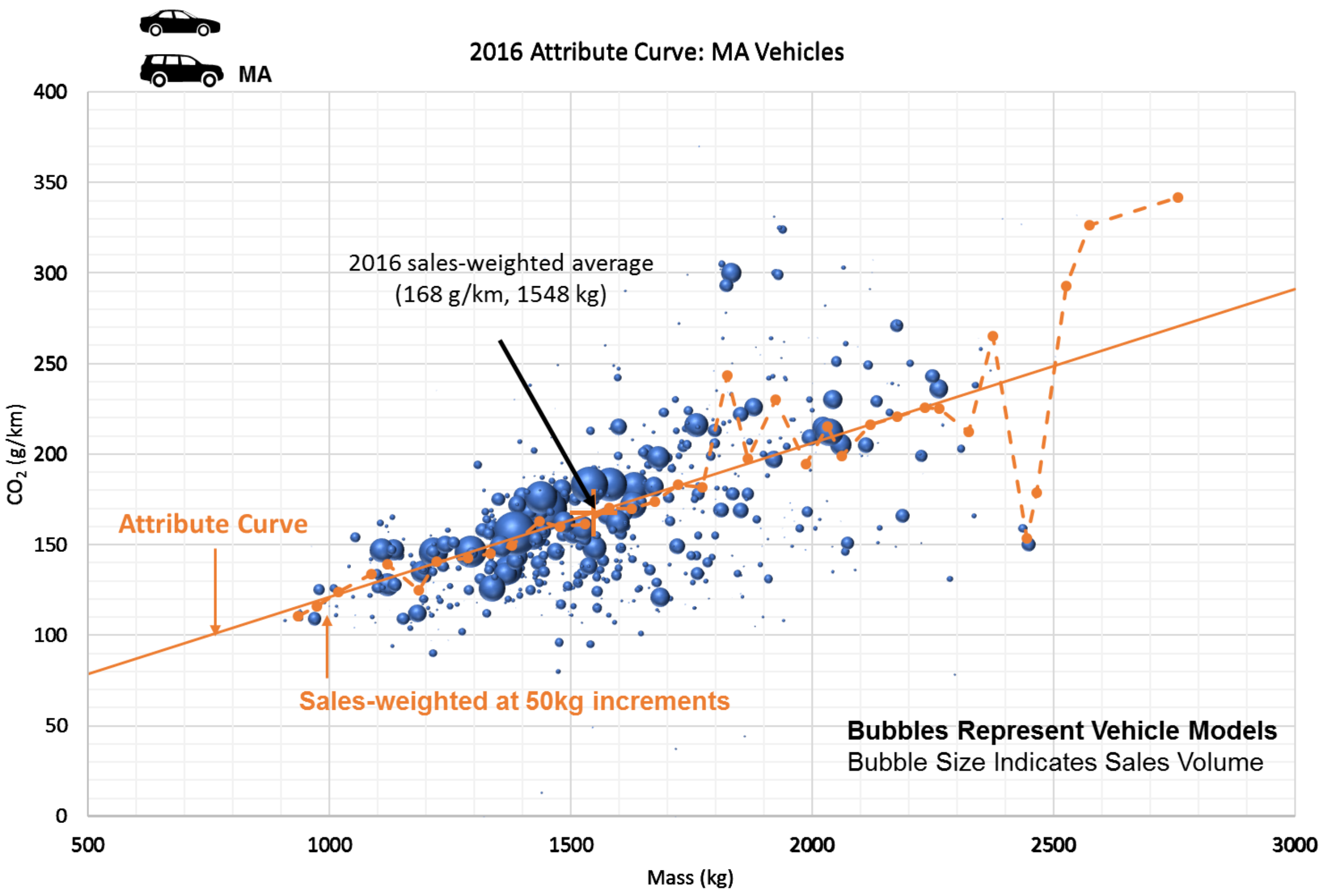


Chart 13 – Attribute curve for MA vehicles, 2016

COMPARISON OF VEHICLE BRANDS TO THE ATTRIBUTE CURVE FOR MA VEHICLES

Although the attribute curve developed in Chart 13 describes a strong relationship between CO_2 and mass on a vehicle level basis, the fleet-average CO_2 of each vehicle brand (based on their 2016 sales) is also compared to this attribute curve to assess its suitability. Chart 14 shows that for the brands with annual sales greater than 1000 MA category vehicles in 2016, their fleet-average CO_2 are distributed above and below the attribute curve, with a number lying very close to the curve. This shows that the attribute curve not only provides a good representation at a vehicle model level, but also at a brand level.

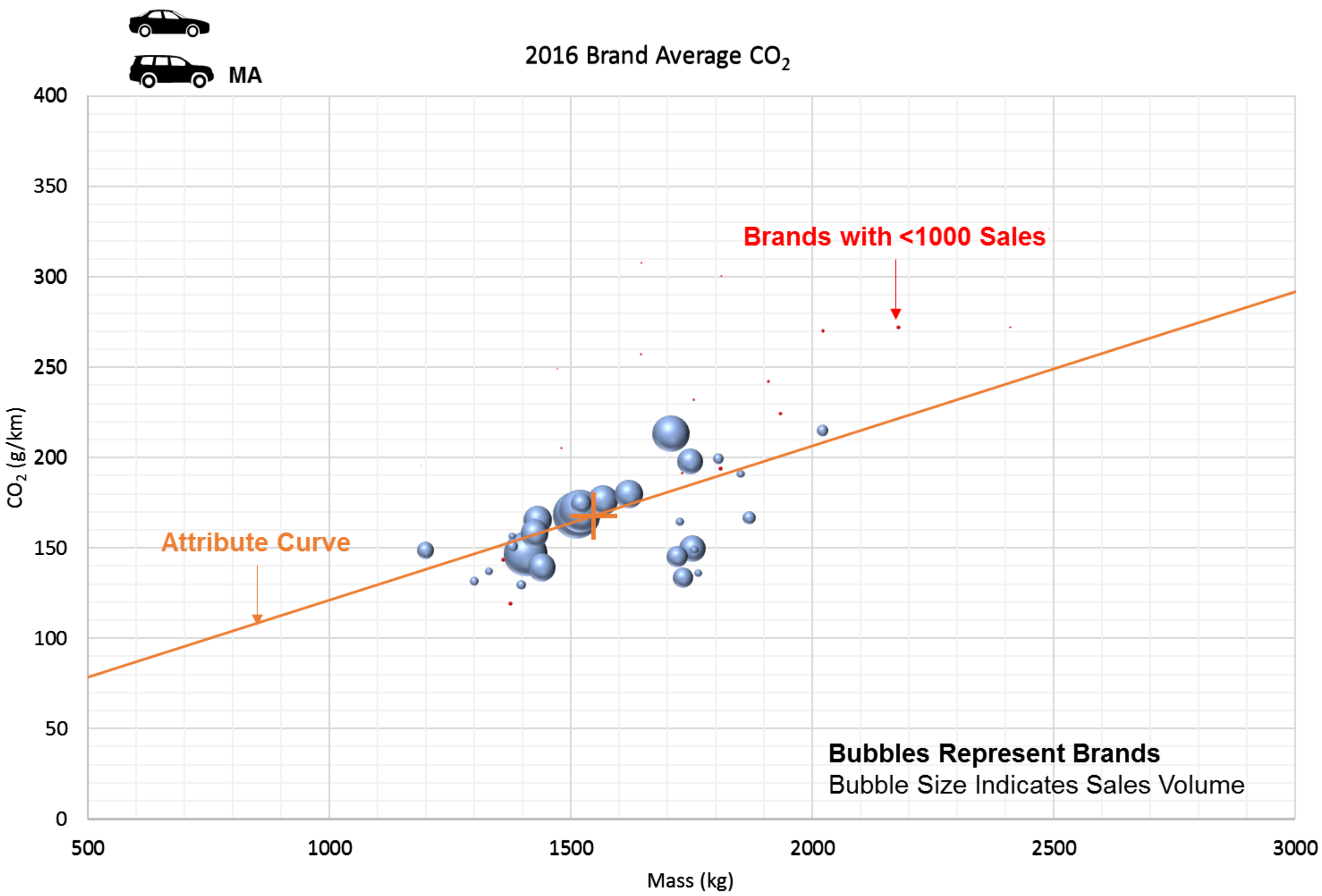


Chart 14 – Brand fleet average CO_2 compared to the 2016 MA attribute curve

NA + MC CATEGORY VEHICLES

A separate attribute curve for NA + MC vehicles (combined into one category) was developed using the same approach as outlined previously. The high scatter in the sales-weighted dashed line shown in Chart 15 illustrates that the attribute curve for NA + MC vehicles is based on a weaker relationship between vehicle mass and CO_2 than exists for MA vehicles (refer Chart 13).

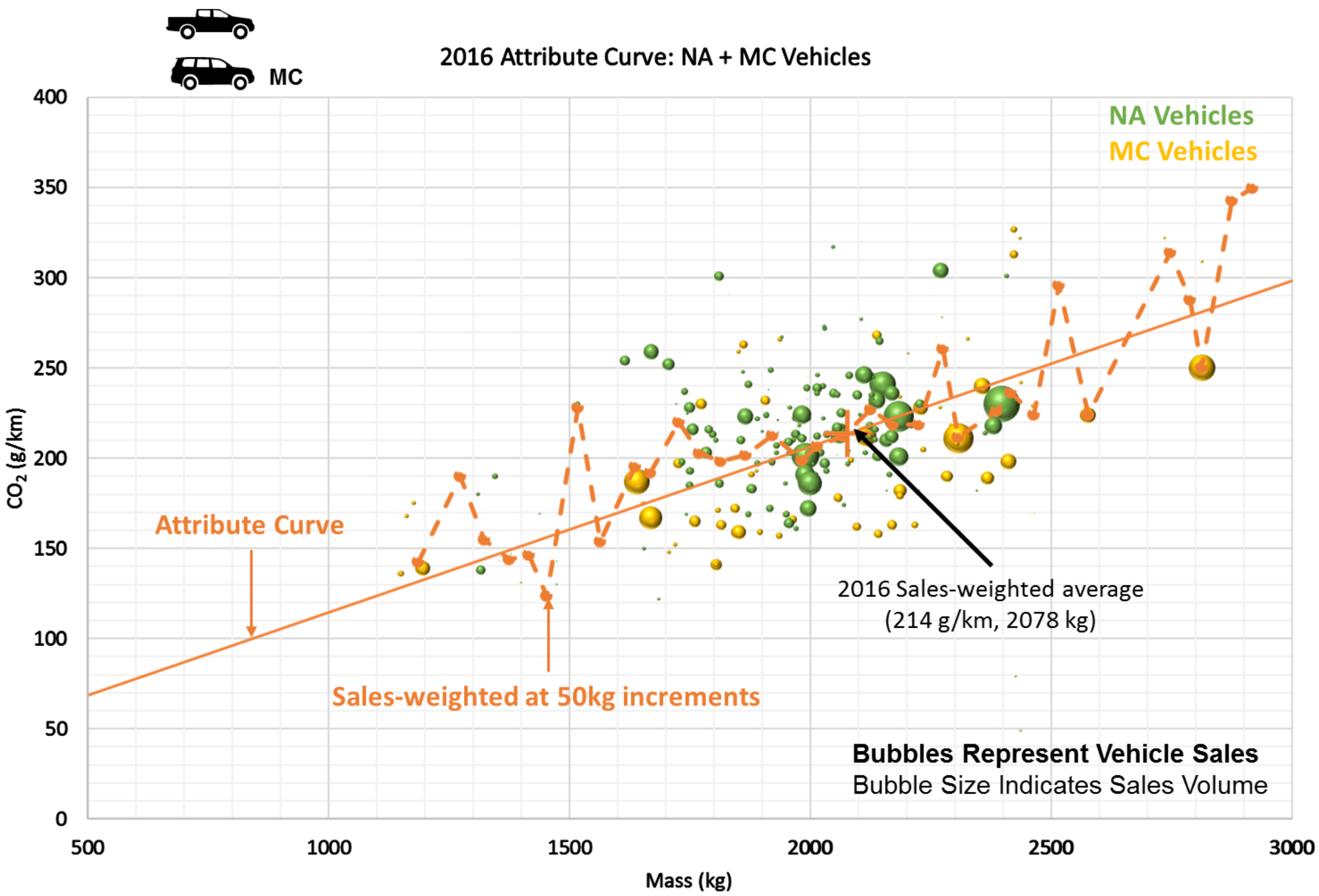


Chart 15 – Attribute curve for NA + MC vehicles, 2016

Although the attribute curve has been designed to best fit the sales-weighted CO_2 data, it can be seen in Chart 15 that the vehicle models with the highest sales (larger bubbles) are scattered fairly significantly above and below the attribute curve. Further analysis was conducted on the use of a single curve for both NA and MC categories and it was determined that it does not pose a disadvantage to either segment type.

COMPARISON OF VEHICLE BRANDS TO THE ATTRIBUTE CURVE FOR NA + MC VEHICLES

Despite a weaker fit of the attribute curve to the underlying vehicle CO_2 and mass data, Chart 16 shows that in comparing the fleet average CO_2 for each of the brands that sold NA and/or MC vehicles to the attribute curve, no one brand is disadvantaged compared to the others.

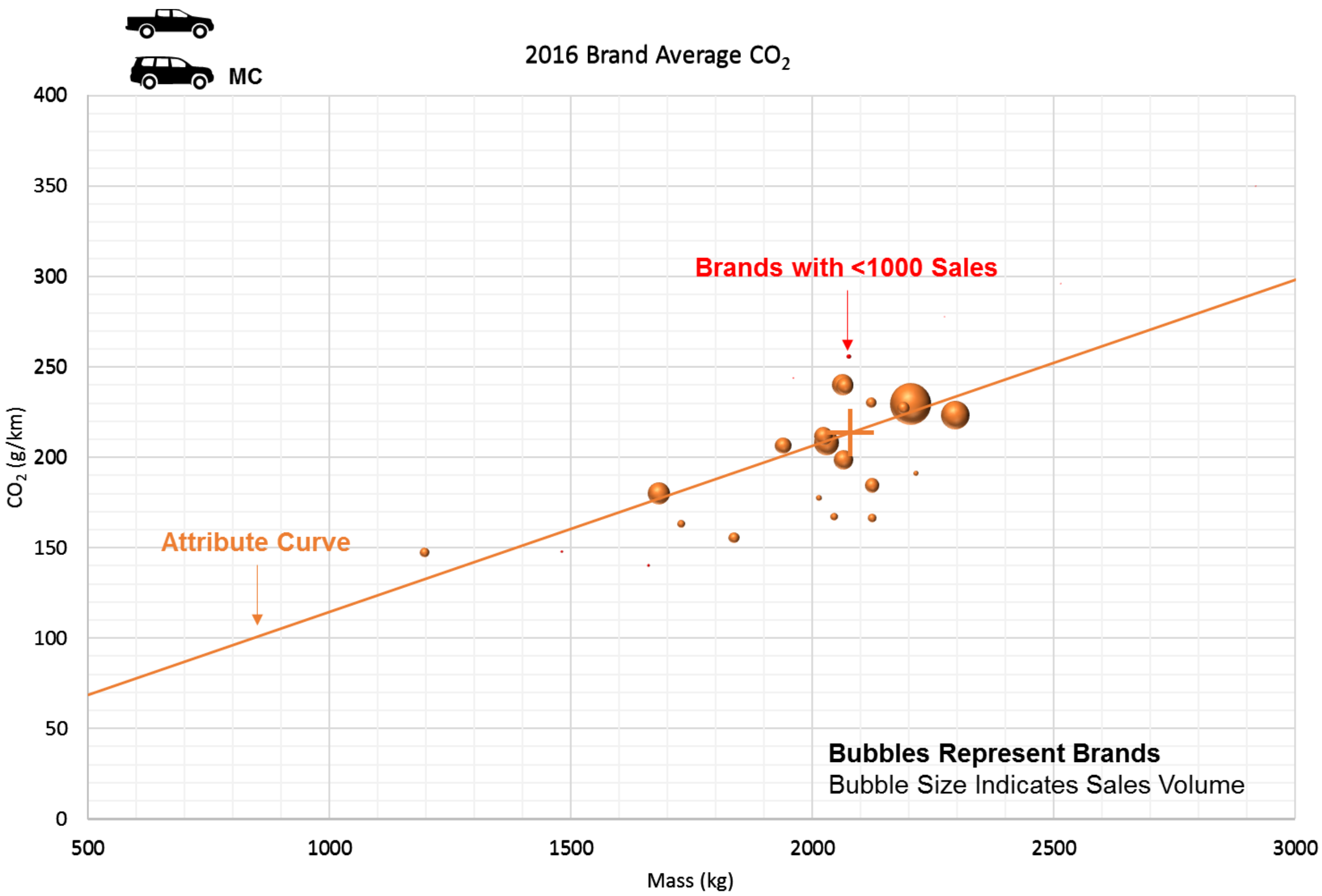


Chart 16 - Brand fleet average CO_2 compared to the 2016 NA + MC attribute curve

SUMMARY OF 2016 NEW VEHICLE CO_2

Table 5 below shows that the 2016 average CO_2 emissions was: 168 g/km from the sale of new MA category vehicles, and 214 g/km from the sale of combined NA + MC category vehicles. These occur at an average mass in running order of 1548 kg and 2078 kg respectively. When combined using a sales-weighted approach, this leads to average CO_2 emissions of 181 g/km for all light vehicles, with average mass of 1699 kg.

2016 NEW VEHICLE CO_2		
Vehicle Category	**Average CO_2 (g/km)**	**Average Mass (kg)**
MA	168	1548
NA + MC	214	2078
All Light Vehicles	**181**	**1699**

Table 5 – Summary of new vehicle CO_2, 2016

The two attribute curves for 2016 formed from the vehicle category groups MA (Chart 13) and NA + MC (Chart 15) are considered to be suitable when compared to the fleet averages for each of the vehicle brands. It is therefore possible that these segments may be grouped in this way to form separate future CO_2 targets.

By grouping MA and NA + MC vehicles into separate targets, it provides the flexibility to introduce different rates of CO_2 reduction for each group in the future. It is considered likely that this will be required due to the high rates of dieselisation (a CO_2 reduction strategy) in the NA/MC categories and the payload and towing requirements of their buyers. NA + MC vehicles are typically less suited to the application of electric or plug-in hybrid powertrains than MA vehicles due to these 'fit for purpose' (payload/towing) constraints. This limitation will continue to be an issue in these segments out beyond 2030 unless there is a technology breakthrough. Chart 17 shows the high dieselisation of the NA + MC category vehicles sold in 2016 when compared to MA category vehicles.

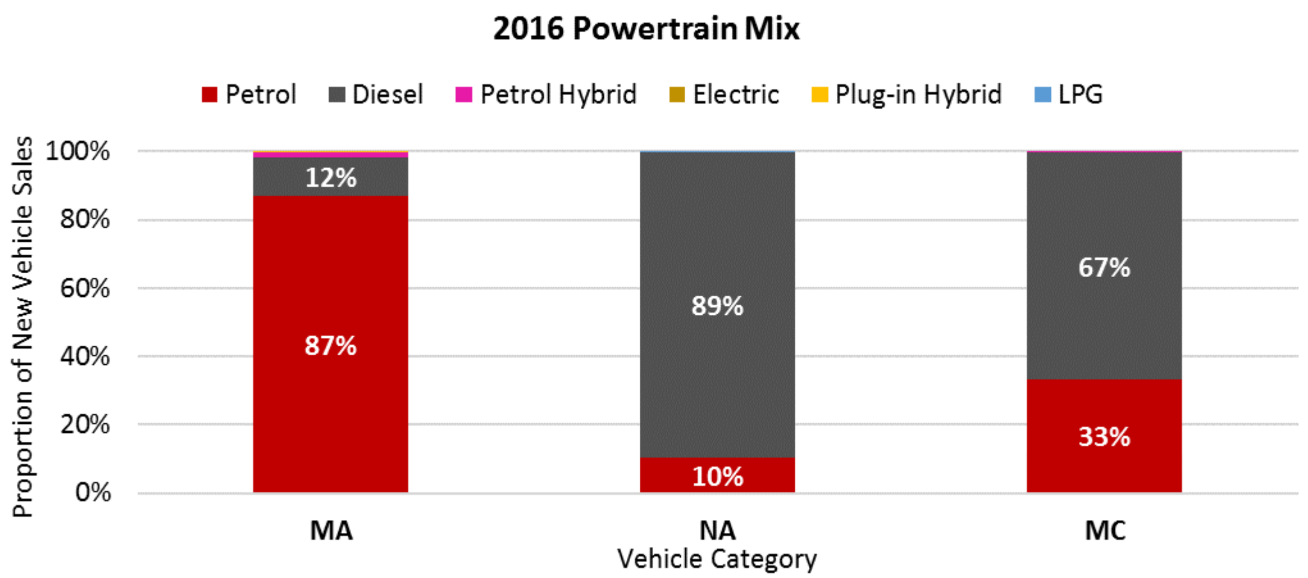


Chart 17 – Sales by powertrain type and vehicle category, 2016

LIGHT DUTY VEHICLE SALES DISTRIBUTION BY PRICE

In order to understand consumer preferences when buying light duty vehicles, the 2016 sales data was analysed by new vehicle price as sourced by Redbook and Vfacts sales data. This price is generally the manufacturer's suggested retail price, and excludes delivery, stamp duty and other government charges.

MA CATEGORY VEHICLES

54% of MA class passenger cars and SUVs sold are priced at under $30,000. Only 1% of the vehicles below $30,000 are non-petrol. 26% of the sales above $30,000 are non-petrol. Vehicles with a technology or powertrain related price premium have higher uptake in the higher price categories. The under $30,000 sales segment is very price sensitive, and it is unlikely that buyers in this category will willingly pay more for technologies or powertrain alternatives to petrol.

In this category, private buyers are far less likely than Government and Business to purchase any alternative powertrain to petrol.

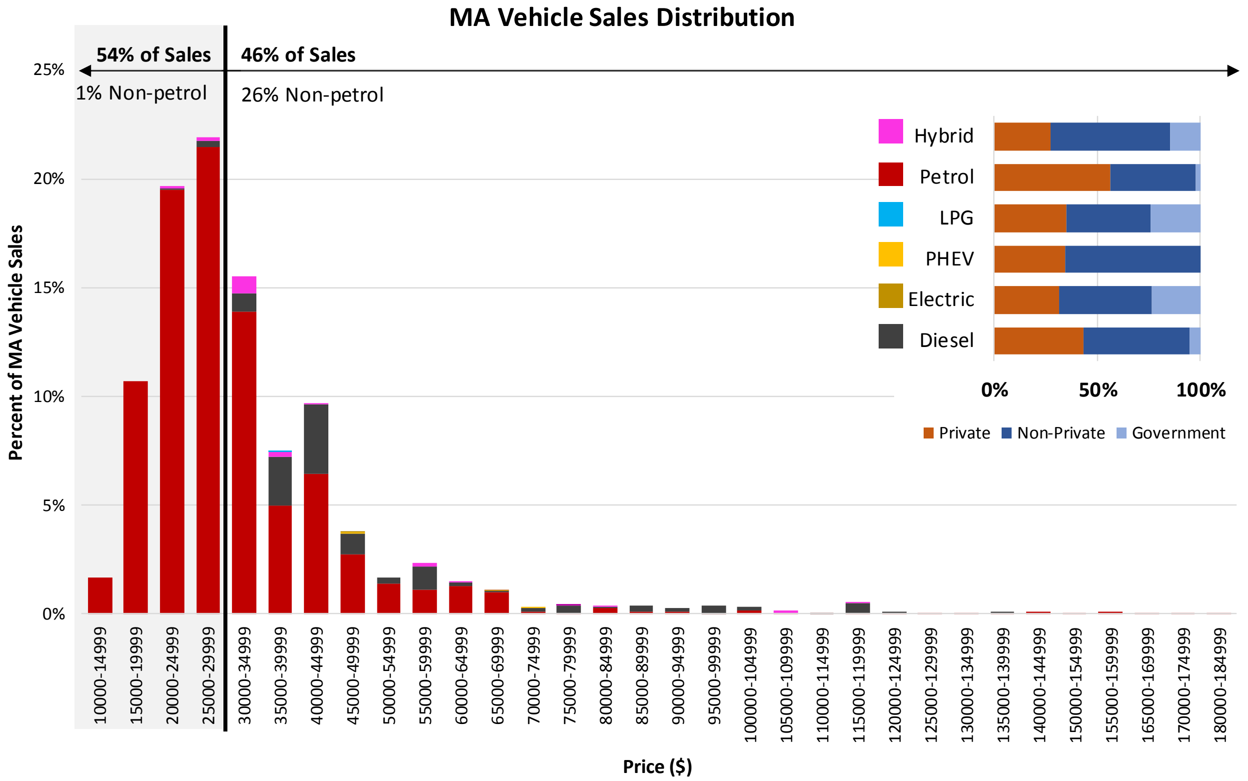


Chart 18 – MA category sales distribution by price

MC CATEGORY VEHICLES

56% of MC sales are above $55,000, 89% of which are diesel and only 0.3% are hybrid. There are no electrified vehicle sales below $55,000 in MC category vehicles, and below $45,000, the rate of dieselisation drops off significantly to 39% of sales. Overall, there are 67% diesel sales in the MC category. There are no pure electric vehicle sales in this category.

Private buyers purchase higher rates of petrol vehicles in this segment than Government and Business. This will be due to the higher price sensitivity of this consumer type.

