Vehicle CO_2 emissions legislation in Australia – A brief history in an international context

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1. Introduction

Road transport is a large and growing source of greenhouse gas emissions. Road transport contributes about 20% of the European Union's (EU) total CO_2 emissions. Light-duty vehicles i.e. passenger cars and light commercial vehicles produce around 15% of the EU's CO_2 emissions.[1] Slightly higher numbers have been reported for the US.[2]

In Australia, road transport contributed 16% to total CO_2 emissions in 2000 and this contribution has been growing to 18% in 2010 and 21% in 2016.[3,4,5,27] Total CO_2 emissions from road transport have increased with almost 30% in the period 2000-2016.[27]

To drive improvements in light vehicle fuel efficiency and reduce the growth of greenhouse gas emissions from the transport sector, fuel efficiency and/or CO_2 vehicle emission standards have been adopted in approximately 80% of the global light vehicle market, including the US, EU, Canada, Japan, China, South Korea and India.[6] Despite the fact that developing countries are mostly users of 'second-hand' vehicle technology, several of them promote similar actions.[7] Mandatory CO_2 standards are internationally recognised as one of the most cost effective strategies to reduce transport emissions.[8]

2. Research question

This study has conducted a brief review of the latest international developments in relation to CO_2 emission standards for motor vehicles, and has made an assessment of on road and real world CO_2 emission rates from the Australian on-road car fleet.

The research question of this study is:

What has Australia achieved in this space over the last 20 years, and how does this compare to international best practice?

3. Addressing the Research Question

The answer to the research question is best told using the chart presented in Figure 1. Figure 1 plots CO_2 emission rates/targets/standards versus base year for the period 2000-2025.

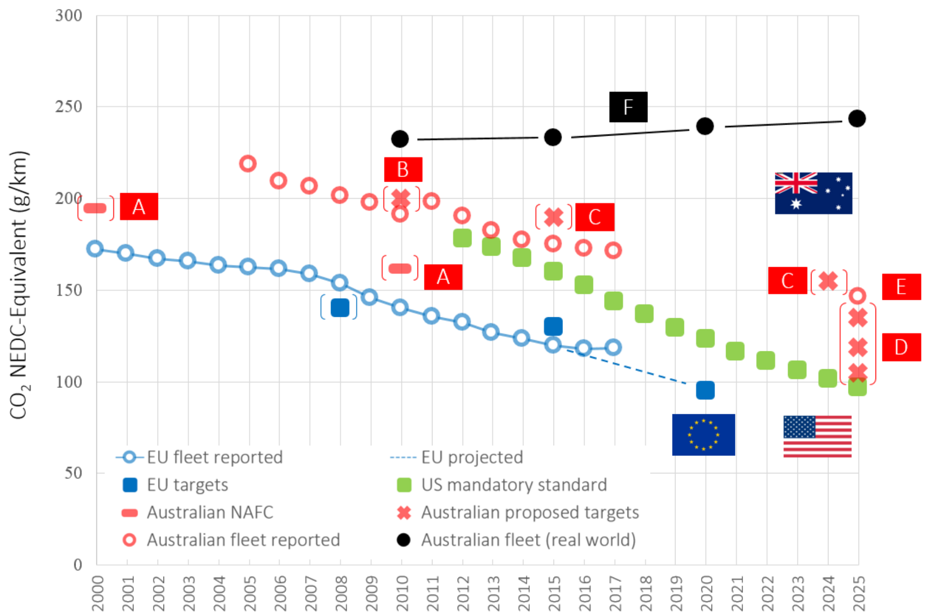

Figure 1 – (Proposed) vehicle CO_2 emission standards for passenger cars in Australia and comparison with international best-practice.

Australia's performance is best understood compared to international best practice. Figure 1 therefore summarises various aspects in relation to CO_2 emission legislation for passenger cars in Europe (blue) and the US (green). It shows relevant aspects for Australia (red), including voluntary targets, proposed standards and real-world emission levels (black). The chart has been constructed using data from various sources.[2,9,10,11,12]

In order to compare the different regions, CO_2 emission rates in Figure 1 have been normalised to New European Drive Cycle or 'NEDC-equivalents' (except for the black dots – real-world emissions), which takes into account different test procedures used around the world.[9] The NEDC is part of a vehicle emissions laboratory test protocol (UNECE R83) that is commonly used around the world for vehicle certification. The drive cycle was developed in the early 1970s and consists of mild accelerations and constant speeds that do not reflect modern driving. As a consequence, CO_2 emission rates are significantly higher on the road in real-world conditions. This (growing) discrepancy is important and will discussed in more detail later in this report.

It is noted that the relative emissions performance of vehicle fleets in particular countries or regions is not only related to the presence of CO_2 vehicle emission standards. It is a reflection of the complex interaction of consumer preferences for particular categories or types of vehicles, the degree to which lower emission technologies and fuels are adopted in the vehicles offered for sale in the market, and the information and policies, which influence both consumers and manufacturers.[8]

The information presented in Figure 1 is unpacked and explained in detail in the following sections. Figure 1 will be (partially) repeated in the subsequent sections to assist the discussion.

4. The International Context

4.1 European Union

In 1995 the European Union (EU) made a proposal to set a fleet average CO_2 emissions target of 120 g/km for 2005. Following this, the EU entered into a voluntary agreement with car manufacturers in 1999 to achieve fleet average emissions of 140 g CO_2/km by 2008. Figure