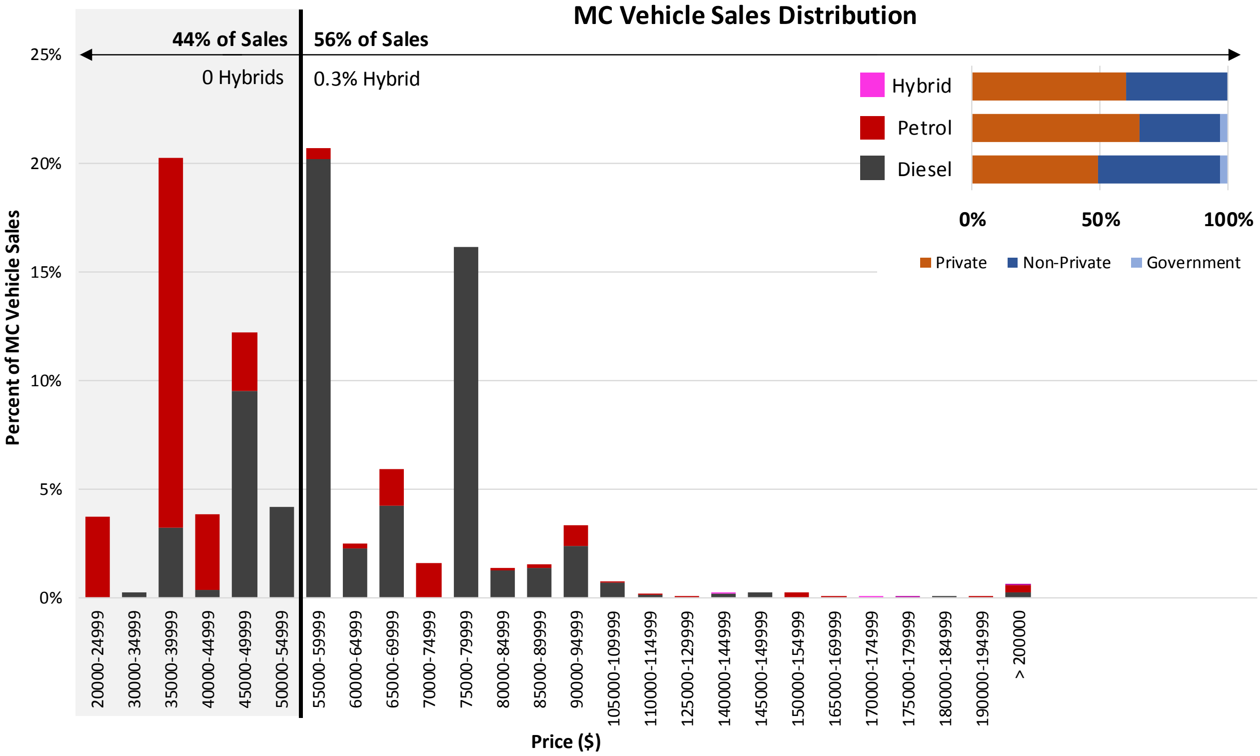


Chart 19 – MC category sales distribution by price

NA CATEGORY VEHICLES

52% of NA sales are above $45,000, and sales are dominated by diesel vehicles with a total of 99% in this price range in 2016. Four electric vehicles were sold in the $35,000 and under category.

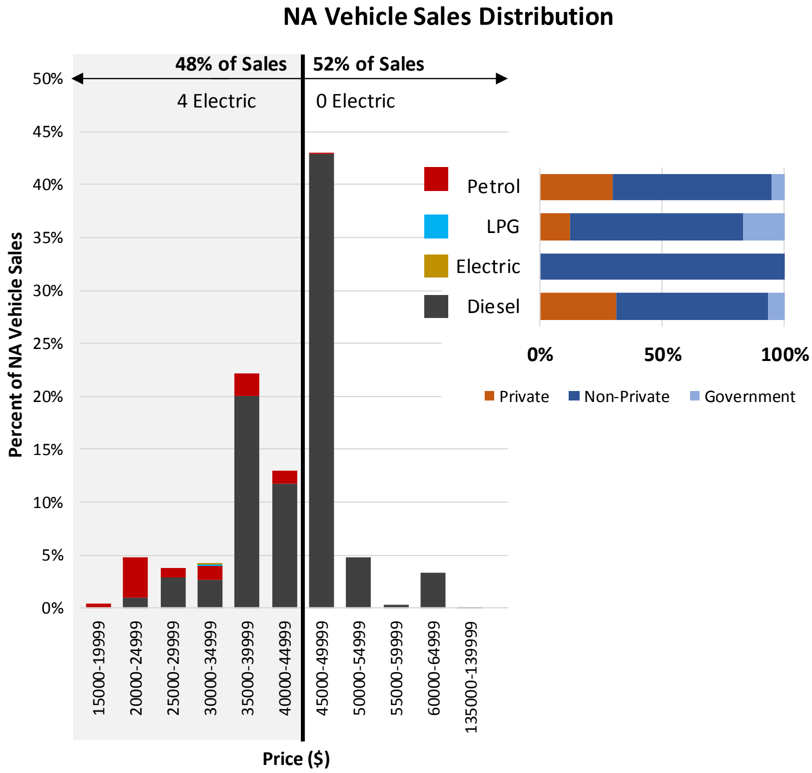


Chart 20 - NA category sales distribution by price

LIGHT DUTY VEHICLE SALES DISTRIBUTION BY ENGINE SIZE

MA CATEGORY VEHICLES

Chart 21 below shows the MA vehicle sales distribution by engine size as a percentage of total MA sales. The majority of MA vehicles sold are 2.0L or less (67%) and predominately petrol.

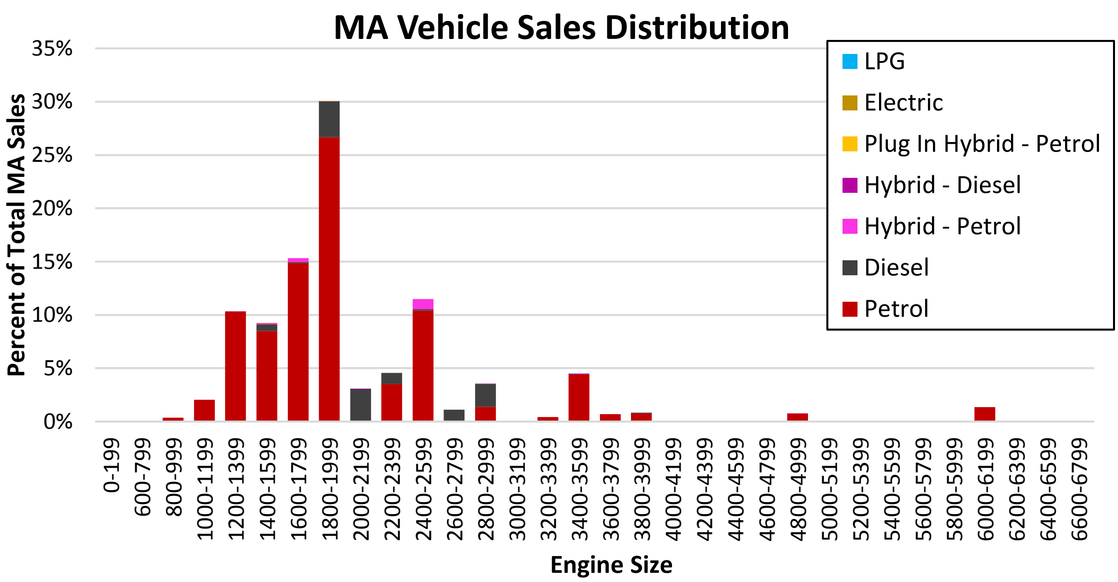


Chart 21 - MA category sales distribution by engine size

MC CATEGORY VEHICLES

Chart 22 below shows the MC vehicle sales distribution by engine size as a percentage of total MC sales.

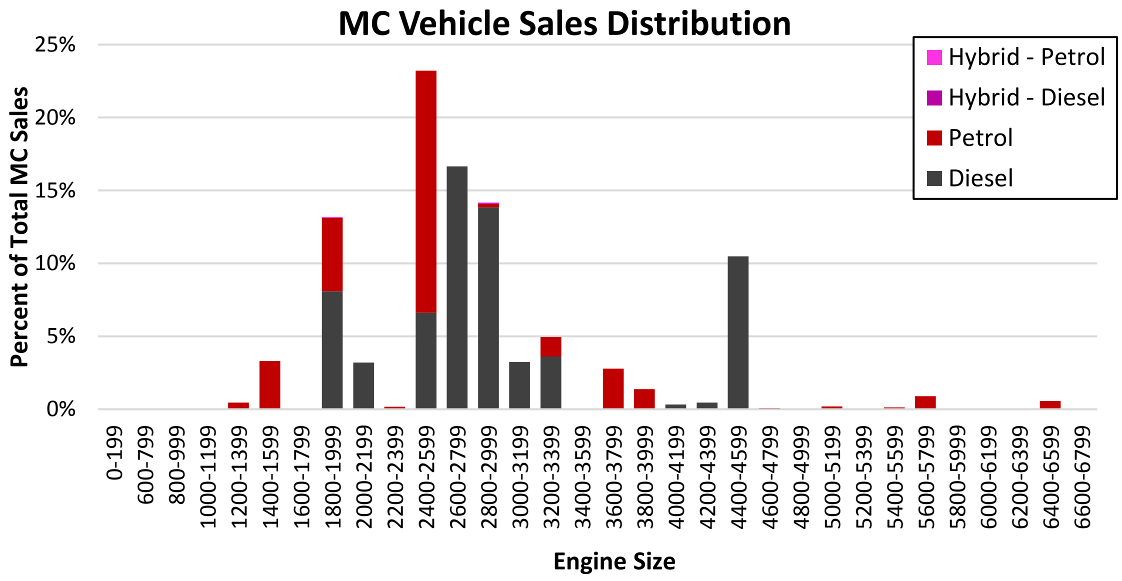


Chart 22 - MC category sales distribution by engine size

NA CATEGORY VEHICLES

Chart 23 below shows the NA vehicle sales distribution by engine size as a percentage of total NA sales.

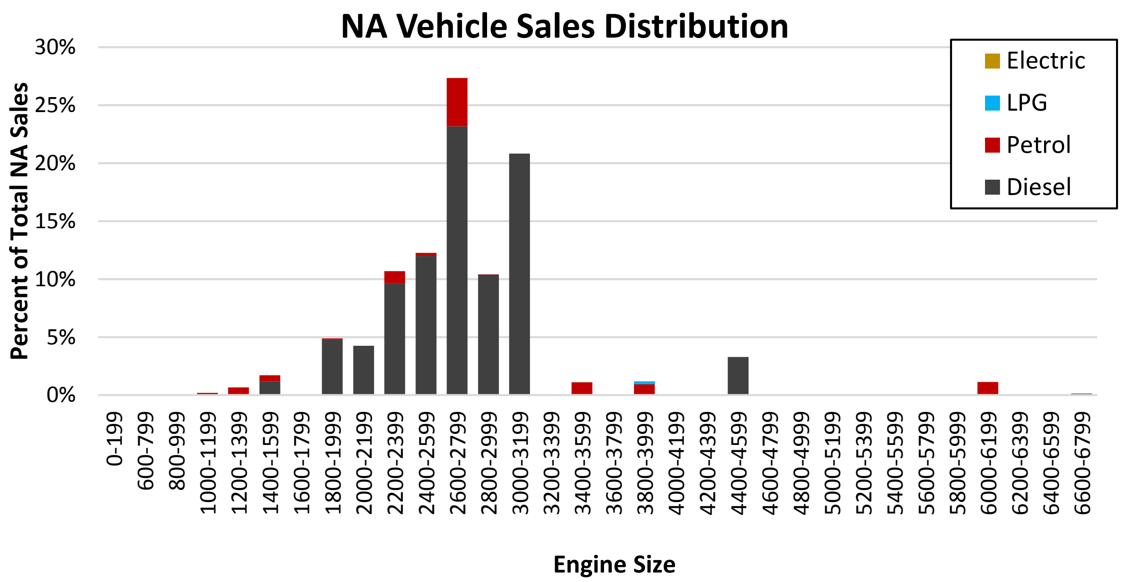


Chart 23 - NA category sales distribution by engine size

UPTAKE OF ALTERNATIVE TECHNOLOGY VEHICLES

ELECTRIFIED VEHICLE MODELS SOLD IN AUSTRALIA IN 2016

Table 6 lists the alternative vehicle models sold in Australia in 2016.

Vehicle	Type	Category
BMW i3	Electric	Passenger
Nissan Leaf	Electric	Passenger
Renault Kangoo	Electric	LCV
Tesla Model S	Electric	Passenger
Honda Accord	Hybrid	Passenger
Honda NSX	Hybrid	Passenger
Infiniti Q50	Hybrid	Passenger
Infiniti Q70	Hybrid	Passenger
Land Rover	Hybrid	Passenger
Lexus CT200H	Hybrid	Passenger
Lexus ES	Hybrid	Passenger
Lexus GS	Hybrid	Passenger
Lexus IS	Hybrid	Passenger
Lexus LS	Hybrid	Passenger
Lexus NX	Hybrid	Passenger
Lexus RX	Hybrid	Passenger
Mercedes Benz C-Class	Hybrid	Passenger
Mercedes Benz E-Class	Hybrid	Passenger
Mercedes Benz GLE-Class	Hybrid	SUV
Nissan Pathfinder	Hybrid	SUV
Porsche Cayenne	Hybrid	SUV
Toyota Camry	Hybrid	Passenger
Toyota Corolla	Hybrid	Passenger
Toyota Prius	Hybrid	Passenger
Audi A3	Plug In Hybrid	Passenger
BMW 3 series	Plug In Hybrid	Passenger
BMW i3	Plug In Hybrid	Passenger
BMX X5	Plug In Hybrid	SUV
Mercedes Benz C-Class	Plug In Hybrid	Passenger
Mitsubishi Outlander	Plug In Hybrid	SUV
Volvo XC90	Plug In Hybrid	SUV

Table 6 – Alternative technology vehicles sold in Australia in 2016

PURCHASERS OF ALTERNATIVE TECHNOLOGY VEHICLES

Chart 24 shows that alternative technology vehicles are predominantly purchased by Government and / or non-private purchasers. Private buyers appear most happy to invest in Toyota's various hybrid models, which is likely a result of Toyota's long-term commitment to hybrid technology.

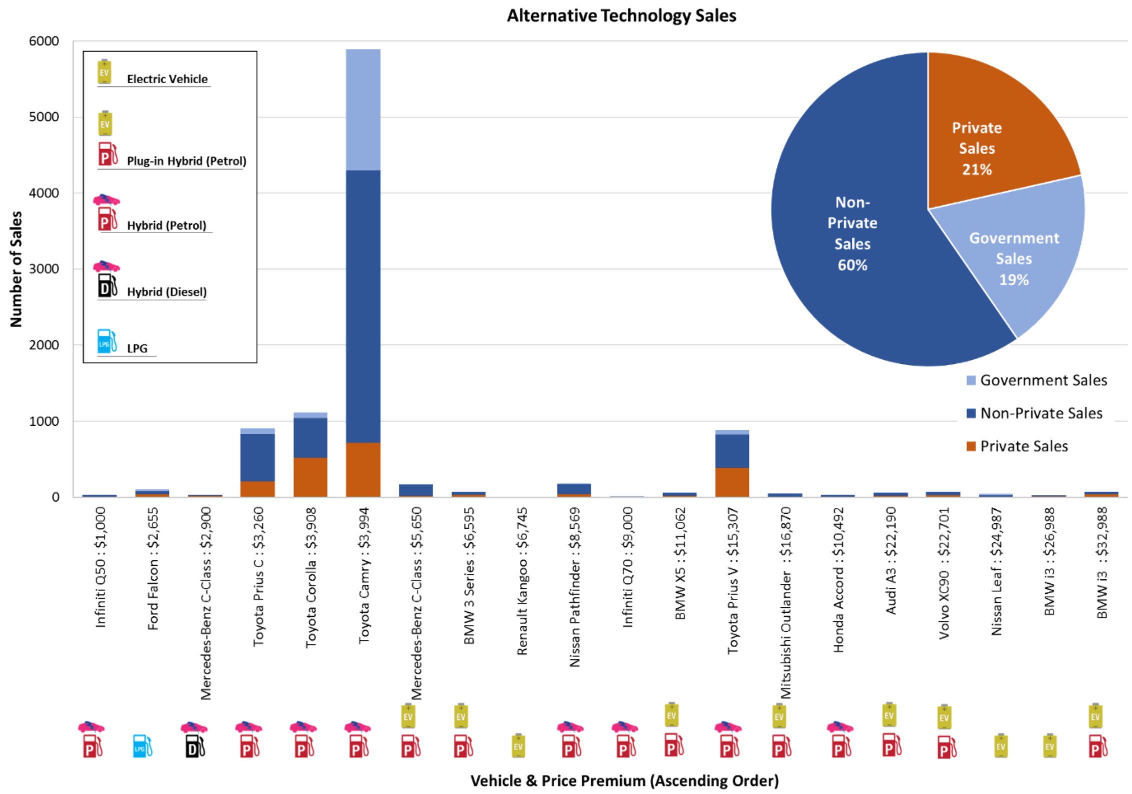


Chart 24 - Price premium for alternative technology vehicles

CONSUMER WILLINGNESS TO PAY FOR ALTERNATIVES TO PETROL VEHICLES

Some manufacturers offer the same model with different fuel or powertrain options.

Chart 25 shows that purchasers of several SUV models are more likely to pay significantly more to buy a diesel variant over the petrol version. The LPG version of the Ford Falcon Ute when available, was preferred by over 30% of purchasers. In the MA category, few consumers are willing to pay extra for diesel, LPG or alternative powertrain technologies unless the vehicle offers a performance advantage, the cost is small or it is a luxury model with a high starting base price.

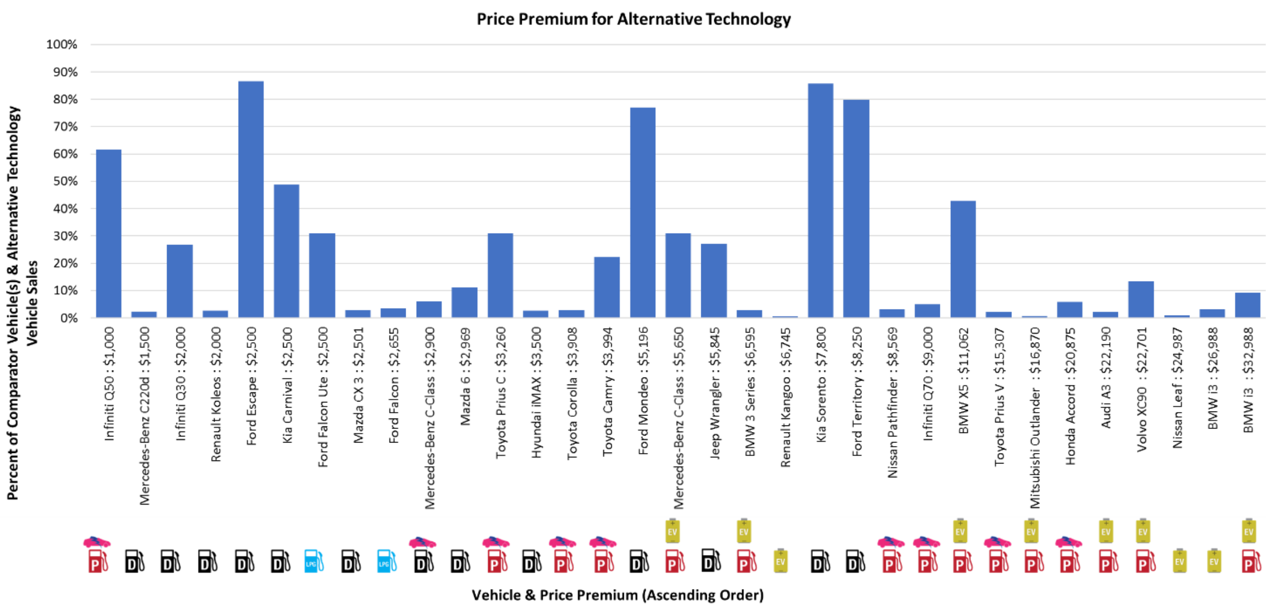


Chart 25 - Willingness to pay for new or alternative technologies

TOWING CAPABILITY OF HYBRID AND ELECTRIC VEHICLES

Many later model hybrid vehicles have towing capability, and most have comparable towing capacity to similar internal combustion vehicles. Table 7 compares the towing capacity of current hybrid and electric vehicles with comparable internal combustion vehicles from the same manufacturer. The Tesla Model X has a towing capacity of 2,250 kg and the Nissan Leaf can tow up to 1,000kg.

Hybridisation is not expected to dramatically affect the load carrying or towing capability of many passenger vehicles, although the payload of light commercial vehicles could be reduced by the additional weight of electrification due to the much larger battery size required, which could be from 8% in a hybrid up to 30% in a fully electric vehicle.

Hybrid and Electric Vehicles with Towing Capability				
Model Group	**Transmission type**	**Vehicle Category**	**Hybrid or Electric Version Braked Tow Capacity (kg)**	**Comparator Braked Tow Capacity (kg)**
Hybrid Vehicles				
BMW X5	Auto	MA	2,700	2,700
Mercedes-Benz C-Class	Auto	MA	1,600	2,000
Lexus RX	CVT	MA	1,500	1,500
Lexus GS	CVT	MA	1,500	1,600
Infiniti Q70	Auto	MA	1,500	1,500
Infiniti Q50	Auto	MA	1,500	1,500
Nissan Pathfinder	CVT	MA	1,650	2,700
Toyota Camry	CVT	MA	300	1,200
Mercedes-Benz E-Class	Auto	MA	2,100	1,900
Mercedes-Benz GLE-Class	Auto	MA	2,000	3,500
Lexus NX	CVT	MA	1,000	1,000
Land Rover Range Rover	Auto	MC	3,000	3,500
Land Rover Range Rover Sport	Auto	MC	3,000	3,500
Porsche Cayenne	Auto	MC	3,500	3,500
Volvo XC90	Auto	MC	2,400	2,250
Electric Vehicles				
Tesla Model X	Auto	MA	2,250	N/A
Nissan Leaf	Auto	MA	1,000	N/A

Source: redbook.com.au

Table 7 – Hybrid and Electric Vehicles with Towing Capability

TOWING RANGE OF ELECTRIC VEHICLES

Depending on the size and aerodynamic qualities of the specific load being towed, towing can significantly reduce the range of any vehicle, regardless of powertrain.

Table 8 compares the reduction in range of electric and internal combustion engine vehicles when towing (expressed as a proportion of their original range). The results are from real-world road tests of caravans, with the range of internal combustion engine vehicles calculated from their real-world fuel economy, and for a fair comparison, using the real-world range of an electric car as a baseline. It should be noted that the information is obtained from various sources, and testing each of the vehicle models with the same caravan would provide more accurate information. (The EV comparison was with the same caravan).

Although the reduction in range of an electric vehicle when towing is not necessarily worse than a vehicle using a petrol or diesel, their absolute lower towing range is still the key consideration for consumers, particularly in Australia. The lower range of an EV compared to an equivalent ICE vehicle results in an already short range being reduced further, making towing a caravan, boat or horse float for long distance or touring purposes possible only if charging stations are regularly spaced along their desired journey.

This highlights the importance of a diverse network of charging stations to gaining market penetration of EVs and that their uptake will be limited to specific segments of the vehicle market, including out to 2030.

Reduction in Real-World Range when Towing a Caravan		
Vehicle	**Caravan weight (tonne)**	**Real world range (km)**
Electric Vehicle		
Tesla Model X (60D)	1.6 tonne	112 km
Tesla Model X (75D)	1.6 tonne	136 km
Tesla Model X (90D)	1.6 tonne	156 km
Tesla Model X (100D)	1.6 tonne	176 km
Internal Combustion Engine Vehicles		
Toyota Landcruiser (2016)	1.4 tonne	932 km
Toyota Landcruiser	2.4 tonne	493 km
Toyota Fortuna	2.5 tonne	417 km
Toyota Fortuna	2.2 tonne	460 km
Mazda BT-50	2.1 tonne	516 km
Mitsubishi Pajero (2009)	2.3 tonne	463 km

Sources: Various

Table 8 – Reduction in range when towing for electric and ICE vehicles

OUTLOOK TO 2030

OVERVIEW

In forecasting the future sales of light vehicles, it is expected that the greatest changes in the land transport sector for 100 years will occur in the next 15 years.

Euro 6d regulations (introduced in late 2017) will make it extremely difficult for manufacturers to produce diesel vehicles that will meet the NO_X requirements in real world testing over the coming years due to a progressive decrease in the applicable conformity factor. This may be considered a "defacto ban" of this powertrain technology.

In response, some manufacturers, such as Volvo have announced that they will no longer develop diesel engines in future (although existing engine platforms will continue to be developed).

Additionally, various countries have stated that they will limit or ban diesel engine vehicles due to their contribution to pollution. These vehicles have previously been promoted due to the CO_2 reductions they provide when compared to conventional petrol vehicles. Various jurisdictions have announced that conventional internal combustion vehicles will be replaced with electric vehicles, although a mix of hybrid and electric vehicles may be more likely in the mid-term.

In Australia the uptake of diesel engine vehicles in the MA passenger category is low compared with that of Europe due to the price premium and lack of regulatory "levers" used in many European countries.

Whilst diesel offers the most cost-effective way of reducing light vehicle CO_2 emissions by 2030, it is not certain how many diesel vehicle models will be offered by vehicle manufacturers in the future. ABMARC advises against any policy promoting the uptake of diesel vehicles in the MA category to reduce fleet CO_2 due to the increase in PM, PN and NOx emissions, and the negative impact that these pollutants have on human health outcomes.

Instead of diesel, consumers may prefer to make the shift to a hybrid petrol vehicle, or (if the total cost of ownership allows) an electric passenger vehicle. In the modelling of the future vehicle sales, the average cost of an electric vehicle (EV) relative to a standard petrol vehicle has been estimated as $10,000 in 2025, reducing to $5,000 in 2030 (2016 prices).

Research into the future cost of electric powertrains, including discussions with technology providers revealed that by 2025, the price premium of an EV relative to an equivalent ICE vehicle varies between zero and $10,000. The risk of using a low forecast price premium for EVs is that if their true cost is greater than an equivalent ICE vehicle, this could result in significant fines for non-compliance with CO_2 targets that rely upon significant EV market penetration. Using a $10,000 price premium for 2025 and $5,000 in 2030 ensures that targets are chosen based on a conservative EV uptake forecast, leading to a higher confidence that the targets can be achieved.

Powertrain Suitability by Vehicle Type 2030

Based on conservative BAU technology cost assumptions (selecting the upper price bound) of electrified vehicles and the fit for purpose requirements in each segment, Table 9 below provides an overview of the appropriateness of various powertrain types in 2030.

Under these assumptions, EV and PHEV MA class vehicles are unlikely to achieve widespread uptake and adoption across the entire MA class by 2030. Many models will be available in the less price sensitive segments of these markets (above $30,000), and these models will likely be purchased for their comparative performance advantages over petrol and diesel powertrains, rather than their green or operating cost credentials.

In the LCV (ute) and MC segments, PHEVs and EVs will be limited in their uptake, not due to price, but fit for purpose limitations being:

- Reduced payload capacity
- Unacceptable towing range

2030 Powertrain Suitability by Vehicle Type					
Vehicle Type	**Petrol**	**Diesel**	**Hybrid**	**PHEV**	**EV**
Passenger	✓	△ Higher Cost Than Petrol	△ Higher Cost Than Petrol	× High Cost	× High Cost
MA SUV	✓	△ Higher Cost Than Petrol	△ Higher Cost Than Petrol	× High Cost	× High Cost
MC SUV	△ High Fuel Consumption Torque < Diesel	✓	△ Reduced Payload	× High Cost Reduced Payload	× Reduced Payload Low Towing Range
LCV Ute	△ High Fuel Consumption Torque < Diesel	✓	△ Reduced Payload	× High Cost Reduced Payload	× Reduced Payload Low Towing Range
LCV Van	△ High Fuel Consumption Torque < Diesel	✓	△ Reduced Payload	× High Cost Reduced Payload	× Reduced payload Low Towing Range

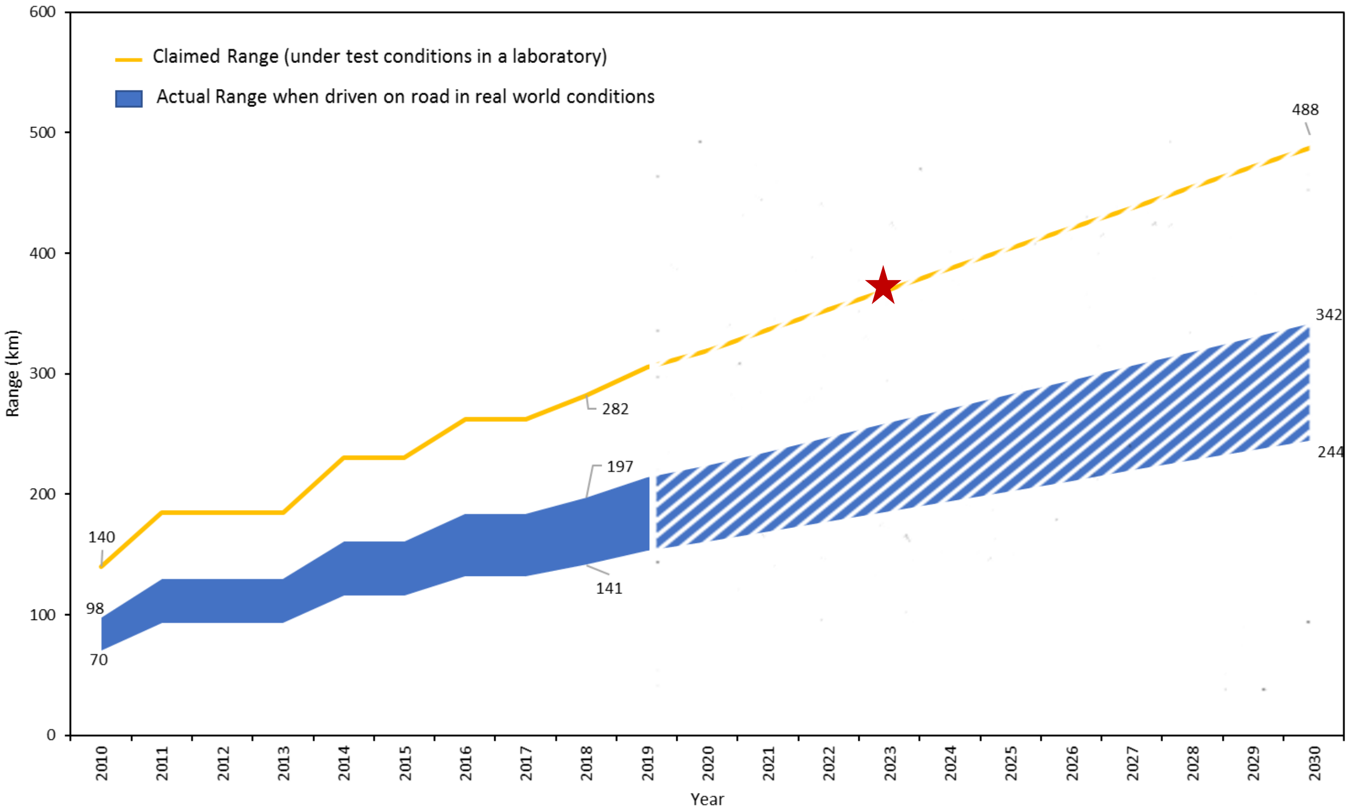
Table 9 – 2030 Powertrain Suitability by Vehicle Type

ELECTRIFIED VEHICLE ANALYSIS

Most vehicle manufacturers are announcing plans to “electrify” their model ranges over the coming years, although many are vague as to the number of models that will be pure electric versus the number that will be a form of hybrid.

Currently, there is no regulation or incentive in place to encourage the uptake of electric vehicles in Australia. Experience overseas has shown that this is required to increase the uptake at the current technology and price levels. Whilst the present range of electric vehicles would suit the day to day requirements of many Australian MA category motorists, consumers are not willing to pay the price premium required for electric vehicles at this time. Concerns also exist regarding range and recharging infrastructure.

Electric vehicle range is forecast to increase, and “range anxiety” is likely to be reduced once the average claimed range reaches around 350 kilometres. This is anticipated to be achieved from around 2023. It should be noted that actual range can be significantly less than the claimed range, as shown in Chart 26 below due to driving style, the use of onboard accessories (such as air-conditioning and radio), and temperatures extremes (common in Australia).



Source: ABMARC, various vehicle manufacturers

Chart 26 - Electric vehicle range trends

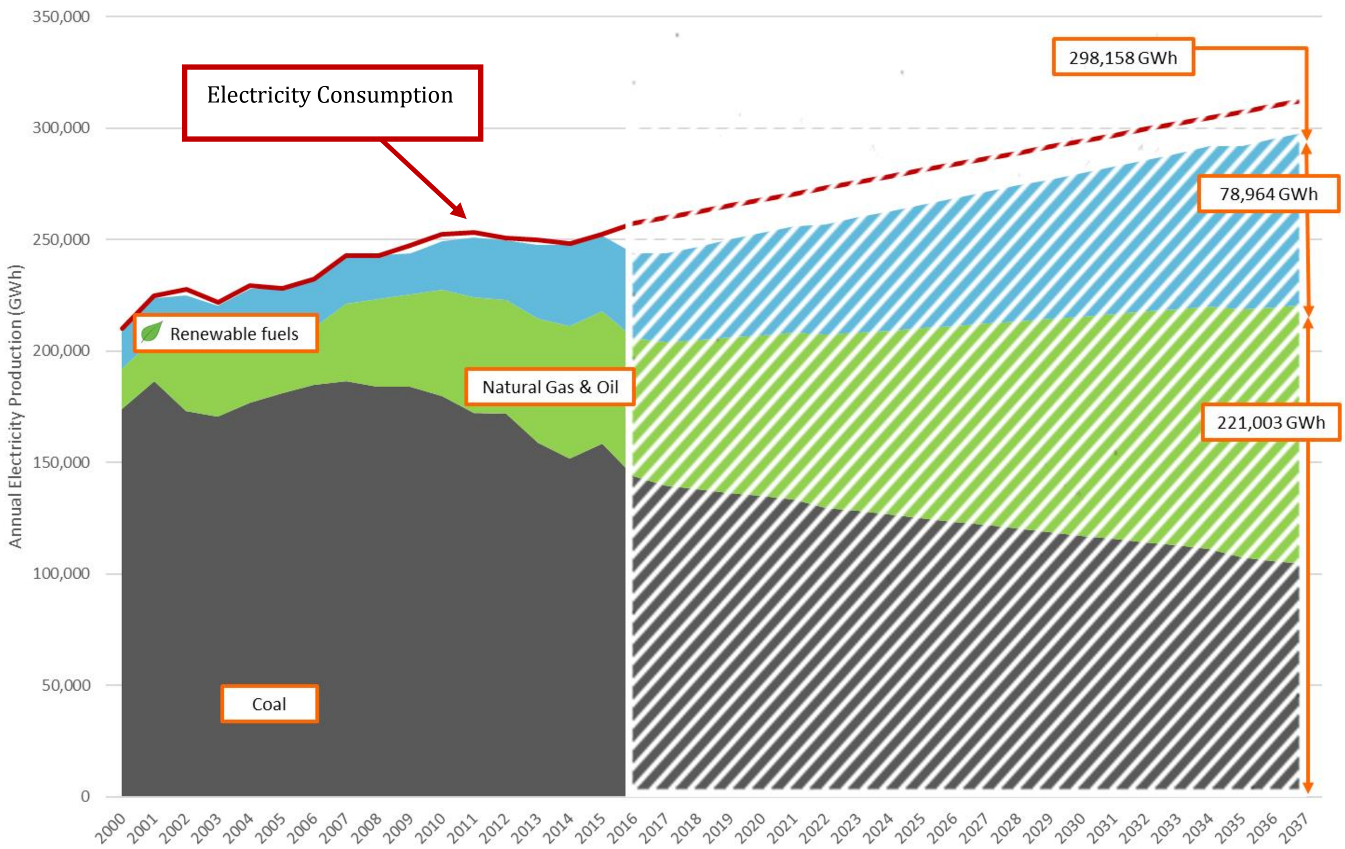
Battery production is increasing, with China leading the world. Globally, there is capacity for approximately 65 GWh annual production. By 2020, capacity is anticipated to reach 240 GWh (based on announcements). The electricity supply in Australia is likely to be uncertain over the next years, however, it is anticipated that the relatively small electric vehicle uptake until 2025 is unlikely to cause specific issues. For the purposes of this analysis, it has been assumed that the current issues in electricity generation will be resolved by the mid-2020s.

Lithium-ion batteries are likely to be the predominant battery over the next 7 years or more. These rely on a number of rare earth materials such as lithium carbonate, cobalt and high-grade graphite. Whilst US Geological Survey data shows that there are likely to be sufficient reserves of these elements, not all reserves are currently being tapped which could limit supply. Further, some elements are currently predominantly mined in the Democratic Republic of Congo (which has questionable labour practices and potential political instability), or in China (which has been accused of "price fixing" and poor labour conditions). Battery manufacturers may seek to secure supplies from countries that do not have significant ethical concerns around their mining practices, and which may be more stable in terms of supply and price. Notwithstanding this, it is currently anticipated that the raw material supply for electric vehicle batteries is likely to be sufficient for the short to mid-term.

The price premium for electric and hybrid vehicles is directly linked to the cost of batteries and, specifically for a hybrid, the complexity of a system with dual propulsion systems (internal combustion engine and electric motors).

Significant development and investment over the past five years to advance lithium battery technologies has reduced the cost per kilowatt hour (kWh) from around USD$1,000 to around USD$150.

Australian Electricity Production and Trend



Source: AEMC, AER, DIIS, ABMARC
Chart 27 - Australian electricity production and trend

A reduction in electricity production from coal in 2015 and 2016 results in a drop in overall production. Australian Government data shows a gap between electricity consumption and generation in 2016. Initial investigation indicates differences in how electricity generation and consumption is handled by various Government agencies; some include consumption from private generation sources (due to impact on greenhouse gas emissions).

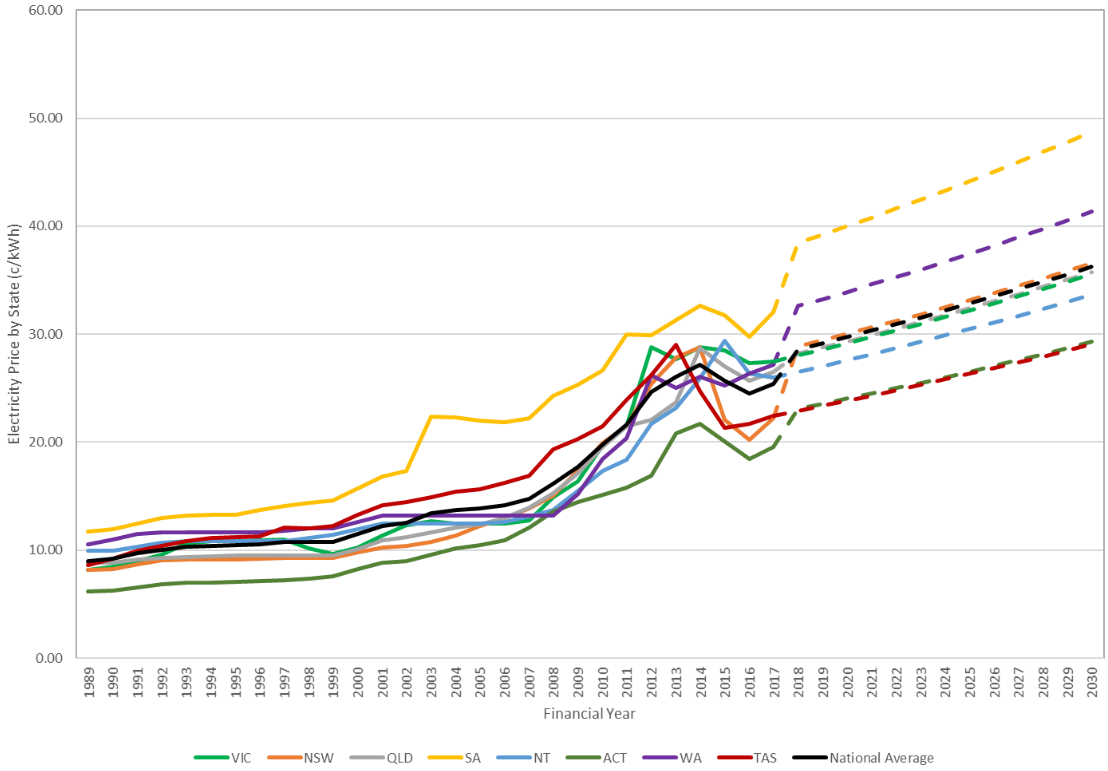
Electricity consumption in 2016 was the highest recorded to date. Electricity consumption continues to increase year on year, with a 2% increase in 2016. Electricity consumption increased 6% over the last ten years.

Uncertainty in supply is expected over the next 3 – 5 years. With the current situation, Australia's electricity network is not in a position to reliably support significant uptake in electric vehicles, if this is resolved, it is likely that the price of electric vehicles will limit their uptake, rather than the electricity supply.

Renewable energy production continues to increase. Small scale solar generation increased 18% in 2016 (Department of Environment, 2017) and amounted to 2.5% of the overall electricity generated. There were approximately 6,750 solar battery installations reported in 2016 and approximately 21,000 are anticipated in 2017.

Electricity Pricing and Trend

Electricity prices continue to rise and are expected to continue to increase into the future, particularly if the 2000 MW Liddell Black Coal power station closes as planned in 2022. Uncertainty in the generation market may cause additional price hikes over the coming years.



Source: AEMC, DIIS, ABMARC, various electricity retailers
Chart 28 - Australian electricity production and trend

South Australian residents currently pay the highest electricity prices in the world, with some reports placing New South Wales, Queensland and Victorian residents in fifth, seventh and ninth place respectively. The average residential retail electricity price is 29.85 c/kWh in the European Union and 15.75 c/kWh in the United States.

Residential "Time of Use" Electricity Prices(c/kWh) (October 2017)								
	VIC	NSW	QLD	SA	NT	ACT	WA	TAS
Peak	38.37	60.96	35.20	48.24	21.40	30.20	50.35	31.31
Off Peak	16.61	14.39	22.00	48.24	17.11	15.86	13.87	14.58
Average	27.49	37.68	28.60	48.24	19.26	23.03	32.11	22.95

Source: Various energy retailers
Table 10 - Residential time of use electricity prices by State

Case Study on the Cost of Running an EV

The costs of operating comparable electric and conventional vehicles from BMW have been compared on a State by State basis. True comparisons are difficult in Australia, as EV models are scarce.

Both vehicle models are currently available in Australia.

Details	Electric Vehicle	Conventional Vehicle
Vehicle	BMW i3	BMW Series 1 (118i)
Energy capacity	94 Ah (33 kWh)	52 L
Energy requirement per 100 km	18.13 kW / 100 km	5.2 L / 100 km
Price	$65,900	$36,900
BMW Service Package (all standard servicing needs for 5 years / 80,000 km)	$920	$1,340
Level 2 charger (inc. installation)	$2,546	$0
Range	Up to 200 km	520 km
Curb weight	1,195 kg	1,360 kg

Source: caradvice.com.au, BMW, evo.co.uk, evse.com.au, ABMARC
Table 11 – Cost of running (energy price) comparison vehicles

Electric vehicles are commonly cited as being significantly less expensive to maintain. Whilst the Service Package price for the BMW 118i is 45% higher than the BMW i3's package, in real numbers, they are only $420 apart in total for five years. This is not considered a significant saving.

To achieve relatively fast charging at home, a Level 2 charger is required. BMW offers a "Wall Box" which retails at a similar price to other commercially available Level 2 chargers. Installation costs are typically cited as approximately $800, however, anecdotally, some new EV owners have needed to have additional work performed to ensure that their home wiring system can handle the load.

Using the average price of petrol per State for 2016, the cost to run the BMW 118i per 100 kilometres is provided in Table 12 below.

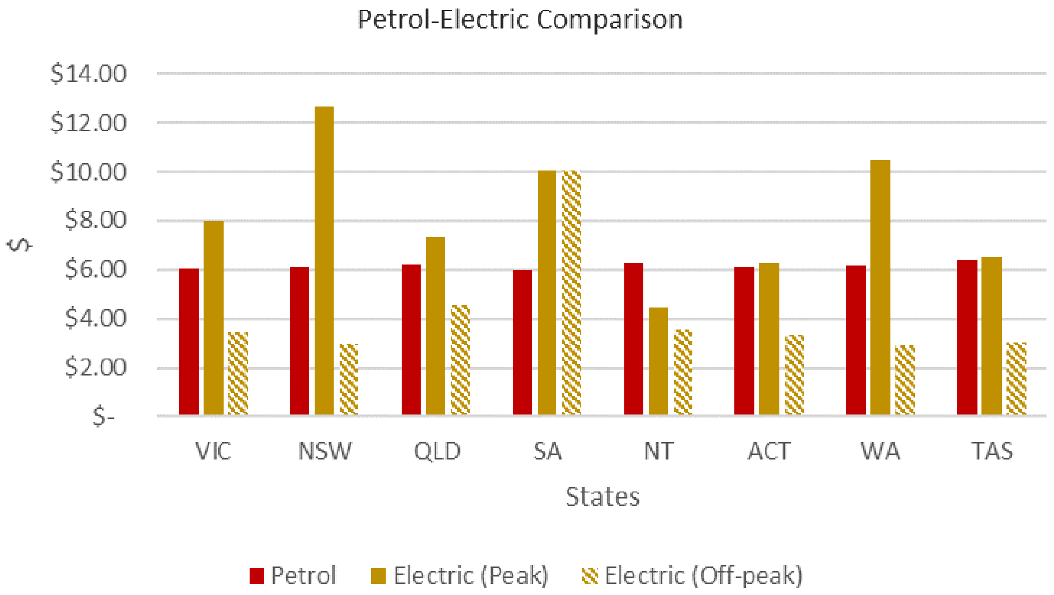
	VIC	NSW	QLD	SA	NT	ACT	WA	TAS
Average petrol price (2016) (cents per litre)	116.4	117.6	119.8	114.6	121.3	117.6	118.3	123.2
Cost to run BMW 118i per 100 km	$6.05	$6.12	$6.23	$5.96	$6.31	$6.12	$6.15	$6.41

Source: AIP, BMW, ABMARC
Table 12 – Energy cost to run a conventional vehicle by State

Using the reported real-world energy requirement of 18.13 kW / 100 km for the BMW i3 and the October 2017 energy prices listed in Table 10, the energy cost of running a BMW 1 series (model 118i) for 100 kilometres is illustrated in Chart 29 below. Charging losses of 15% have been applied.

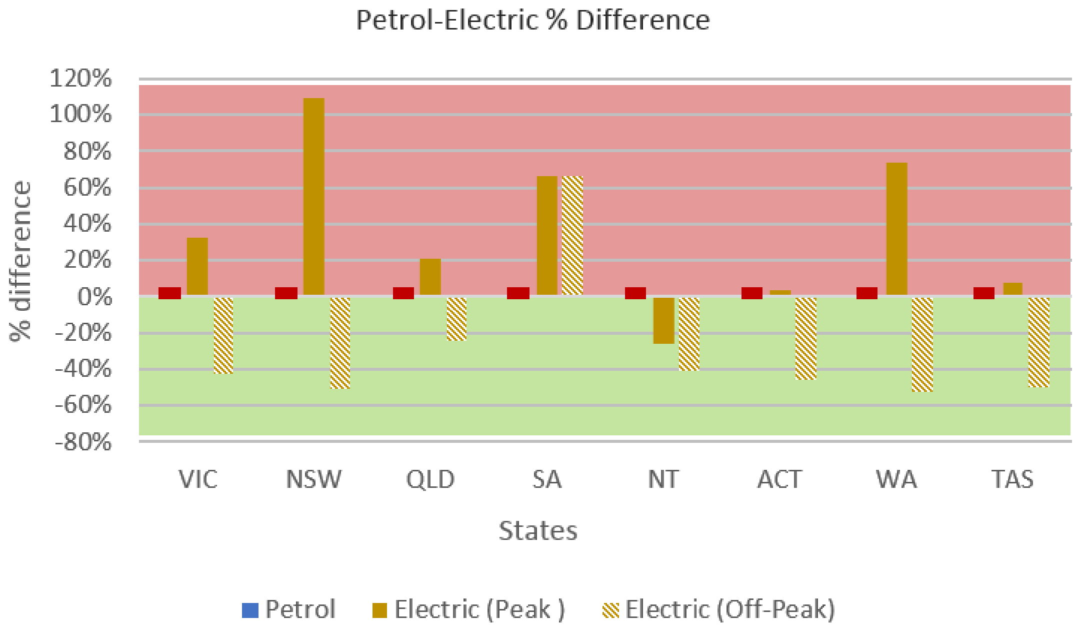
It can be seen that in all states and territories, with the exception of South Australia, it would be cheaper to run an electric vehicle than a conventional vehicle if it were exclusively recharged during off-peak times. However, in seven States or Territories it would be more expensive to operate the electric vehicle if charged during peak times.

Using the price to operate the vehicle on petrol for each State as a baseline, the percentage difference in running cost can be seen in Chart 30 below.



Source: ABMARC based on various data
Chart 29 – Comparison between petrol and peak and off-peak electricity energy costs

In Chart 30 below, the petrol running cost is the respective baseline for each State. The peak and off-peak electric percentage differences are calculated from that baseline.



Source: ABMARC based on various data
Chart 30 - Energy cost to run an electric vehicle for 100 kilometres by State

Chart 29 and Chart 30 above reflect "real" retail costs. It should be noted that some energy retailers, such as AGL, are currently offering customers "unlimited" charging for their electric vehicles for $1 per day. AGL will install a separate meter for EV use, and will also subsidise the cost of a Level 2 charger.

MODE SHIFTING

Commuter traffic (rail, bus and car) is expected to continue growing, despite a downwards trend in people obtaining drivers licences. Taking an intermodal approach to public transport by viewing the entire transport network (including foot and cycle paths) as a whole and optimising scheduling is likely to assist in increasing the number of people using public transport, particularly in the inner-city and inner suburbs.

It is likely that autonomous vehicles, potentially with ride-sharing capability, will be considered part of the public transport infrastructure from around 2025.

Despite improvements in intermodal transport, congestion is expected to continue increasing to 2030 due to increases in activity and increased population. Migration to high–speed internet “connected” regional towns within commutable distance from capital cities may be increasing, however, anecdotally, this appears to be a stronger trend with older, retired, demographics “cashing in” their city properties.

Autonomous cars are expected to become relatively common from 2020. Autonomous vehicles are expected to change the purchase criteria used by new buyers, with traditional features such as engine performance, handling and drivability making way for reliability, low fuel consumption, individual connectivity/entertainment, and comfort.

Mode shifting may result in a decrease in the average kilometres travelled per vehicle to 2030, however, overall vehicle numbers and Vehicle Kilometres Travelled is anticipated to continue increasing.

A reduction in the number of people obtaining drivers licences, and an aging population, are expected to provide a ready market for autonomous vehicles.

New technology is being taken up more and more rapidly, with consumers accepting new technologies faster than ever before. The design cycles of new products are decreasing significantly, including for new road vehicles. The “generation” length of technology (such as computing technology) is also decreasing. These advances mean that digital disruption provides the greatest ‘unknown’ in forecasting trends, and a regular review of trends and opportunities is recommended.

2030 BUSINESS AS USUAL FORECAST

KEY MODELLING ASSUMPTIONS

In developing the BAU forecast for the sales of new light vehicles in 2030, the following assumptions were made:

- PC market share reduces to 32% of light vehicle sales (25% decrease from 2016).
- SUV market share increases to 49% of light vehicles sales (26% increase from 2016).
- LCV market share increases to 19% of light vehicles sales (2% increase from 2016).
- MC category vehicles (as a proportion of SUVs) remain constant at 2016 levels (21% of SUV sales).
- New vehicles sales increase at a rate of 2.1% per annum from 2016 to 2025, reducing to 1.8% growth per annum from 2025 to 2030.
- Oil will remain plentiful and (relatively) cheap and the relative price difference between fuels will remain.
- As vehicles will no longer be manufactured in Australia, changes in vehicle efficiency will largely be propelled by overseas government regulation; this will see a continued decrease in the average fuel consumption of new vehicles.
- That Australian fuel quality will continue to meet the technology requirements of vehicles.
- The vehicle test cycle used to measure vehicle CO_2 emissions continues to be the NEDC, or is translated into an NEDC equivalent.
- Electric vehicles will be readily available and will have an average price premium of $10,000 in 2025, reducing to $5,000 by 2030.
- Euro 5 emissions standard will continue to be the minimum mandatory standard in Australia, however it is not known if manufacturers will support highly efficient engines, such as those available overseas to meet CO_2 targets, out to 2030.
- Manufacturers' market share remains the same in 2030 as in 2016.
- The average vehicle mass remains constant and changes in the overall (sales-weighted) fleet mass are due to changes in the fleet mix.
- The ability of LCVs and MC category SUVs to reduce CO_2, when compared with MA category vehicles is significantly less due to the already high dieselisation rates and fit for purpose requirements of buyers.
- Unique domestically produced vehicles that are still sold in 2016 (Holden Commodore, Ford Falcon and their Ute derivatives) will be replaced in 2030 by models with similar utility and smaller, more efficient engines.
- In determining the technology and powertrain adoption required to meet CO_2 targets, the lower cost options are selected first before progressing to the higher cost. In the case of powertrain, a natural progression has been used whereby petrol penetration is replaced by diesel and a small proportion of hybrid powertrains, remaining mindful of the current buying habits of consumers. In the case where the highest technology options have been utilised and yet the CO_2 targets are still not satisfied, an increase in electric powertrains will occur whilst further reducing petrol and increasing the proportion of hybrids.
- Although lean-burn direct injection and homogenous charge compression ignition (HCCI) petrol technologies potentially offer significant CO_2 reduction, they have not been considered as viable options for this analysis. At present, few manufacturers utilise lean-burn direct injection across a significant proportion of their fleet, and although Mazda has recently announced the planned mass production of an HCCI, it is not yet known whether this will be introduced to Australia, and if so, whether the technology would achieve significant penetration.
- The vehicle brands present in the 2016 Australian market continue to be present in 2030, with the addition of no new brands.

LIMITATIONS OF MODELLING AND ANALYSIS

- The requirement by manufacturers for vehicle operators to use a higher octane fuel (at a higher price than regular unleaded) or the additional costs that are likely to be incurred to meet future vehicle emissions standards have not been considered in this analysis.
- The ability of manufacturers to meet a limit curve is sensitive to the fleet mix. As the modelling and limit curve development has required fleet mix forecasts to be established, it may not accurately reflect consumer choice in 10 years. For this reason, it is recommended that policy development in this area include a mechanism for updating the limit curves to reflect changes in the fleet over time.
- As the fleet average CO_2 is sensitive to the sales mix, regular review of actual sales and limit curves is recommended to ensure that the long-term targets are met.
- Through research ABMARC has conducted, it is believed that the average price of an electric vehicle could be cost comparative to an average internal combustion engine by 2025. Taking a conservative approach for the purpose of this analysis, the price premium in 2025 has been set at $10,000, reducing to $5,000 by 2030. It is assumed that an increase in EVs and PHEVs will be able to be supported by our electricity infrastructure.
- The project has not considered the cost for vehicles to meet more stringent vehicle emission standards, or if vehicle manufacturers will produce 'de-tuned' technologies for markets lagging behind global fuel quality and/or emissions standards.
- To avoid ambiguity, reference to the separate CO_2 targets for MA vehicles and NA + MC vehicles is used (as used in Europe and the US). Achieving a single target value for all vehicles combined is not considered as this would require control over the relative sales contributions from the two component groups.
- Credit banking or trading between manufacturers has not been considered in this analysis.
- Super-credits (multipliers for low or zero emission vehicles) has not been included.

TECHNOLOGY COSTS AND CO_2 REDUCTIONS

Table 13 details the costs of various technologies and their respective CO_2 reductions that have been applied to the 2016 fleet in order to produce a business as usual forecast. The costs are in 2016 equivalent prices, and it is these values that are attributed to the technology improvements of each of the top 10 vehicle brands in order to meet the limit curves in 2030.

Technology	CO_2 Reduction	Cost per vehicle in 2030
LPG Engine		
LPG Engine	12.0%	$1,800
Petrol Engine		
MPFI: DOHC with VVT or VVT & Lift	2.6%	$954
Stoichiometric Direct Injection	10.0%	$410
DI with Turbocharging & Downsizing	12.0%	$1,797
Diesel Engine		
Standard Engine	16.0%	$2,800
V6 Variable Geometry Turbo	28.0%	$4,700
I4 Variable Geometry Turbo	28.0%	$4,300
I4 Twin Turbo	32.0%	$4,400
Downsized Turbo	38.0%	$4,200
Automatic Transmission		
5 Speed	2.5%	$0
6 Speed	4.4%	$0
7 Speed	5.0%	$117
8 Speed or Higher	6.0%	$117
Manual Transmission		
6 Speed	2.0%	$411
Constantly Variable Transmission		
CVT	5.0%	$315
Dual Clutch Transmission (DCT)		
6 Speed	6.7%	$54
7 Speed	7.5%	$485
8 Speed	8.5%	$485
Hybrid Technology		
Belt Drive Alternator Starter (42V)	7.5%	$556
Mild Petrol Hybrid	31.0%	$3,150
Mild Diesel Hybrid	39.0%	$4,838
Petrol Dual Motor Full Hybrid	45.0%	$3,870
Electric Technology		
EV (300 km nominal range)	100.0%	$5,000

Table 13 – Technology costs and CO_2 reduction applied to the 2016 new vehicle fleet

ALL LIGHT VEHICLES

Chart 31 shows the BAU vehicle CO_2 forecast for 2030 compared with 2016. In terms of absolute CO_2, the greater reductions in CO_2 have been achieved by the higher mass vehicles, in particular, the NA and MC categories. This has the effect of lowering the slope of the general relationship between mass and CO_2 when considering all light vehicles together as one data set.

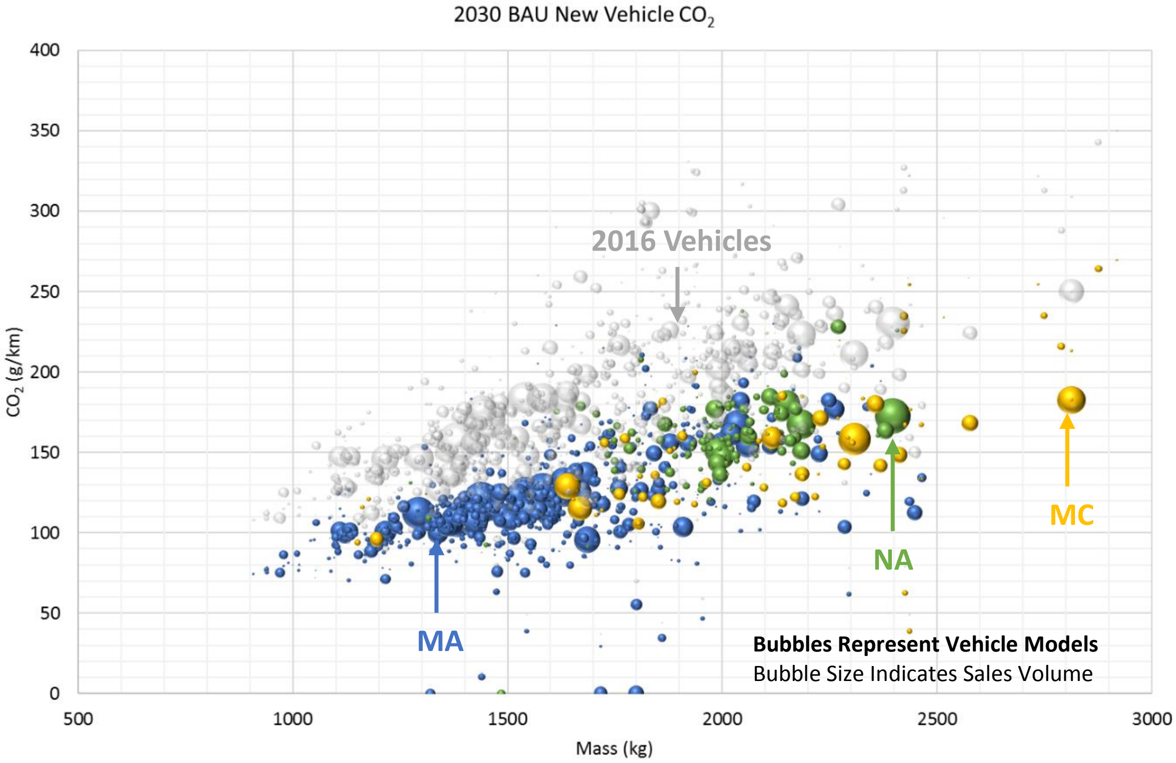


Chart 31 – BAU CO_2 forecast for all light vehicles, 2030

MA CATEGORY VEHICLES

Chart 32 shows that the attribute curve formed to fit the 2030 BAU forecast for MA vehicles is a good fit to the vehicle CO_2 data. The sales weighted average CO_2 is 121 g/km, corresponding to an annual reduction of 2.3% from 2016. The average mass increase from 1548 kg in 2016 to 1609 kg in 2030 is attributed to the higher sales of heavier SUVs compared with 2016, rather than a forecast of cars getting heavier generally.

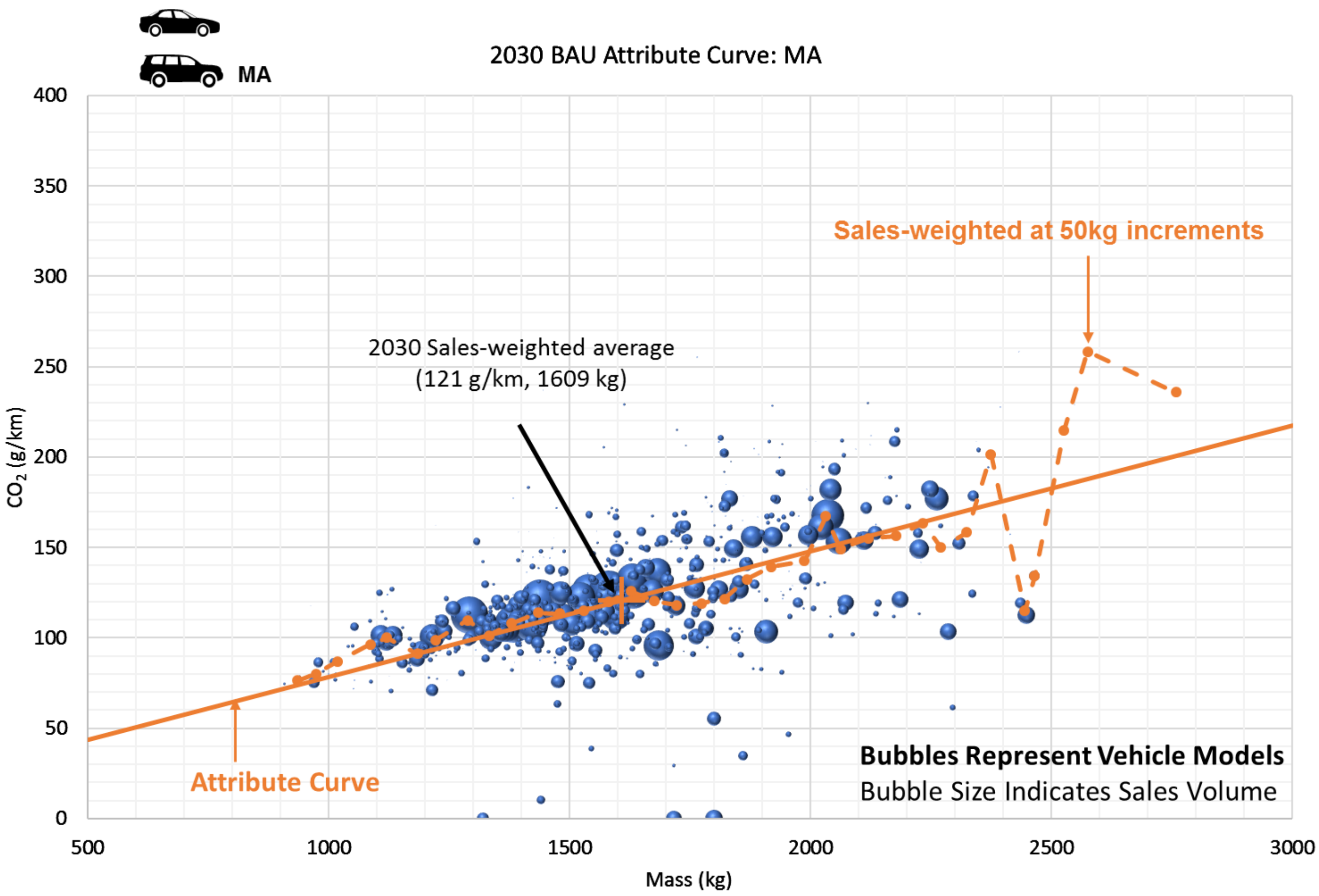


Chart 32 - BAU attribute curve for MA vehicles, 2030

COMPARISON OF VEHICLE BRANDS TO THE ATTRIBUTE CURVE FOR MA VEHICLES

Comparing the MA attribute curve to the forecast fleet-average CO_2 of the brands in 2030 shows good agreement, with most brands centred on the attribute curve and some placed significantly below it. By excluding brands with less than 1000 sales, there are no manufacturers that are highly disadvantaged by the attribute curve.

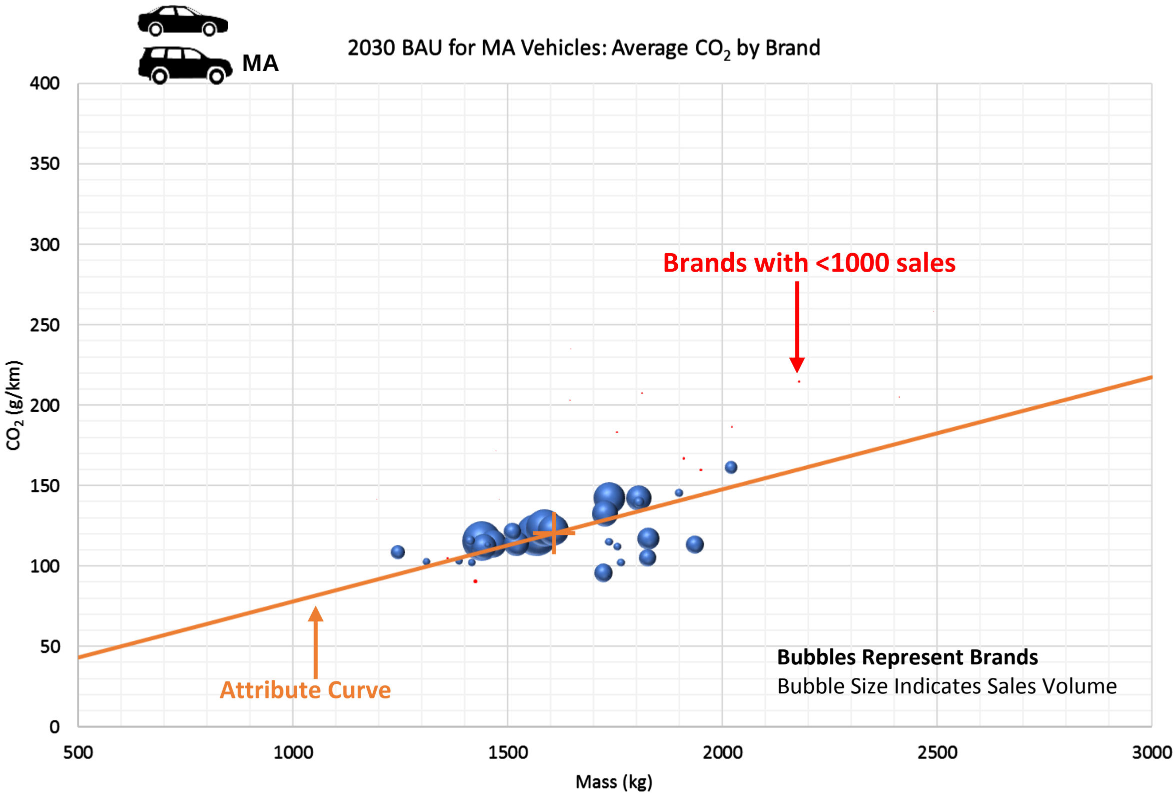


Chart 33 – Brands compared to the MA attribute curve, 2030

NA + MC CATEGORY VEHICLES

The attribute curve for NA + MC category vehicles in Chart 34 is based on CO_2 data with greater scatter than that of the MA category. Consequently, comparing this to the fleet average CO_2 of the brands is a useful check to assess the suitability of the curve.

Using the modelled 2030 vehicle data set, the sales-weighted average CO_2 for NA + MC vehicles is forecast to be 157 g/km, corresponding to an annual reduction of 2.2% from 2016. The average vehicle mass of 2098 kg has increased by only 20 kg since 2016 due to a stable sales mix that has been modelled over this time period.

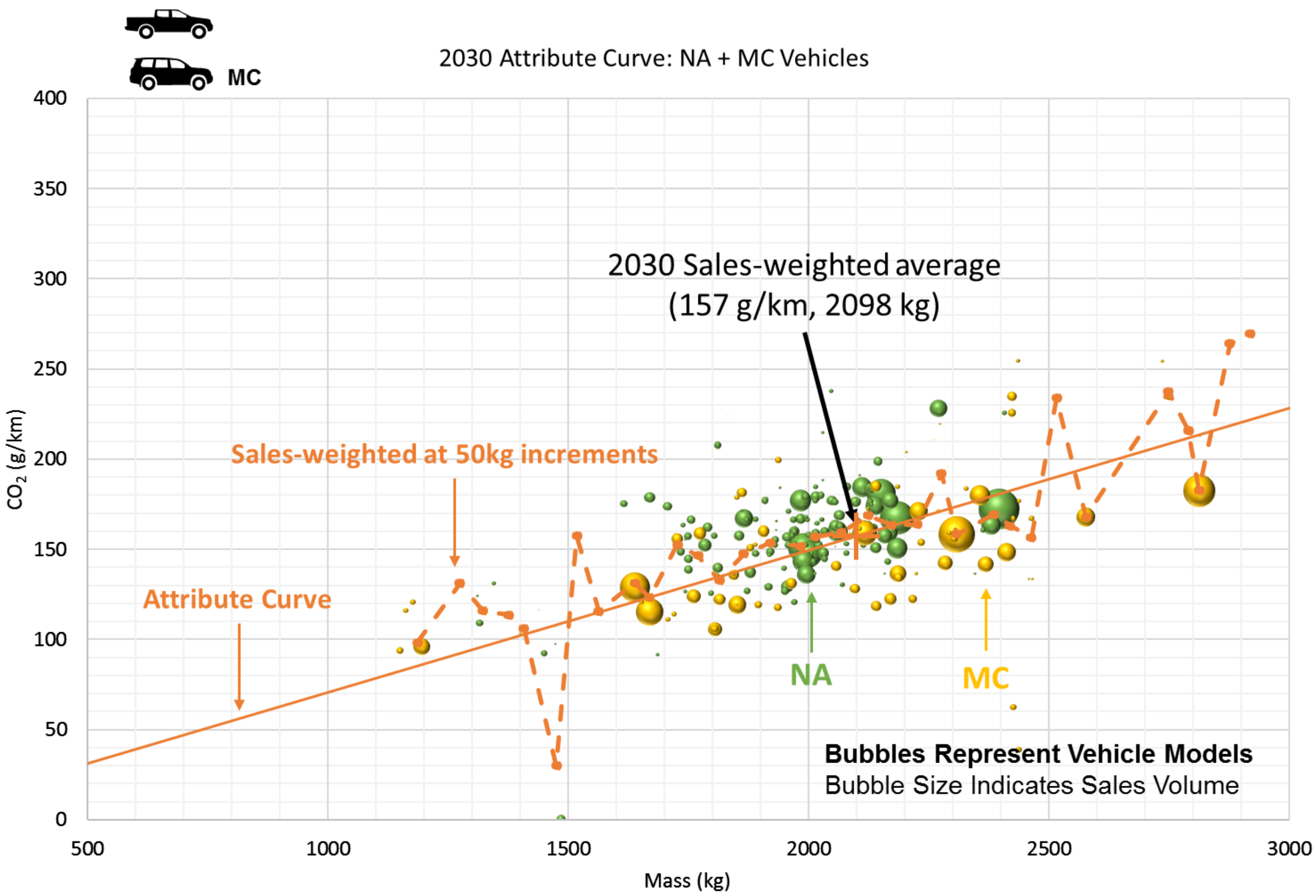


Chart 34 - BAU attribute curve for NA + MC vehicles, 2030

COMPARISON OF VEHICLE BRANDS TO THE ATTRIBUTE CURVE FOR NA + MC VEHICLES

When comparing the average CO_2 for each brand in 2030, Chart 35 shows that most brands lie on or below the attribute curve, confirming that it is fit for purpose and does not severely disadvantage any manufacturer, providing that those brands with less than 1000 vehicle sales are excluded.

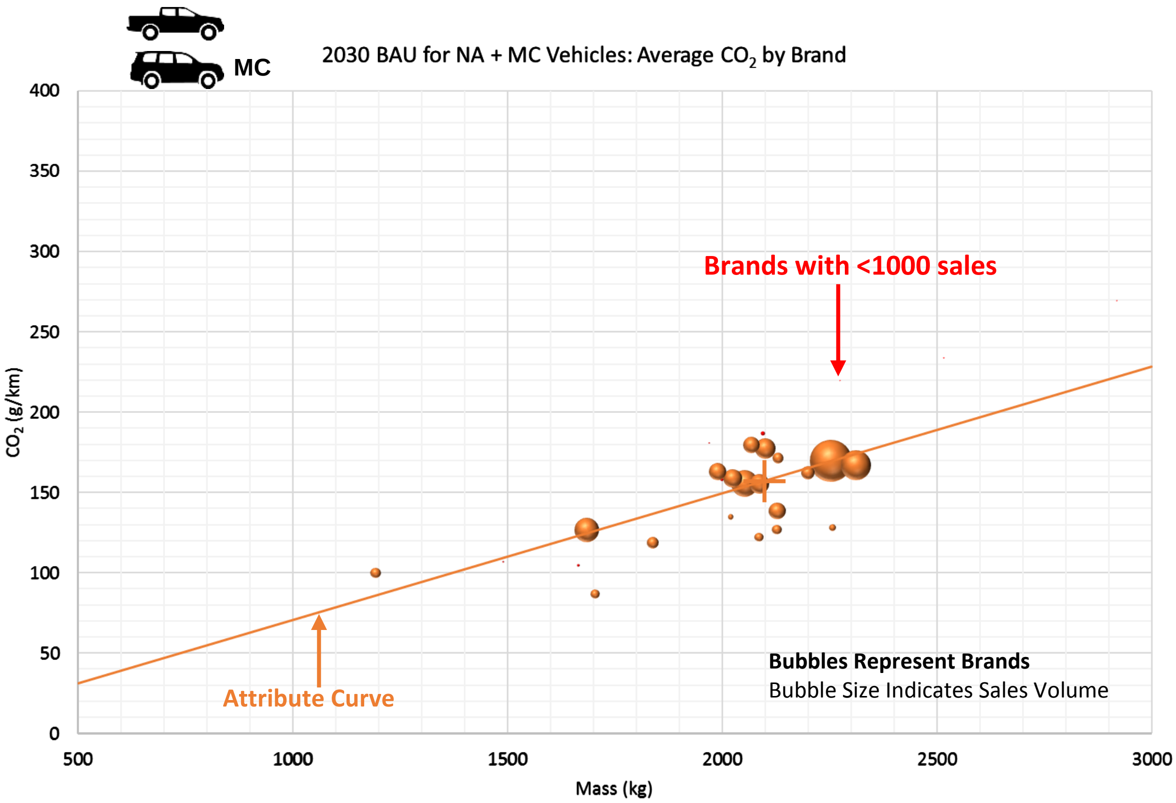


Chart 35 - Brands compared to the NA + MC attribute curve, 2030

CO_2 TARGETS FOR AUSTRALIA - PROPOSAL

OVERVIEW

Australia's commitment to the Paris climate change agreement has resulted in an economy-wide target of reducing greenhouse gas emissions by 26 to 28% of the 2005 levels by 2030, and it is recognised that reducing the CO_2 emissions from new light vehicles will help contribute to the success of this goal.

To date, even without a formal CO_2 policy Australia has benefited from a reduction of CO_2 emissions from light vehicles as other global markets implement fuel efficiency and/or CO_2 targets which place demands on vehicle manufacturers to improve their vehicles. In devising CO_2 targets for Australia, we must be mindful of the trajectory of CO_2 reductions set in other jurisdictions to ensure that a comparable, yet realistic improvement is achieved by Australia.

By studying the absolute value of CO_2 targets from other countries or regions, an understanding of the size of the reduction possible is gained. Also, by studying the trajectory of these targets an understanding of the rate of consumer acceptance and deployment of these technologies by manufacturers can be determined.

THE CO_2 TARGET MECHANISM – A GLOBAL PERSPECTIVE

PASSENGER CAR TARGETS

EUROPE

Chart 36 compares the BAU trajectory of Australia's passenger cars and SUVs to that of Europe (who combine these two vehicle groups to assign a CO_2 target). As of 8th November 2017, the European Commission proposed that CO_2 emissions from new cars must be 15% lower than in 2021 by 2025, and 30% lower than in 2021 by 2030. These percentage reductions have been applied to the 2021 target value of 95 g/km, but it is believed that the targets will in practice be a relative reduction to the actual CO_2 emissions in 2021. These targets correspond to a year on year reduction of 3.3% from 2021 to 2030, which is similar to the BAU trajectory forecast for Australia.

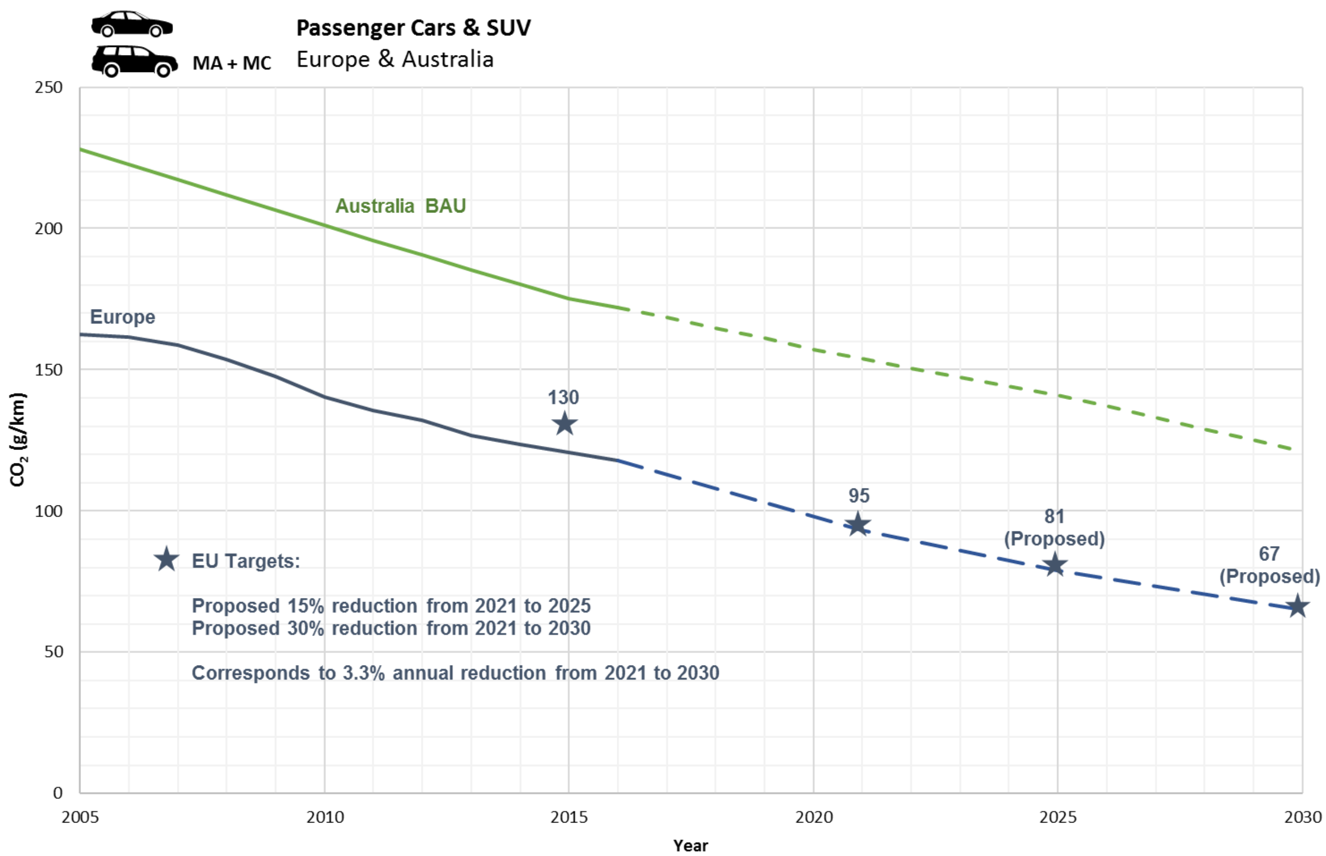


Chart 36 – Australian and European vehicle CO_2 trajectories compared, PC+SUV, 2005 to 2030

USA

Chart 37 compares Australia's predicted BAU trajectory for passenger cars with that of the USA. Vehicles defined as passenger cars in the US are equivalent to combining passenger cars and MA category SUVs in Australian terms, and so these vehicles have been used for comparison. Predicted US targets have been translated into equivalent CO_2 values using the ICCT's conversion tool for petrol vehicles (ICCT, 2014). ABMARC believes that the ICCT conversion factors may not be the most suitable method to convert the USA's fleet average and CO_2 targets into equivalent NEDC values. Using the US targets without any credits or incentives applied, their trajectory must satisfy a 3.5% annual reduction from 2021 onwards.

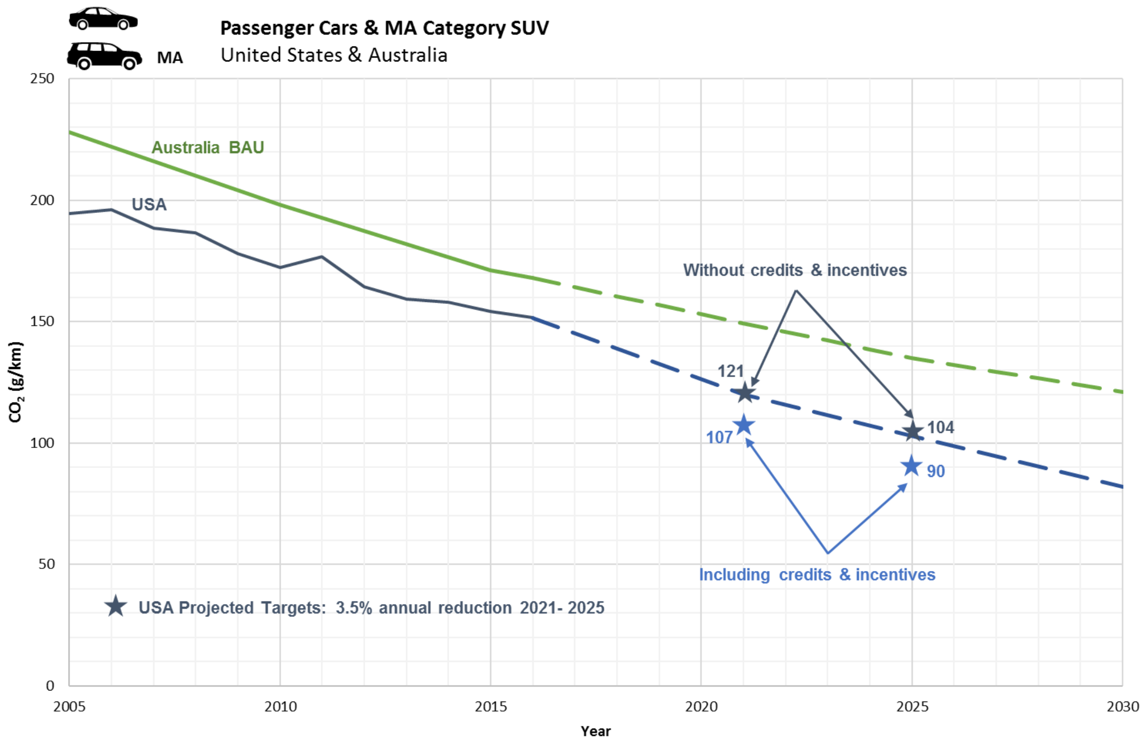


Chart 37 – Australian and US vehicle CO_2 trajectories compared, MA Vehicles, 2005 to 2030

LIGHT COMMERCIAL VEHICLE CAR TARGETS

EUROPE

In Europe, a separate CO_2 target is assigned to light commercial vehicles only (NA category) which predominantly are vans. At present there is a 147 g/km target set for 2020. As of 8th November 2017, the European Commission proposed that CO_2 emissions from new vans must be 15% lower than in 2021 by 2025, and 30% lower than in 2021 by 2030. It is believed that the targets will in practice be relative reductions to the actual CO_2 value attained in 2021. Chart 38 compares these targets to Australia's BAU for LCVs. The 2025 and 2030 Europe targets have been projected out, requiring a year-on-year CO_2 reduction of 3.3%.

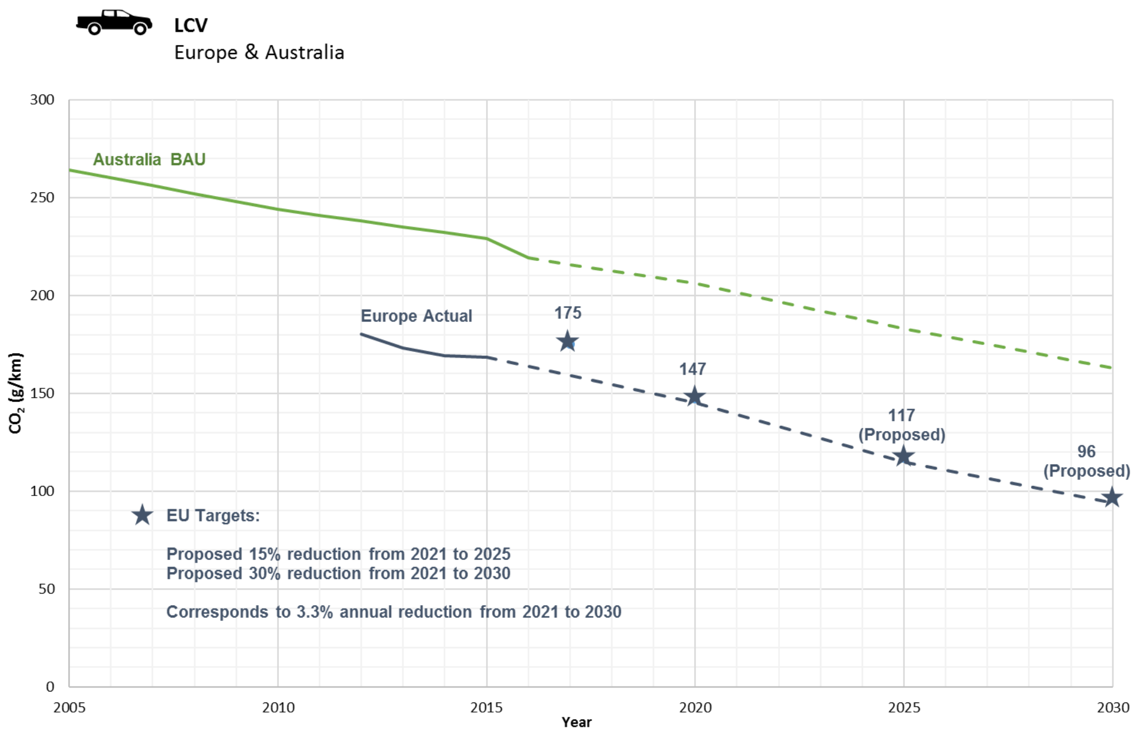


Chart 38 - Australian and European vehicle CO_2 trajectories compared, LCV, 2005 to 2030

USA

In the USA, a CO_2 target applies to light trucks, which includes four-wheel drive vehicles. The Australian vehicles that are most comparable are LCVs (NA category vehicles) and MC category SUVs. Australia's BAU for these vehicles is plotted against the USA's fleet average CO_2 and targets for light trucks, after converting the US targets into an NEDC equivalent using the ICCT conversion tool. As shown in Chart 39, the US targets without credits and incentives applied require a 3.7% annual CO_2 reduction from 2021 to 2025.

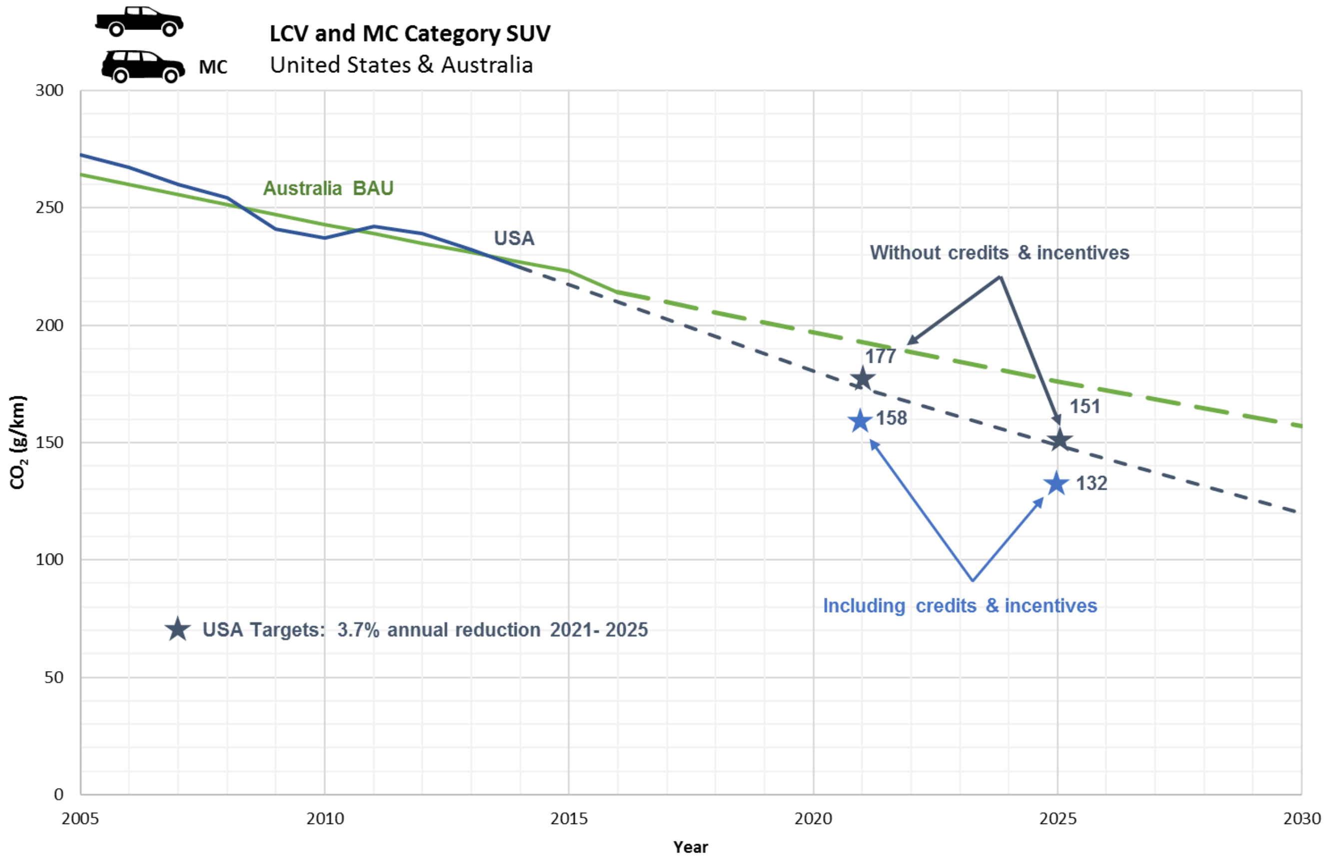


Chart 39 - Australian and US vehicle CO_2 trajectories compared, LCV + MC, 2005 to 2030

CREDITS AND INCENTIVES TO ACHIEVE CO_2 TARGETS

A variety of mechanisms are used in the US and Europe to help achieve their CO_2 targets and encourage the uptake of fuel efficient vehicles. Table 14 compares the credits and incentives that manufacturers are able to use in the US and Europe, and summarises the maximum size of credit that can be claimed. The values of US credits shown in Table 14 are converted into NEDC equivalent values using the ICCT conversion tool, which is considered by ABMARC to underestimate the NEDC value.

INCENTIVES FOR LOW EMISSION VEHICLES

In both Europe and the US, incentives are offered for the sale of low emissions vehicles by treating the sale of these vehicles as worth more than that of other vehicles. In Europe these are referred to as 'Super Credits', and they manifest themselves as a sales multiplier, applicable to any vehicle with NEDC CO_2 emissions of less than 50 g/km (this generally includes PHEVs). In the US, there are different sales multipliers for EVs and PHEV.

For both Europe and the US, the value of the multiplier is generally higher in years preceding a target date, reducing as time progresses to the target year. This incentivises the adoption of EVs and PHEVs by manufacturers, particularly when an overall CO_2 credit can be carried forward to subsequent years. In order to reduce complexity, Table 14 shows the range of values that are used by Europe and the US as the exact values of the incentive multipliers differs by CO_2 target and year.

Comparison of Maximum Credits and Incentives used in CO_2 Legislation		
Europe	**USA**	
Incentive Multiplier for Low Emission Vehicles (Super Credits)		
Any Vehicle with CO_2 < 50 g/km	EV	PHEV
Between 3.5 and 1.0 (Dependent upon year/target and up to a max. of 7.5 g/km over a 3-year period)	Between 2.0 and 1.0 (Dependent upon year/target and a max. volume applies)	Between 1.6 and 1.3 (Dependent upon year/target and a max. volume applies)
Maximum Total Credits (consisting of sub-sections 1 to 3)		
7 g/km	PC	LCV + SUV
	15 g/km [1] (23.8 g/mile)	18 g/km [1] (29.4 g/mile)
1. Off-Cycle Credits		
7 g/km maximum credit (Only applicable whilst NEDC is the legislated cycle)	6 g/km max. combined credit for all light vehicles (10 g/mile)	
2. A/C Refrigerant Leakage Credits		
Not Applicable	PC	LCV + SUV
	8 g/km using HFC-134a (12.6 g/mile) 9 g/km using Lower GWP refrigerants (13.8 g/mile)	10 g/km using HFC-134a (15.6 g/mile) 11 g/km using Lower GWP refrigerants (17.2 g/mile)
3. A/C Efficiency Credits		
Not Applicable	PC	LCV + SUV
	3 g/km (5 g/mile)	5 g/km (7.2 g/mile)

Note: US credits in g/km have been converted to NEDC g/km equivalent using the ICCT conversion tool.
[1] Assumes a 50:50 split between PC and LC+SUV for the off-cycle credits

Sources: (US) 49 CFR Parts 523, 531, 533. et al. and 600, EC 443/2009, EC 333/2014
Table 14 – Summary of maximum credits and incentives used in CO_2 legislation

OFF-CYCLE CREDITS

Off-cycle credits allow a vehicle manufacturer's fleet average CO_2 to be reduced by recognising the benefits that improved technologies can have on the CO_2 produced by vehicles, even though these are not measured by the official drive cycles. Examples of these are solar panels incorporated into the vehicle, active aerodynamic improvements, thermal control technologies and (for the US only), engine idle/stop. In Europe, the use of idle/stop (or start/stop) technology is permitted in the NEDC, and is already commonly used to reduce the CO_2 of light vehicles.

Whereas the US has specific, recognised technologies that can be used (each with specific credits which are added, up to a maximum combined total for all the technologies), in Europe any off-cycle technology (referred to as eco-innovations) is theoretically possible to be used, provided its efficacy is demonstrated and approved. A maximum of 7 g/km for all off-cycle credits can be a claimed by a manufacturer to reduce their fleet-weight average in Europe.

A/C REFRIGERANT LEAKAGE CREDITS

This recognises the reduced impact that air conditioning refrigerants have on global warming due to the fact that over the life of a vehicle, the refrigerant is prone to evaporating from the vehicle into the atmosphere. US regulations allow a credit value to be attributed to the use of A/C refrigerants with lower global warming potential (GWP), and these values are determined by considering the useful life of the vehicle, with different credits applicable to passenger cars or light commercials and SUVs. Table 15 compares the global warming potential of refrigerants commonly used in air conditioning. In Europe, there are no credits permitted for the use of lower global GWP refrigerants.

Global Warming Potential of A/C Refrigerants	
Refrigerant	**Relative GWP (CO_2 = 1)**
HFC- 134a	1430
HFC-152a	124
HFO-1234yf	4

Source: (US) 49 CFR Parts 523, 531, 533. et al. and 600
Table 15 – Global Warming Potential of A/C Refrigerants

A/C EFFICIENCY CREDITS

The US regulatory framework awards credits for the use of specific air conditioning technologies which improve vehicle efficiency, each with a credit value that applies. Examples of these are: improved condensers and blower motor controls which limit wasted electrical energy. The values in Table 14 relate to the maximum possible credit that can be attained by adding all of these credits together.

In Europe, no credits are offered for the use of improved A/C technology even though neither the NEDC or the future WLTC require the use of A/C during CO_2 measurement testing (which would otherwise quantify these A/C improvements).

CREDIT TRANSFER

In the US, vehicle manufacturers are allowed to offset a credit from one CO_2 standard to the other (e.g. from passenger cars to light trucks). This provides brands flexibility in a situation where, for example, exceeding the limit value for their light trucks can be compensated for by CO_2 reduction from their passenger cars. Reducing the average CO_2 for passenger cars through increased sales of hybrids or EVs could be more viable for a brand than with light trucks, enabling the same overall CO_2 emissions whilst allowing a brand to offer vehicles that their customers wish to purchase.

AUSTRALIAN PROPOSED CREDITS AND INCENTIVES

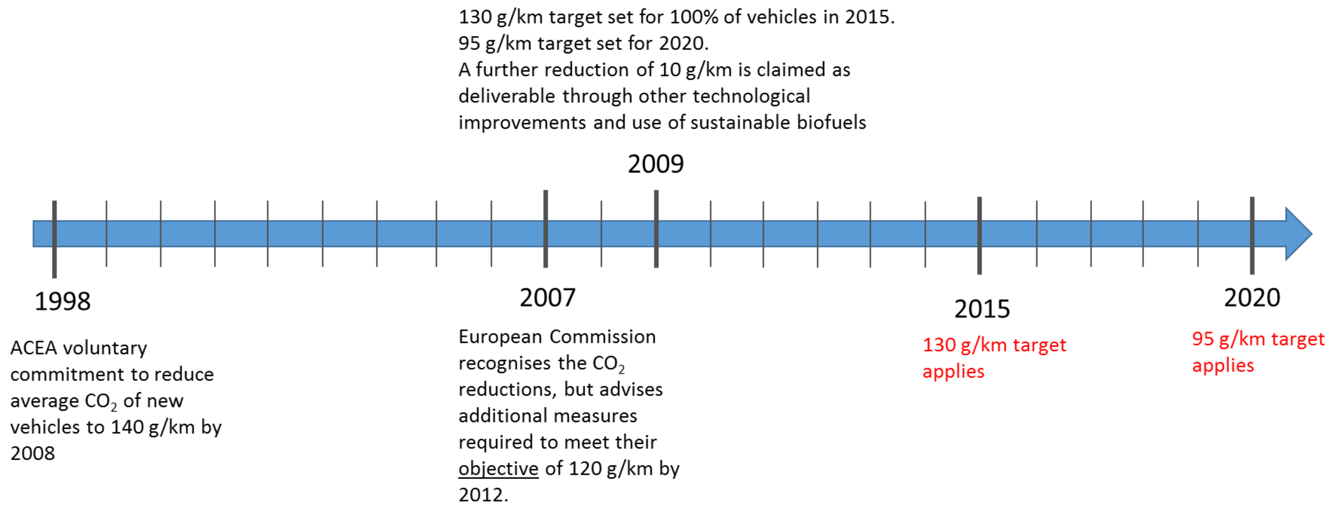
For the purpose of this study the following mechanisms and credits are proposed:

1. The use of A/C refrigerant and efficiency credits to the following values:
   a. MA class: 10 g/km CO_2
   b. NA + MC class: 15 g/km CO_2
2. It is proposed that CO_2 credit transfer between the MA vehicles / NA + MC targets for a brand is permitted in any policy developed for Australia, providing the greatest flexibility possible for vehicle manufacturers.

Super credits have not been included as it is considered that their use will de-incentivise the uptake of low emission (but higher cost) powertrains in the target year. ABMARC recommends that the use of super credits should only be applied where banking is also an available mechanism.

EUROPEAN CO_2 TARGET IMPLEMENTATION TIMELINE

Figure 1 shows the timeline for implementation of CO_2 standards for passenger cars and SUVs in Europe. The first CO_2 target introduced for light vehicles in Europe was the 130 g/km target applying to PC + SUV of 2015. This, together with the 95 g/km target for 2020 was set in 2009, giving 6 years and 11 years advance notice, respectively. Even before the legislation was set, as far back as 1998 there was a voluntary commitment by ACEA (European Automobile Manufacturers' Association) to reduce the average CO_2 of new vehicles to 140 g/km by 2008, showing that manufacturers have a long lead time to develop more efficient vehicles and translate these into sales in Europe. On 8th November 2017, the European Commission proposed target reductions of 15% and 30% from their 2021 emissions by 2025 and 2030 respectively. This provides a lead time of 12 years to 2030.



Source: EC 443/2009

Figure 1 – European CO_2 target timeline for PC + SUV

It is proposed that Australia adopt a 2030 target year. This would provide an 11-year implementation timeline (assuming that policy development commences in 2019). This proposal is in-line with the European timeline for adoption of a CO_2 standard out to 2030. Note that, as discussed previously, this work has assumed BAU emissions reductions until 2022, giving 8 year's notice from the point at which a regulation is formally enacted.

CO_2 TARGETS AND LIMIT CURVES

The CO_2 targets for Europe and the US (shown in Chart 36 to Chart 39) require different year on year percentage reductions, or trajectories in order to be achieved. Preliminary targets for 2025 and 2030 were developed using the following approach:

1. Apply CO_2 reductions consistent with a BAU until 2022 (allowing time to implement the necessary policy and manufacturers to update product plans)
2. From 2022 until 2030, apply annual CO_2 reductions consistent with the trajectories required in Europe or the US.

The columns titled "Europe" and "US" refer not to the absolute targets used in those regions, but the target for Australia if we were to have a year-on year CO_2 reduction that is required in Europe or the USA over the 2022-2030 timeframe. A "Europe or US +" trajectory has annual CO_2 reductions that are greater than those required in the US, and a "Europe or US –" trajectory has annual CO_2 reductions that are less than those required in Europe.

Initial target setting was conducted by analysing various trajectories applied to the Australian light vehicle fleet using the two categories of vehicles as used in Europe:

1. PC +SUV (combining passenger cars with all SUVs)
2. LCV (Light commercial vehicles which are NA category Vehicles)

Table 16 summarises the various targets proposed. The 'Target A' values used in the Government's draft Regulation Impact Statement (RIS) on improving the efficiency of light duty vehicles published on 20 December 2016, as well as targets currently proposed by the FCAI are included for reference.

Proposed CO_2 Targets for Australia by applying different trajectories (g/km)										
Year	Vehicle Category	ABMARC BAU [1]	RIS [2]	FCAI [3]	Europe -	Europe	Europe +	US -	US	US +
2025	PC + SUV	129	94	129	140	136	131	140	136	132
	LCV	178	151	177	182	176	170	186	180	175
2030	PC + SUV	121	51	108	123	113	104	125	115	106
	LCV	157	110	148	158	146	134	169	156	143

Table 16 – Proposed Australian CO_2 targets by applying different trajectories

[1] ABMARC business as usual prediction if no CO_2 targets are implemented in Australia
[2] Target A values are projected out to 2030.
[3] FCAI targets combine MC category vehicles with LCV and assume a BAU progression until 2020, followed by a 3.5% annual CO_2 reduction from 2022 to 2030.

The CO_2 target values of 106 g/km and 143 g/km for 2030 were chosen from Table 16, with the amendment that the 143 g/km target for LCV should also apply to MC category SUVs due to their high mass making them analogous to LCVs. Therefore, the 106 g/km target applies to all MA category vehicles (combining passenger cars and MA SUVs), and the 143 g/km target applies to NA + MC category vehicles (which combines light commercial vehicles with larger, MC category SUVs).

Appendix 1 details the annual CO_2 reductions required for the original categories of passenger cars plus SUVs and light commercial vehicles, showing how the trajectory was applied to arrive at the 106 g/km and 143 g/km targets. Appendix 1 additionally provides the year by year CO_2 reductions required under the MA and NA + MC category split.

CHOSEN CO_2 TARGETS, CREDITS, INCENTIVES AND DEROGATIONS

Two separate CO_2 targets for 2030 have been chosen; a 106 g/km target for MA category vehicles and a 143 g/km target for NA + MC category vehicles combined. The changes to the new vehicle fleet required to meet these targets are considered under two scenarios.

Both scenarios work towards the same CO_2 targets, but scenario 1 has the least administrative burden with no credits or incentives used, whereas scenario 2 uses credits. Scenario 2 is similar to that used in the US, where credits recognise that improved air-conditioning (A/C) efficiency and use of reduced global warming potential (GWP) refrigerants benefit real-world greenhouse emissions, even though the legislated laboratory tests cannot measure their impact on CO_2. Table 17 summarises the targets and the two scenarios.

Chosen CO_2 Targets, Credits and Incentives						
Scenario	**Target Year**	**Vehicle Category**	**CO_2 Target**	**CO_2 Credit (Air Conditioning)**	**CO_2 Transfer within a brand?**	**Low Emission Vehicle Super Credits?**
1	2030	**MA**	106 g/km	None	No	No
		NA + MC	143 g/km	None	No	No
2	2030	**MA**	106 g/km	10 g/km	Yes	No
		NA + MC	143 g/km	15 g/km	Yes	No

Table 17 – Chosen CO_2 targets, credits and incentives

Table 18 details the categories proposed to be eligible for derogation from compliance with the limit curve. These apply to a brand's total annual sales for the vehicle category and limit curve in question. This allows brands with low sales to be exempt from compliance with the limit curves that might otherwise result in penalties which might cause them to no longer offer those vehicles for sale in Australia.

Derogations from Compliance with a Limit Curve	
Brand Annual Sales Total	**Compliance with CO_2 Limit Curve**
Vehicles < 1,000	Limit Curve does not apply (CO_2 reporting only)
1,001 < Vehicles < 10,000	Limit curve does not apply (Must demonstrate a similar CO_2 reduction from a 2018 baseline) Alternatively, brands may choose to comply with the limit curve
Vehicles > 10,001	Limit Curve Applies

Table 18 –Chosen derogations for compliance with the limit curves

JUSTIFICATION OF TARGETS, CREDITS, INCENTIVES AND DEROGATIONS

The targets of 106 g/km for MA vehicles and 143 g/km for NA + MC vehicles were chosen after consultation with the AAA. These targets require annual CO_2 reductions of 4.0% for MA category vehicles, which is greater than the 3.3% annual reduction required in the US from 2022 to 2030. The higher CO_2 reduction for MA vehicles helps offset the slightly lower annual CO_2 reduction of 3.5% required for NA + MC vehicles compared to the 3.7% annual reduction required in the US from 2022 to 2030.

The slightly lower annual CO_2 reduction for NA + MC category vehicles in Australia is warranted, as the majority of these vehicles already utilise high technology, low CO_2 diesel powertrains, and a higher annual rate of CO_2 reduction when compared to the US would be very challenging for the Australian fleet to achieve.

Combining NA + MC vehicles groups light commercial vehicles with four-wheel drive capable SUVs (which tend to be heavier than MA category SUVs). This provides a target that may be better suited to the type of SUVs required to operate in the rugged conditions often found in Australia.

To aid compliance with the limit curves required to meet these targets, a CO_2 credit of 10 g/km can be applied to each brand's average CO_2 for MA vehicles and 15 g/km for NA + MC vehicles. This recognises the benefit that improved air conditioning efficiency and reduced global warming potential refrigerants have on the long-term greenhouse gas emissions attributed to vehicles, even though these factors are not measured in the emissions laboratory test. The CO_2 credits that can be applied are less than the equivalent of 15 g/km for passenger cars and 18 g/km for SUVs and LCVs that are permitted under the regulations to help brands reach the CO_2 targets often quoted for the US.

To further aid flexibility for vehicle brands and maintain maximum consumer choice, in each year, a credit accrued against one vehicle category limit curve can be offset against a debit for the other vehicle category limit curve, a method that is permitted in the US.

Super credits for low CO_2 vehicles (such as PHEVs and EVs) are not considered in this work, as this reduces regulatory administration burden and also avoids the possibility that the uptake of these vehicles in Australia might be reduced if their value to reducing CO_2 is so high that brands need not sell so many of them.

The recommendation for the allowing derogations from compliance with the limit curves is intended to ensure that vehicles from minor brands can continue to be offered for sale, preserving customer choice, whilst not adversely impacting the overall CO_2 emissions from light vehicles. The derogation categories proposed are similar to those in Europe.

IMPACT OF THE TARGETS ON THE PARIS CLIMATE CHANGE AGREEMENT

Table 19 below summarises the annual CO_2 contribution (in million tonnes, Mt) from the sale of new light vehicles under a variety of scenarios. The total CO_2 emitted is calculated from the forecast new sales volume (combining MA, MC and NA vehicles) by the respective annual vehicle kilometres travelled (VKT). The same VKT has been used for both scenarios in 2030, such that the benefit of the 106 g/km and 143 g/km targets can be quantified. The annual CO_2 produced by the sale of new light vehicles in 2016 constitutes a 14% reduction on 2005 levels. Using 2030 CO_2 targets of 106 g/km and 143 g/km for MA vehicles and NA + MC vehicles respectively, it would provide a 29% reduction in the annual CO_2 emissions from new light vehicles compared with 2005. This contribution surpasses the Paris climate change agreement's economy-wide target of reducing greenhouse gas emissions between 26-28% below 2005 levels, although it is recognised that this is of the new fleet and not the Australian Parc.

CO_2 Emissions from New Light Vehicles (MA, MC and NA Combined)						
Year	Scenario	Vehicle Average CO_2 (g/km)	New Vehicle Sales	Average Annual VKT (km)	Annual Total CO_2 (Mt)	Reduction from 2005 New Vehicle Fleet
2005	Actual	245	952,884	14,581	3.4	-
2016	Current	180	1,145,165	14,152	2.92	14%
2030	Business as Usual	132	1,504,924	13,671	2.72	20%
2030	Using 106 g/km and 143 g/km targets	117	1,504,924	13,671	2.41	29%

Table 19 – Impact of the CO_2 targets on the Paris climate change commitment (new vehicle sales only)

LIMIT CURVES FOR THE 2030 TARGETS

From the targets in Table 17, limit curves are derived for each of the two vehicle categories, and it is these limit curves that vehicle manufacturers must comply with in order to fulfil the 2030 target.

LIMIT CURVE FOR MA VEHICLES

Chart 40 shows that the as the 106 g/km target for MA vehicles in 2030 requires a 12% reduction from the BAU average, a 12% reduction in gradient of the BAU curve is used to form the limit curve.

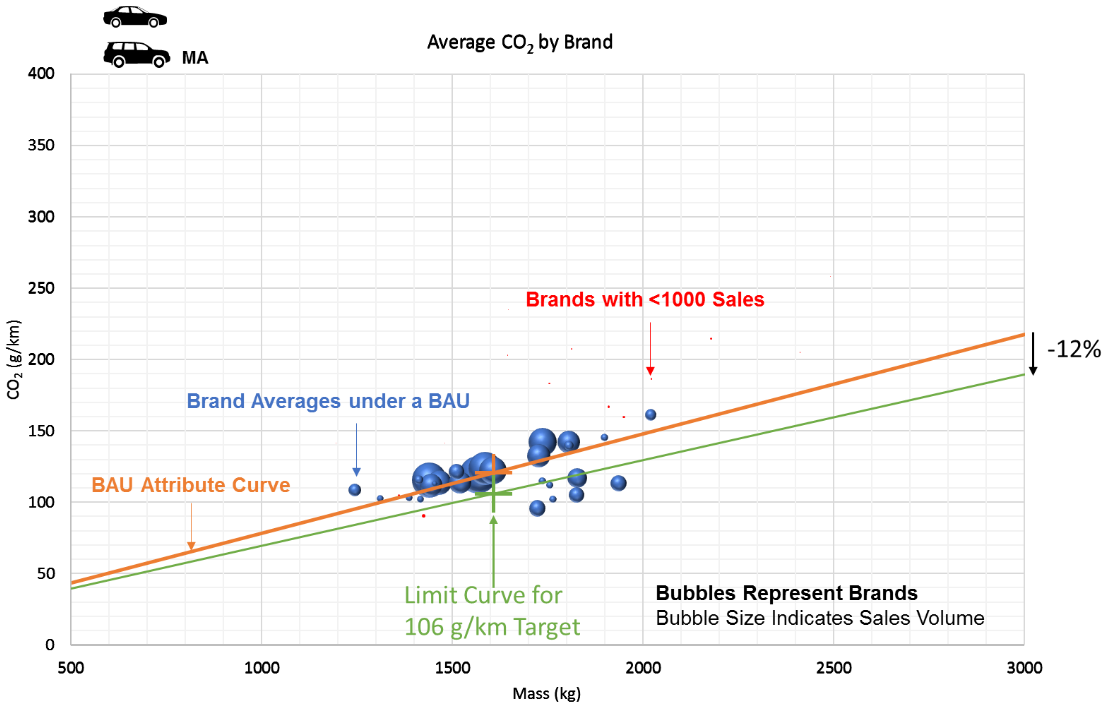


Chart 40 – Brands compared to the limit curve for MA vehicles in 2030

Brands with sales of less than 1,000 vehicles are included for reference, and although they would not be expected to comply with the limit curve, it is recommended that these brands report their fleet vehicle specific CO_2 and sales to aid future policy development. Brands with total sales of between 1,001 and 10,000 vehicles are not required to meet the limit value curve, but may choose to do so.

The brands are compared to the limit curve, each with a different fleet average CO_2 and mass. Those brands which are situated above the limit curve would incur a penalty for non-compliance, calculated as the distance above the limit curve multiplied by their total annual sales, multiplied by the penalty cost per g/km of CO_2 above the limit curve (Stated as $100 per g/km in the Government's proposed model for an Australian fuel efficiency standard distributed to stakeholders on 10 July 2017).

Using the 106 g/km target for MA vehicles provides a limit curve that is forecast to be satisfied by six of the brands, although none of these are part of the top 10 brands for sales forecast in 2030.

LIMIT CURVE FOR NA + MC VEHICLES

Chart 41 shows that the limit curve for NA + MC vehicles corresponding to a 143 g/km target requires a 9% reduction from the BAU. Comparing the fleet average CO_2 for each of the brands forecast shows that most brands (and all of the top 10 brands by sales) lie above the limit curve, and therefore would be subject to a penalty unless they reduce their average CO_2 beyond their forecast business as usual improvements.

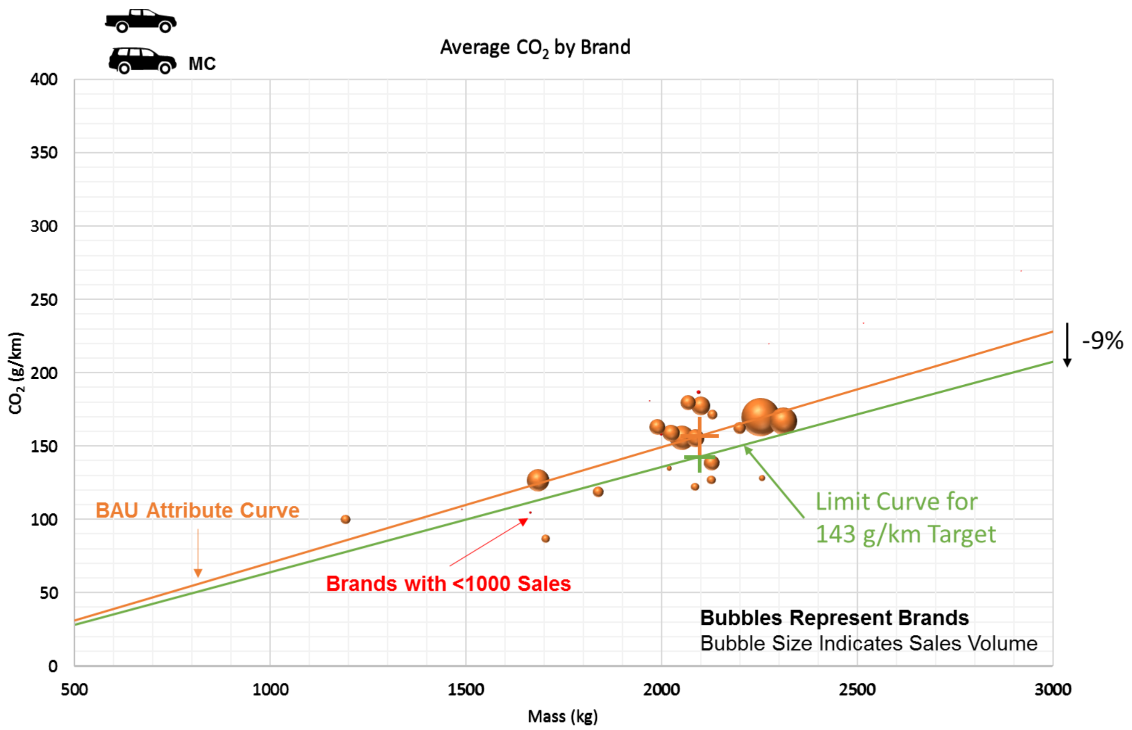


Chart 41 – Brands compared to the limit curve for NA + MC vehicles in 2030

Suitability of the standard for brands that sell only LCVs

In order to address the concern that a standard that combines NA with MC category SUVs might disadvantage brands that sell only LCVs, Chart 42 highlights the two brands that, based on 2016 sales, are forecast to produce LCVs in 2030, but not MC category SUVs. The brands with less than 1000 sales are excluded are they are considered to be exempt from a penalty. It can be seen that Renault, due to its sales of predominantly diesel vans, lies significantly below the limit curve. Although Hyundai is situated above the curve, it is no more disadvantaged by this standard than many other brands (shown in orange) which sell both LCVs and MC category SUVs.

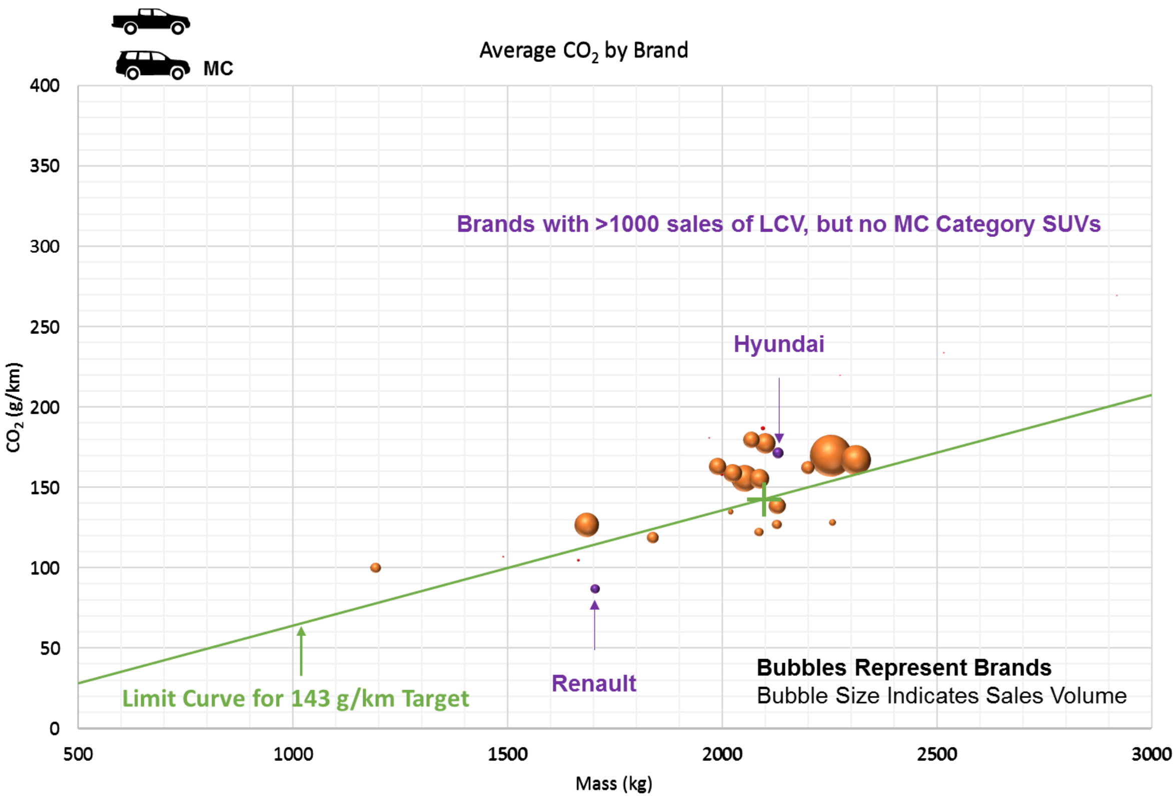


Chart 42 – Brands with sales of NA but not MC vehicles compared to the limit curve for NA + MC in 2030

VIABILITY OF TARGETS WITH RESPECT TO AVAILABLE TECHNOLOGY

In the previous section, comparing the limit curves to the brands showed that some brands are likely to incur a penalty unless they change the technology used in their vehicle mix. In this section, the limit curves are compared to the vehicles forecast to exist in 2030 to understand if the pool of vehicles to choose from could allow manufacturers to comply with their target.

MA VEHICLES

Chart 43 displays those MA vehicles forecast for 2030 that, when their sales-weighted average CO_2 is calculated, will satisfy the limit curve for the 106 g/km target. Some of the vehicles lie above the limit curve, as they are balanced out by the vehicles that lie below the limit curve. It shows that theoretically, 48% of the MA vehicles in 2030 when combined would satisfy the target, representing a substantial proportion of the possible new vehicle fleet. It is noted that this is just an example, and a brand could comply with the target by maintaining sales of vehicles with much higher CO_2 than those vehicles plotted in Chart 43, provided that they are counter-acted by sufficiently high sales of vehicles with CO_2 emissions that lie below the limit curve.

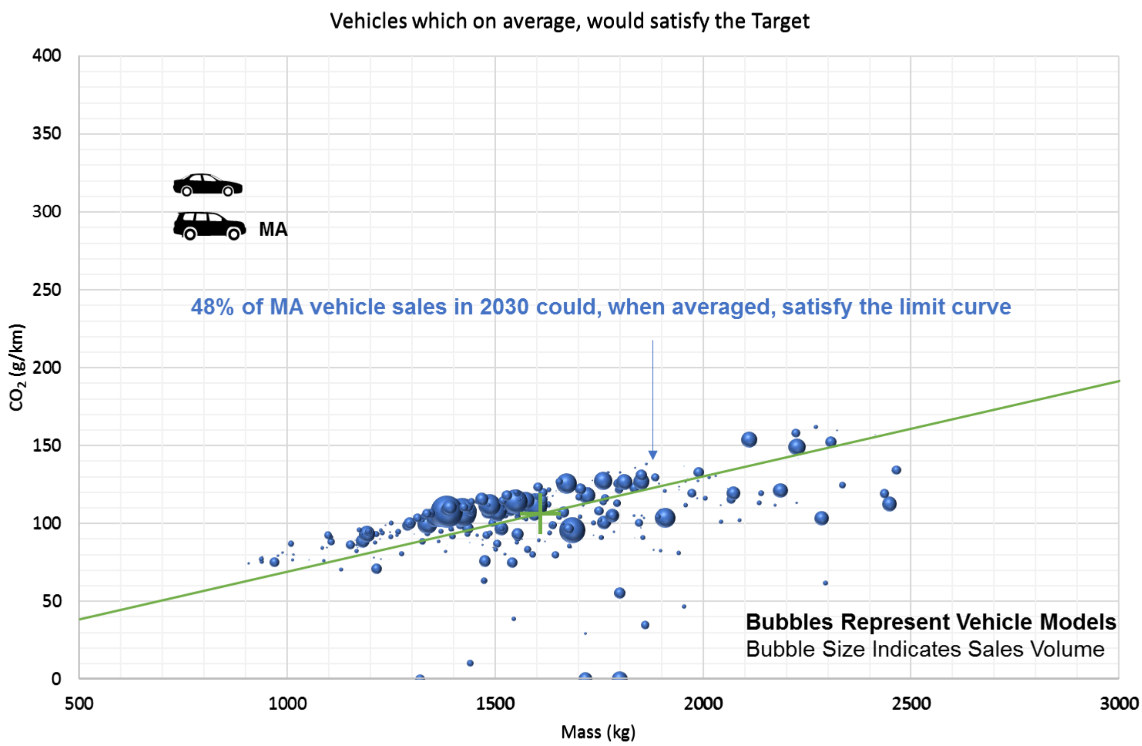


Chart 43 – MA vehicles that would satisfy the 2030 target

NA + MC VEHICLES

Chart 44 displays those NA + MC vehicles forecast for 2030 that, when the sales weighted average is calculated, would satisfy the limit curve. These represent 55% of the light vehicle fleet sales in 2030, confirming that there will exist sufficient vehicle technology that could enable compliance with the target. Although it shows that the technology will theoretically exist, similarly to MA vehicles it is noted that the vehicles shown in Chart 44 may not represent the vehicle mix for a given vehicle brand.

It is also noted that the average CO_2 for the example of vehicles shown is 148 g/km at a mass of 2173 kg, which although satisfying the limit curve, exceeds the 143 g/km target by 5 g/km. This demonstrates that compliance with the limit curve may not necessarily result in the overall 143 g/km target being met.

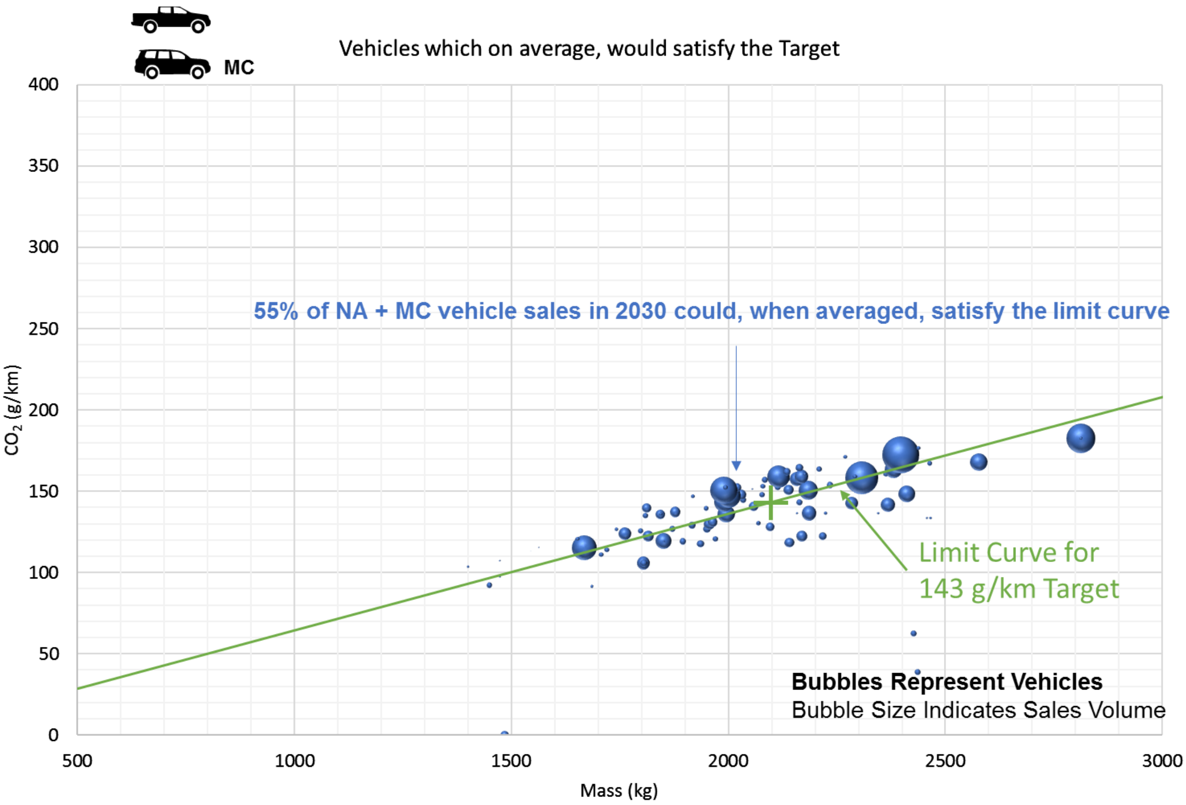


Chart 44 – NA & MC vehicles that would satisfy the 2030 target

POWERTRAIN MIX REQUIRED TO MEET THE 2030 TARGETS

MA VEHICLES (SCENARIO 1: WITHOUT CREDITS OR TRANSFER)

As a simple overview, the sales mix of vehicles by powertrain type required to meet the 106 g/km target is determined by considering all of the MA vehicles together. This helps identify whether, compared to the BAU, a strong shift in sales is required which would be hard to achieve. Chart 45 compares the powertrain mix for new sales of all MA vehicles under three scenarios: 2016 actual sales, 2030 business and usual and the powertrain mix required to meet the target.

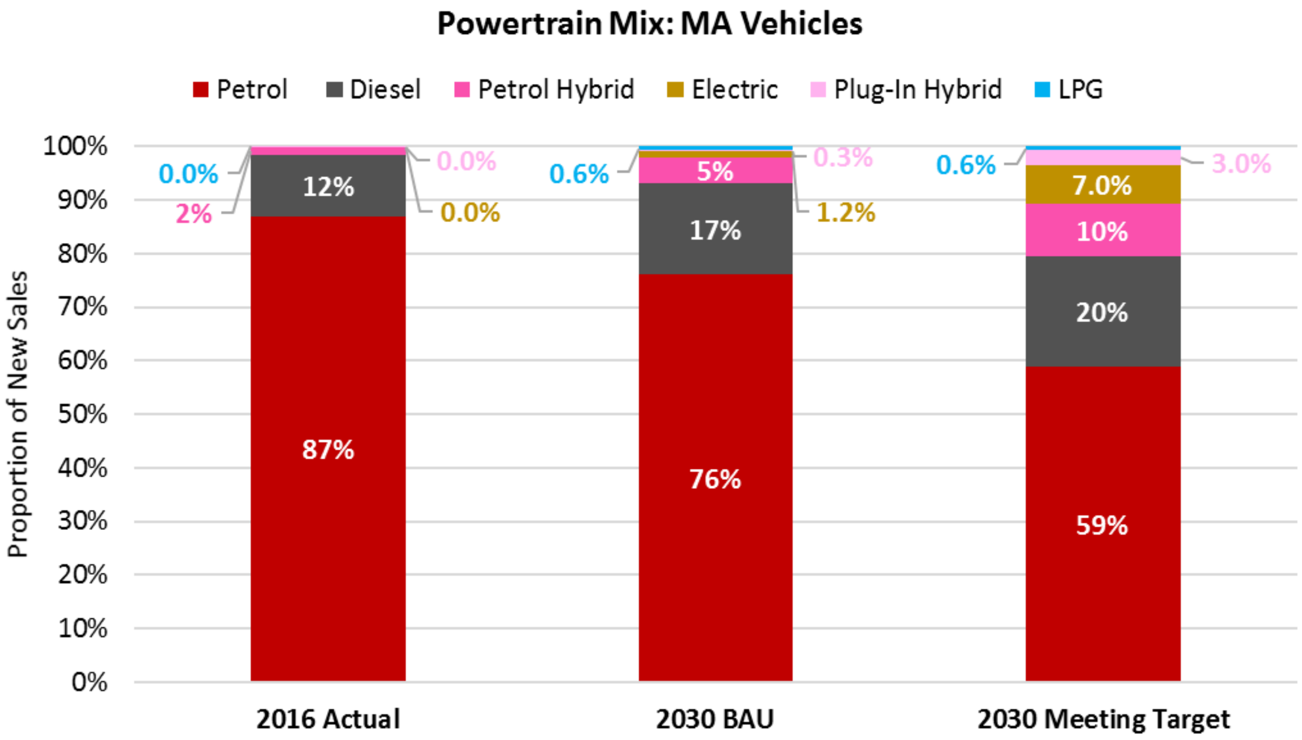


Chart 45 – Powertrain mix of MA vehicles required to meet the 2030 target

As this chart is based on all MA vehicles together, it is noted that the powertrain mix required for each brand to comply with the limit curve could differ significantly from this. Chart 45 shows that the 106 g/km target is still not an easily achievable goal, as a significant shift is necessary from the sale of petrol vehicles to electric, hybrid and PHEV powertrains. In order to comply, 7% of new sales must be electric, 10% hybrid and 3% must be PHEV. Compared to the 2030 BAU forecast, this will require a large increase in the purchase of these vehicles which may require the use of incentives.

Top 10 Brands

Chart 46 shows the forecast sales mix by powertrain type for the top 10 MA brands (by sales) in 2030 under a business as usual scenario. Only Toyota is forecast to have significant sales of petrol hybrids, with 17% of their new sales, and Nissan is forecast to have electric vehicles constituting 6% of their sales. It is noted that the modelling attributed a high proportion of LPG sales to Ford as, in 2016 the modelling (which used the 2016 fleet data), only Ford sold LPG vehicles. Although LPG sales are forecast to be less than 1% of all brand's vehicles sold in 2030, these are not expected to be sold by Ford alone, but instead distributed across a number of vehicle brands.

Chart 47 shows the powertrain required for each of the top 10 MA vehicle brands in 2030 in order for them to comply with the 106 g/km limit curve if credits or transfer were not allowed. Compared with the BAU forecast in Chart 46, a significant volume of electrified vehicles must be sold in 2030 in order to meet this target. For the top 10 brands combined, 9% of their sales must be electric vehicles, 3% plug-in hybrid and 16% petrol hybrid. Some brands are required to achieve EV sales as high as 13% of their total in 2030, and petrol hybrid sales proportion as high as 46%.

For some brands, petrol hybrids were chosen in preference to diesel as those brands demonstrated their buyers prefer petrol vehicles over diesel. In 2030, the CO_2 emissions of a petrol hybrid are expected to be similar to that of a diesel vehicle and so these powertrain types can be considered to be interchangeable.

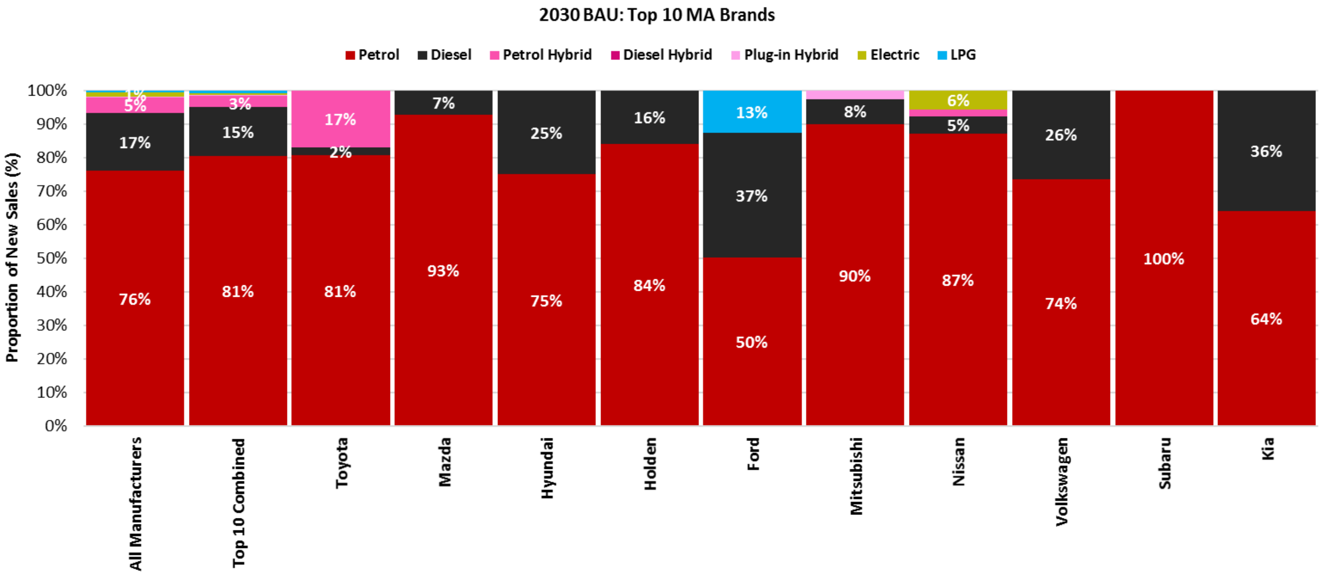


Chart 46 – Powertrain mix of the top 10 MA vehicle brands in 2030 under business as usual

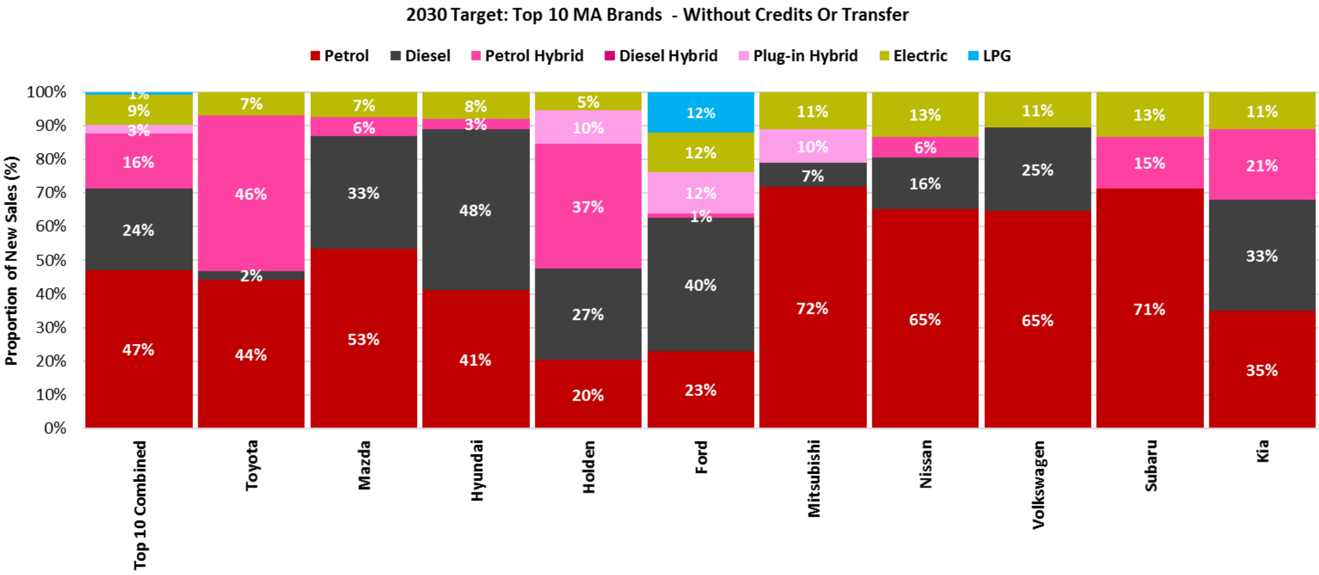


Chart 47 – Powertrain mix required for the top 10 MA vehicle brands to meet the 2030 limit curve without credits or transfer

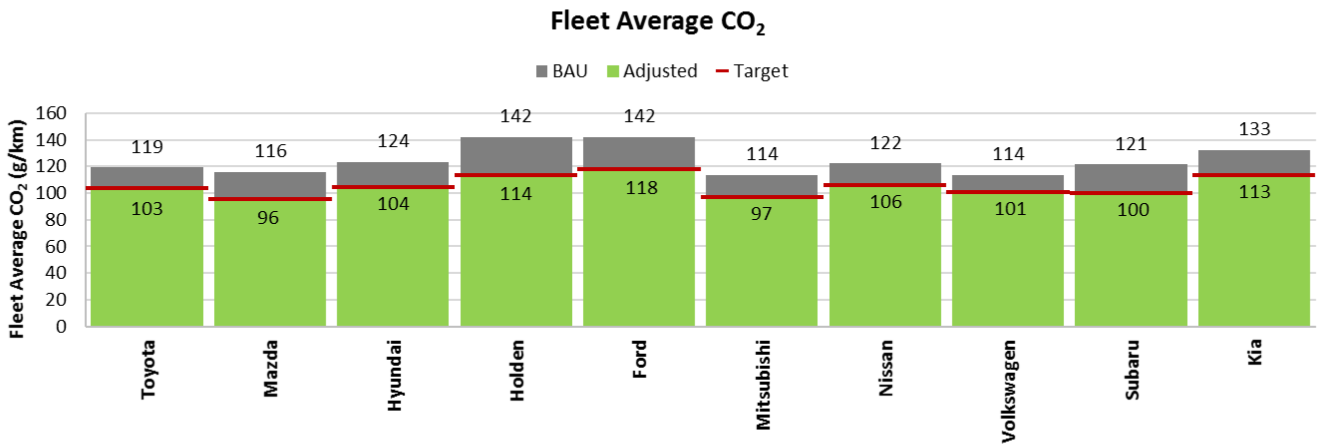


Chart 48 – Fleet average CO_2 of the top 10 MA vehicle brands in 2030 without credits or transfer

Chart 48 compares the fleet average CO_2 for each of the top 10 MA brands in 2030 under a BAU with their respective targets, showing the CO_2 after adjustments have been made to their technology and powertrain mix. Brands with a higher fleet average vehicle mass will have a higher CO_2 target, but on average, each brand is required to reduce their average CO_2 by approximately 16% from the BAU in order to comply with the limit curve for the 106 g/km target in 2030. Because no credits or transfers are applied, each brand's adjusted fleet average CO_2 is equal to their target value.

NA + MC VEHICLES (SCENARIO 1: WITHOUT CREDITS OR TRANSFER)

In determining the powertrain mix required to meet the 143 g/km target for NA + MC vehicles, Chart 49 shows that approximately 5% of new sales in 2030 are required to be electric vehicles, in addition to 7% of sales being hybrids. Due to the larger battery size and weight of PHEVs, it is considered less suitable for light commercial vehicles and four-wheel drive vehicles to use this technology at it would significantly affect the function of the vehicles. Electrification of smaller vans is considered to be viable as these generally have lower requirements for range, towing and in some instances, payload, and so the majority of the uptake for EVs is expected to be in vans of gross vehicle mass less than 2.5 tonnes.

Due to the high proportion of diesel engines already used by this category of vehicles, when compounded with the utility required by those purchasing LCVs and MC category SUVs, any more significant changes to the powertrain mix is considered to be difficult to achieve. This raises a concern for the potential of significant further CO_2 reduction beyond 2030.

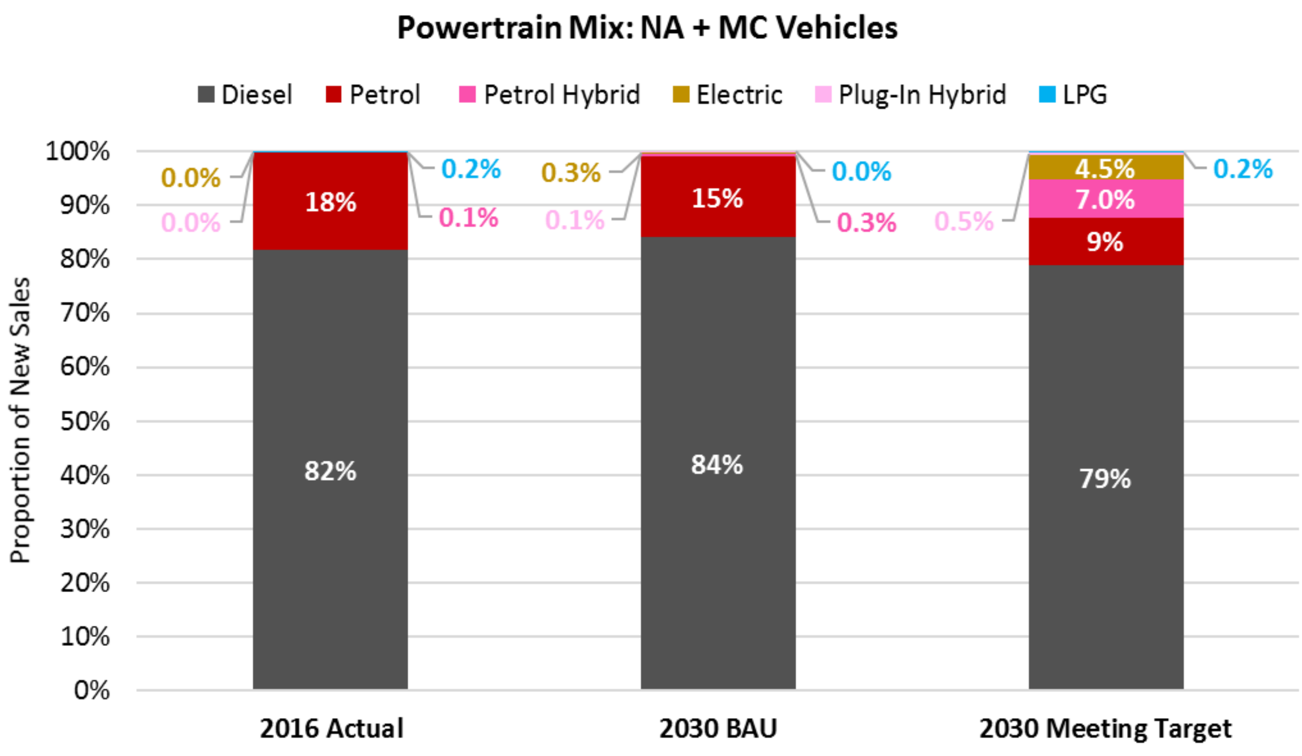


Chart 49 – Powertrain mix of NA + MC vehicles required to meet the 2030 target

Top 10 Brands

Chart 50 shows the forecast sales mix by powertrain type for the top 10 brands selling NA + MC vehicles in 2030 under a business as usual. As Kia is forecast to be among the top 10 brands by total vehicle sales in 2030 it is included, even though the modelling (based on 2016 sales data) does not forecast any sales of NA or MC vehicles. Diesel powertrains are expected to dominate this vehicle category, with the exception of Subaru which is forecast to have 84% of sales using petrol engines as Subaru sells only MC category vehicles, whose buyers in 2016 prefer to select the petrol variant.

Chart 51 shows the sales mix by powertrain type necessary for these brands to comply with the limit curve for NA + MC vehicles in 2030, if credits or transfers were not allowed. Chart 52 compares the fleet average CO_2

of the brands under a business and usual, and their adjusted values once the technology and powertrain adjustments summarised in Chart 51 are applied. On average a 14% reduction in CO_2 from the BAU is necessary across the brands to meet their respective targets (this compares to 9% overall), and with already high use of advanced technology diesel engines, the only viable option to significantly reduce CO_2 is the use of electric powertrains.

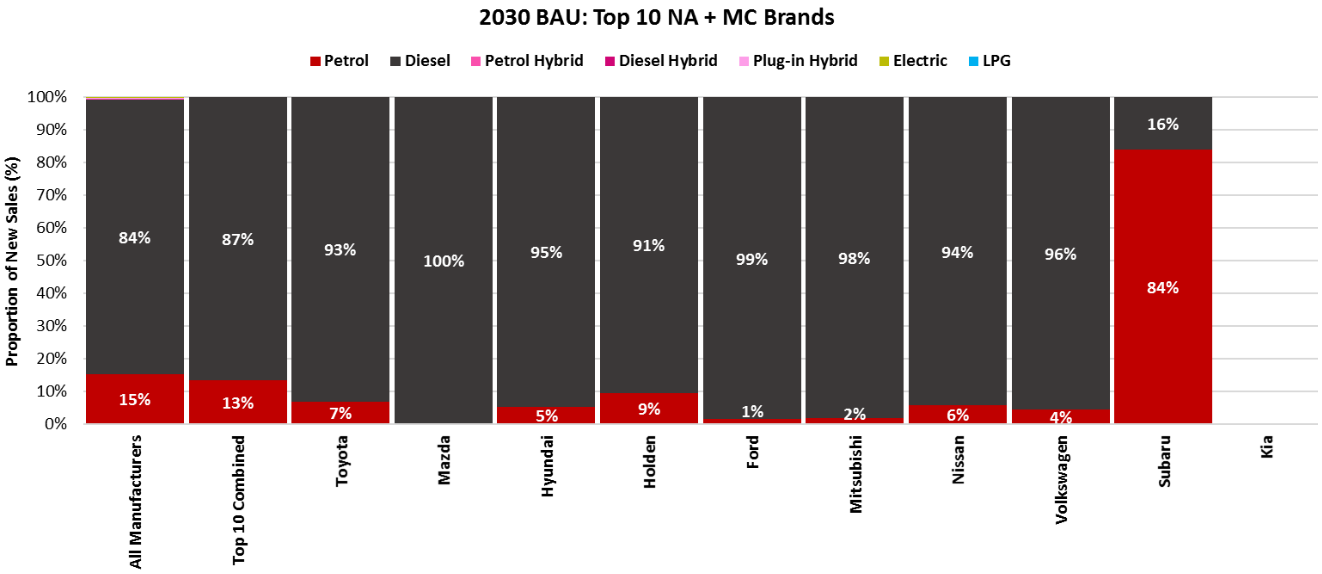


Chart 50 - Powertrain mix for the top 10 NA + MC vehicle brands in 2030 under business as usual

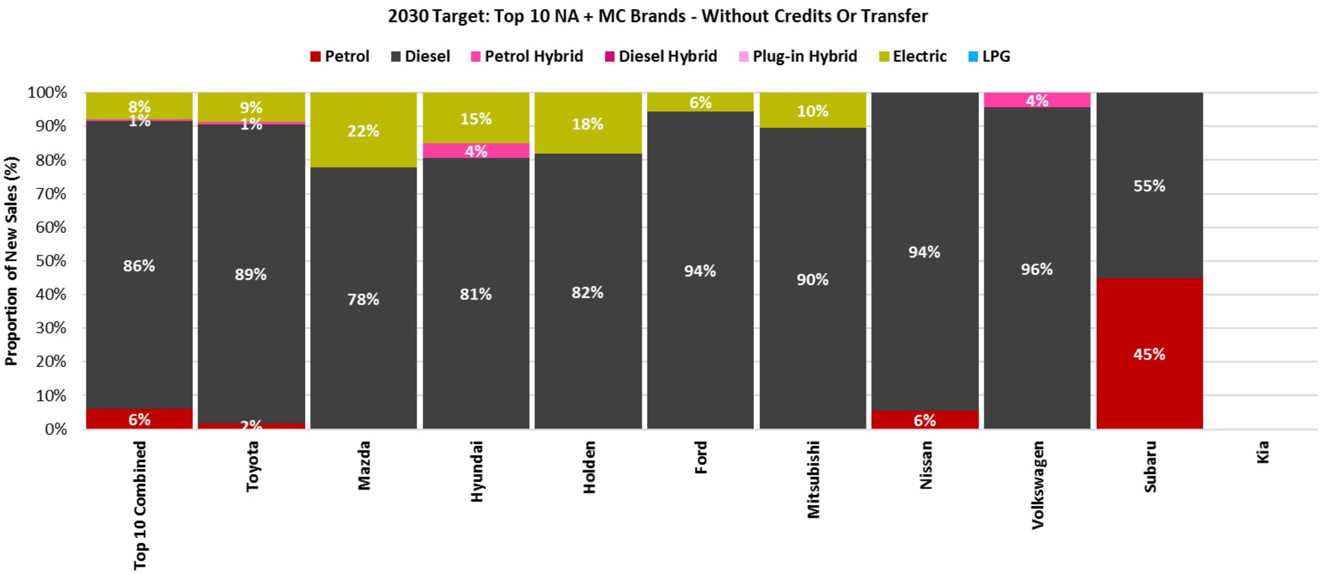


Chart 51 - Powertrain mix required for the top 10 NA + MC vehicle brands to meet the 2030 limit curve without credits or transfer

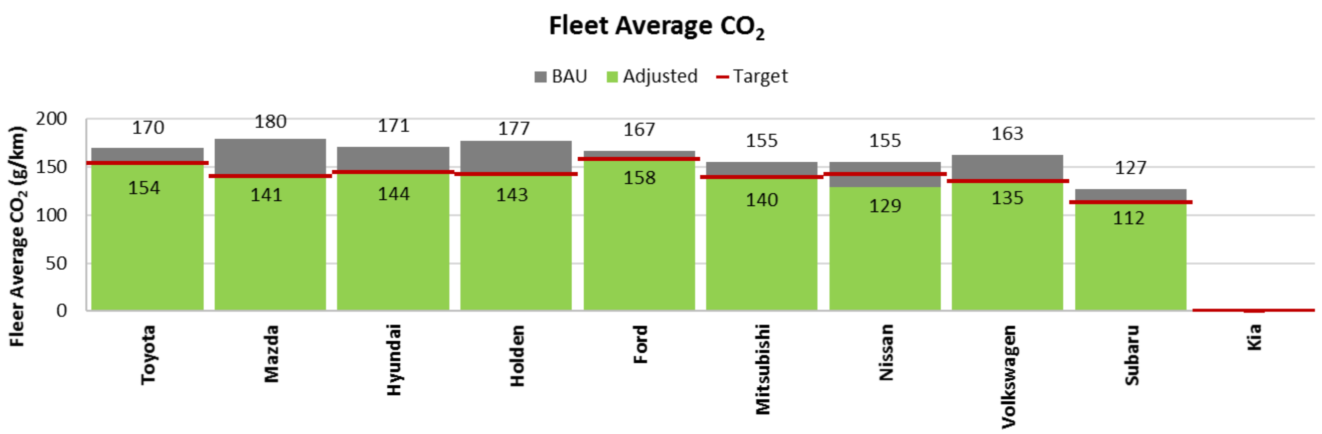


Chart 52 - Fleet average CO_2 for top 10 NA + MC vehicle brands in 2030 without credits or transfer

Due to the similar fuel efficiency performance of high technology diesel and hybrid powertrains, significant CO_2 reductions for the NC and MC vehicles is expected to be a sizable challenge for brands selling into Australia when using the 143 g/km target. The viability of shifting sales of light commercial vehicle or four-wheel drive capable SUVs to an electric powertrain is much less likely than that for passenger cars due to the utility requirements of these vehicles. A need to tow, a long fuel range and rugged, durable operation of NA and MC vehicles have resulted in buyers selecting diesel as the powertrain of choice which from a technical perspective meets all of these requirements. Until similar real-world performance can be attributed to EVs, or diesel hybrids performing heavy-duty tasks can be proven, this is expected to seriously inhibit the penetration of these technologies.

As a result of this, the impact of allowing transfer of CO_2 credit from a brand's MA vehicle average to their average for NA + MC vehicles is considered, in addition to use of credits for air conditioning systems with improved efficiency and lower global warming potential refrigerants (as per the US regulatory system).

MA VEHICLES (SCENARIO 2: USING CREDITS AND TRANSFER)

Top 10

Chart 54 shows the sales by powertrain type in 2030 that are required for the top 10 brands selling MA vehicles if credits and transfer of CO_2 between segments are permitted. A CO_2 credit of 10 g/km is applied to each of the brands for the use of improved efficiency of air conditioning systems and lower GWP refrigerants, out of a maximum 15 g/km of credit that is permitted in the US regulatory system. For comparison, Chart 53 is included above Chart 54, showing the powertrain forecast under the BAU.

The use of air conditioning credits significantly lowers the fleet average CO_2 of each brand such that their forecast CO_2 under the BAU is closer to the target, requiring a less dramatic shift to alternative technologies. By using the credits, the combined top 10 require only 4% of new sales to be from EVs and 8% from petrol hybrids compared to 9% and 16% respectively if no credits were used (as shown in Chart 47).

Chart 55 shows that the adjusted fleet average CO_2 for Holden is below their target, allowing the credit attributed to this to be applied to their fleet average for NA + MC vehicles, reducing the burden on their larger vehicles by offsetting against the smaller vehicles. Conversely, Ford's adjusted fleet average CO_2 when using credits and transfers is slightly above their target as this would allow credit to be transferred from their NA + MC vehicles to help compliance with their MA vehicle target.

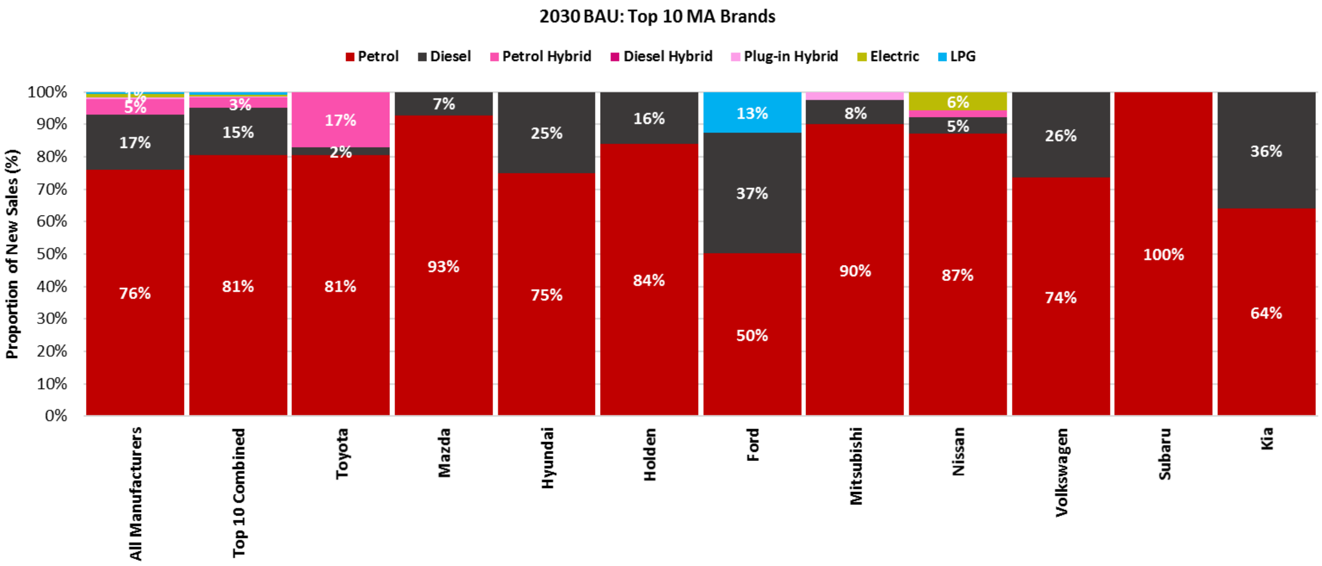


Chart 53 - Powertrain mix of the top 10 MA vehicle brands in 2030 under business as usual

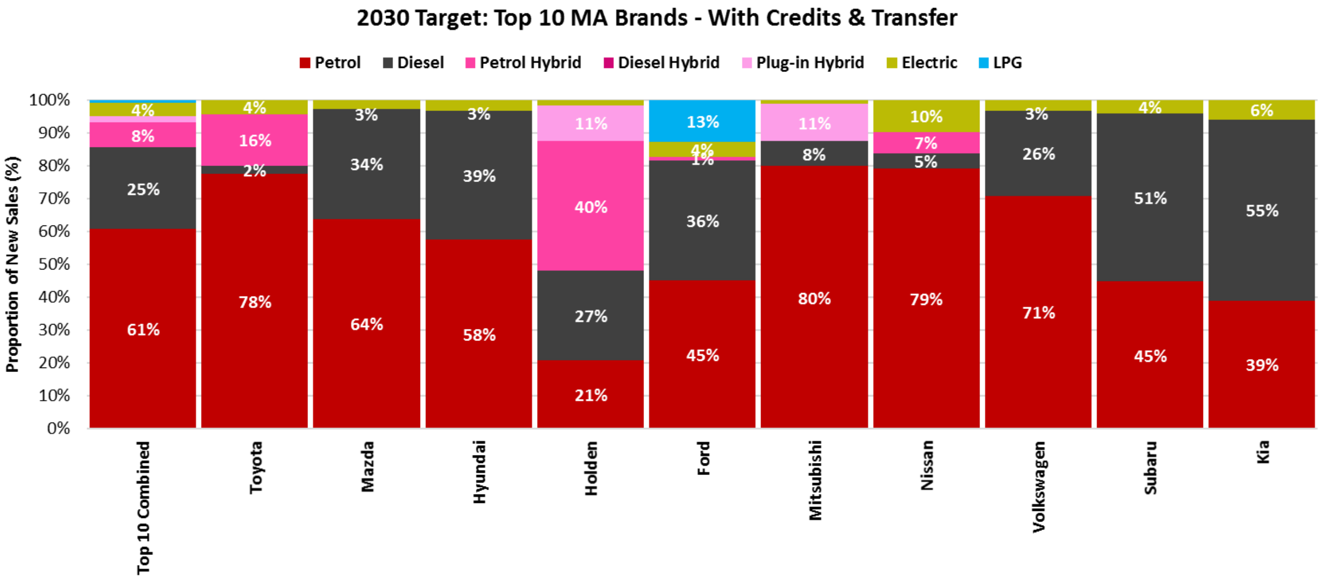


Chart 54 - Powertrain mix required for the top 10 MA vehicle brands to meet the 2030 limit curve using credits and transfer

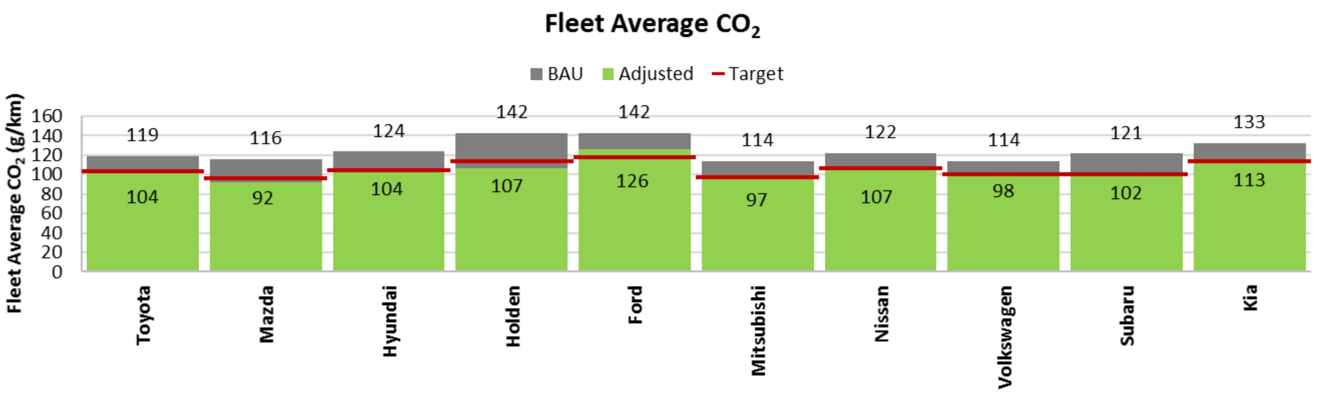


Chart 55 - Fleet average CO_2 of the top 10 MA vehicle brands in 2030 using credits and transfer

NA + MC VEHICLES (SCENARIO 2: USING CREDITS AND TRANSFER)

Top 10

The BAU prediction for sales of NA + MC vehicles by powertrain type in 2030 is repeated in Chart 56, and can be compared to the powertrain required to comply with the limit curve if credits and transfer were permitted, as shown in Chart 57. A credit of 15 g/km is applied to each of the brands in 2030 (out of a maximum of 18 g/km allowed in the US) that is attributed to the use of high efficiency air conditioning systems and refrigerants with low GWP.

The credits enable a much similar product mix to the BAU forecast be offered in 2030, whilst meeting the limit curve for the 143 g/km target for NA+ MC vehicles. This provides a higher possibility to achieve the target than if credits and transfer were not allowed under a CO_2 standard. Only Hyundai and Volkswagen are forecast to require the use of electric powertrain in part of their fleet, with 6% of Hyundai's new sales from EV considered to be possible if the equivalent of their iLoad van has an electric option. It is considered that vans offer the only viable opportunity for use of electric powertrains in light commercial vehicles due to their form factor and payload that could be reduced to facilitate the use of a battery whilst still offering utility as a delivery vehicle within cities.

Chart 58 confirms that Ford's adjusted fleet average for NA + MC vehicles is below their target (due to their significant use of high-tech turbo diesel engines), enabling this credit to be transferred to offset their higher fleet average CO_2 for MA vehicles.

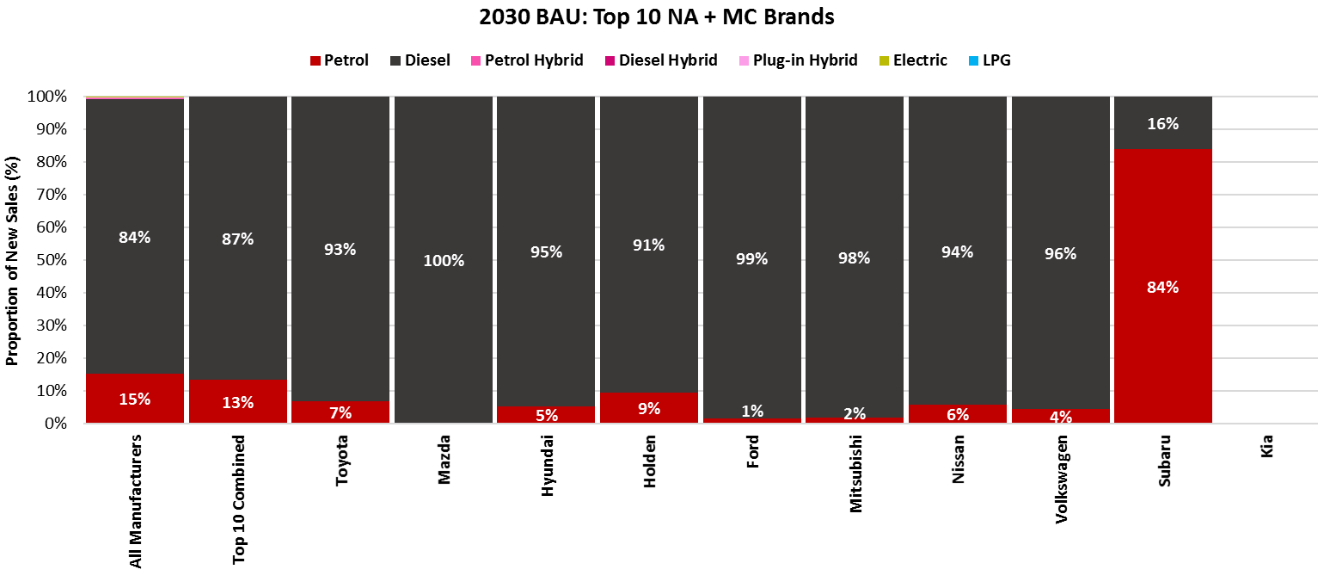


Chart 56 - Powertrain mix for the top 10 NA + MC vehicle brands in 2030 under business as usual

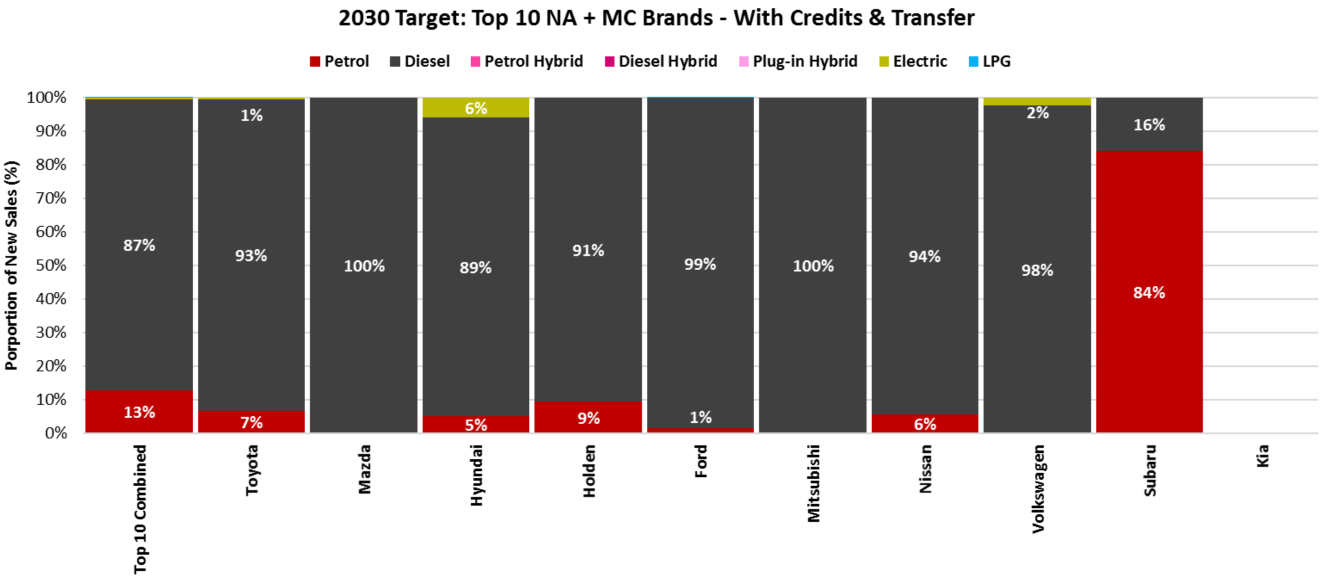


Chart 57 - Powertrain mix required for the top 10 NA +MC vehicle brands to meet the 2030 limit curve using credits and transfer

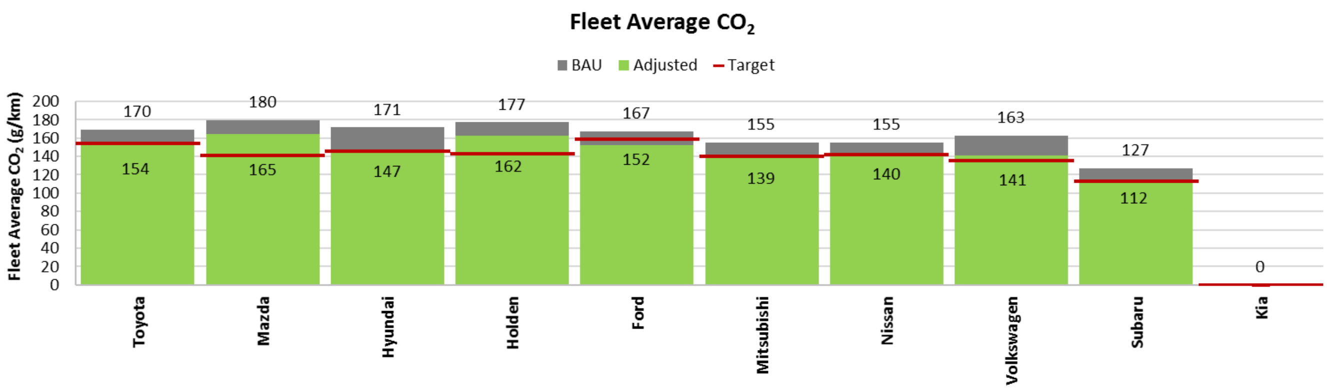


Chart 58 - Fleet average CO_2 of the top 10 NA + MC vehicle brands in 2030 using credits and transfer

COST TO COMPLY WITH THE 2030 TARGETS

The technology adoption and cost burden will not be evenly shared across all vehicle types and segments when complying with the targets. Previous analysis of buying behaviour and fit for purpose requirements reveals that within both the MA category and NA + MC, there will be subsections that will be required to accept and purchase higher cost fuel saving technologies as the other market segments cannot or will not.

MA VEHICLES

Chart 59 shows the cost above the BAU and proportion of sales required by the top 10 brands in order to comply with the MA limit. Under Scenario 1, significantly more vehicles must be sold with costs higher than the BAU compared to Scenario 2 when CO_2 credits and transfer is used.

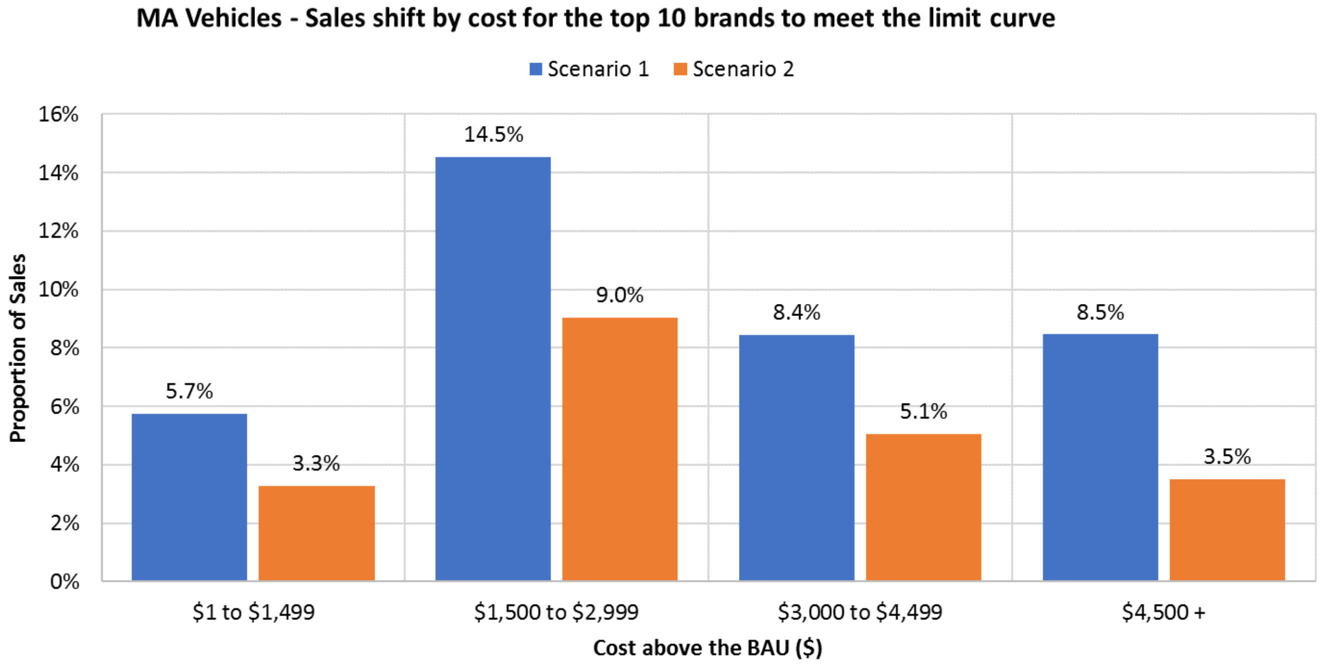


Chart 59 – Cost above the BAU for the top 10 brands to comply with the MA limit curve

In the MA category, analysis of 2016 data demonstrates that there is a very low rate of adoption of alternative powertrain technologies (<1%) in vehicles with a base purchase price less than $30,000. This is due to the price sensitive nature of this segment. Therefore, higher cost alternative technologies in 2030 can be assumed to be purchased only by buyers of cars with a base price greater than $30,000, which contributes only 46% of the total segment.

In Scenario 1, 68% of buyers of cars in the MA category who purchase a vehicle >$30,000 will be required to spend $2000 or more and 20% will be required to spend $5000 more in order for manufacturers to comply with the target. In Scenario 2, 38% of buyers of cars in the MA category who purchase a vehicle >$30,000 will be required to spend $2000 or more and 9% will be required to spend $5000 more in order for manufacturers to comply with the target. This is summarised in Table 20.

Proportion of vehicles required to increase costs to meet the limit curve				
MA Vehicles	Scenario 1		Scenario 2	
Cost Above BAU	>$2,000	$5,000 (Electric)	>$2,000	$5,000 (Electric)
All vehicles	31%	9%	17%	4%
Vehicles >$30k	68%	20%	38%	9%

Table 20 – Proportion of MA vehicles with increased costs to meet the limit curve

NA + MC VEHICLES

Chart 60 shows the cost above the BAU and proportion of sales required by the top 10 brands in order to comply with the NA + MC limit. Under Scenario 1, significantly more vehicles must be sold with costs higher than the BAU compared to Scenario 2 when CO_2 credits and transfer is used.

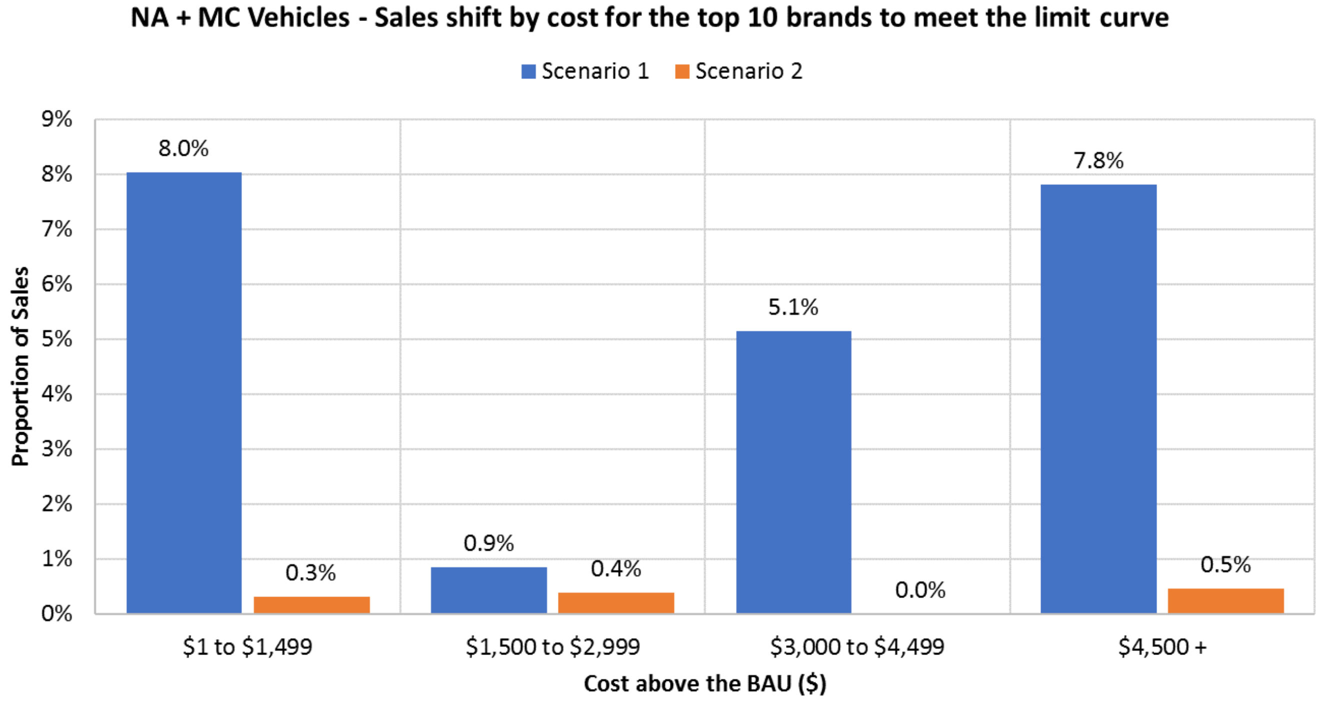


Chart 60 - Cost above the BAU for the top 10 brands to comply with the NA + MC limit curve

In the NA + MC category, analysis of vehicle technology to 2030 and operator fit for purpose requirements reveals that there is very limited opportunity to deploy electrified powertrains (EV and PHEV) due to the payload and towing needs in this segment. Analysis of 2016 sales data illustrates the NA + MC category already has very high adoption rates of efficient diesel engine vehicles with comparatively good CO_2. In this category, the burden of electrified technology adoption to achieve any CO_2 standard will most likely fall to vans and a limited number of MC class vehicles.

In Scenario 1, whilst only 14% of average sales will be required to spend greater than $2000 to achieve the target, this will increase to 80% of van buyers and 3% of MC buyers in order for manufacturers to comply with the target. Of these, 45% of van buyers and 2% of MC buyers will be required to spend an additional $5000.

In Scenario 2, whilst only 1% of average sales will be required to spend greater than $2000 to achieve the target, this will fall to 5% of van buyers in order for manufacturers to comply with the target. Of these, only 3% of van buyers will be required to spend an additional $5000. This is summarised in Table 21.

Proportion of vehicles required to increase costs to meet the limit curve				
NA + MC Vehicles	Scenario 1		Scenario 2	
Cost Above BAU	>$2,000	$5,000 (Electric)	>$2,000	$5,000 (Electric)
All	14%	8%	1%	0%
Vans (80% Share)	80%	45%	5%	3%
MC (20% Share)	3%	2%	0%	0%

Table 21 - Proportion of NA + MC vehicles with increased costs to meet the limit curve

RETROSPECTIVE ON THE MODELLING

The 2030 targets of 106 g/km target for MA vehicles and 143 g/km target for NA + MC vehicles still require a large shift in the types of vehicles sold when compared to the business as usual forecast.

The use of credits related to air conditioning is a significant enabler to achieve the targets whilst still providing real improvements in reducing the greenhouse warming impact of vehicles.

The use of CO_2 credit transfer (within a brand) from one vehicle category to another provides flexibility that could maintain utility and customer choice whilst still allowing targets to be met. It could result in higher vehicle technology costs being applied to one vehicle segment in order to maintain a more cost-effective vehicle segment where price is more sensitive (e.g. electric luxury vehicles could offset diesel utes).

It is noted that under the assumptions made and with the use of credits and transfer of credits within a brand, it will be challenging for manufacturers to meet the selected 2030 targets, particularly in the NA + MC category, and that the cost burden to achieve the targets will not be evenly distributed among vehicle sales, but focused particularly on MA category vehicles with a base price over $30,000 and NA category vans.

APPENDIX 1 – ANNUAL CO_2 CHANGE REQUIRED TO MEET THE TARGETS

Table 22 below shows the annual change in CO_2 required to meet the 106 g/km and 143 g/km targets. In the original analysis the light vehicle fleet was separated to provide a target for passenger cars and SUVs, and a target for light commercial vehicles.

These targets correspond to a BAU progression forecast until 2022, followed by a trajectory for PC + SUVs with annual CO_2 reduction that is 1% (per annum) greater than the 3.3% annual reduction required in the US between 2022 and 2030. For LCVs, the trajectory required from 2022 to 2030 is greater than the 3.7% annual reduction required in the US over this time frame. In both cases, the US target trajectories relate to targets with credits applied.

	PC + SUVs		LCVs	
Year	CO_2 (g/km)	Annual % Change	CO_2 (g/km)	Annual % Change
2016	172	-	219	-
2017	168	-2.2%	215	-1.7%
2018	165	-2.2%	212	-1.7%
2019	161	-2.2%	208	-1.7%
2020	157	-2.2%	204	-1.7%
2021	154	-2.2%	201	-1.7%
2022	151	-2.2%	198	-1.7%
2023	144	-4.3%	190	-4.0%
2024	138	-4.3%	182	-4.0%
2025	132	-4.3%	175	-4.0%
2026	126	-4.3%	168	-4.0%
2027	121	-4.3%	161	-4.0%
2028	116	-4.3%	155	-4.0%
2029	111	-4.3%	148	-4.0%
2030	**106**	-4.3%	**143**	-4.0%

Table 22 – Annual CO_2 change required to meet the targets for preliminary vehicle categories

After the selection of these targets based on preliminary analysis, vehicle segmentation was confirmed such that MC category SUVs were incorporated with light commercial vehicles. This led to a 106 g/km target applying to MA category vehicles, and a 143 g/km target applying to NA combined with MC category vehicles (referred to as "NA + MC").

Table 23 details the annual CO_2 reductions necessary to 2030 of the modelled vehicle categories. The corresponding CO_2 values for 2016 of 168 g/km and 214 g/km reflect the actual average CO_2 for MA and NA + MC category vehicles, respectively.

Due to the change in vehicle segmentation, slightly lower annual CO_2 reductions are presented in Table 23 compared with those in Table 22, even though the target values for 2030 are the same. This is because the starting CO_2 values in 2016 have changed with the segmentation of vehicles in each target. At 4.0%, the CO_2 reductions for MA vehicles from 2022 to 2030 presented in Table 23 is greater than the 3.3% required in the US over this timeframe. NA + MC vehicles have an annual reduction of 3.5% compared to the 3.7% annual reduction required in the US from 2022 to 2030.

	MA		NA + MC	
Year	CO_2 (g/km)	Annual % Change	CO_2 (g/km)	Annual % Change
2016	168	-	214	-
2017	164	-2.2%	210	-2.0%
2018	161	-2.2%	206	-2.0%
2019	157	-2.2%	201	-2.0%
2020	154	-2.2%	197	-2.0%
2021	150	-2.2%	193	-2.0%
2022	147	-2.2%	190	-2.0%
2023	141	-4.0%	183	-3.5%
2024	135	-4.0%	177	-3.5%
2025	130	-4.0%	170	-3.5%
2026	125	-4.0%	164	-3.5%
2027	120	-4.0%	159	-3.5%
2028	115	-4.0%	153	-3.5%
2029	110	-4.0%	148	-3.5%
2030	**106**	-4.0%	**143**	-3.5%

Table 23 - Annual CO_2 change required to meet the targets for the final chosen vehicle categories

REFERENCES

Background

2016 New Vehicle CO_2 Analysis

1. ABMARC, 2016, Analysis of the Australian 2015 New Light Vehicle Fleet and Review of Technology to Improve Light Vehicle Efficiency.

CO_2 Targets for Australia - Proposal

The CO_2 Target Mechanism – A Global Perspective

1. International Council on Clean Transportation, 2014, Development Of Test Cycle Conversion Factors Among Worldwide Light-Duty Vehicle CO_2 Emission Standards, [Online]. Available at: http://www.theicct.org/sites/default/files/publications/ICCT_LDV-test-cycle-conversion-factors_sept2014.pdf
2. 49 CFR Parts 523, 531, 533. et al. and 600. 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards; Final Rule, October 15, 2012. [Online]. Available at: https://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/2017-25_CAFE_Final_Rule.pdf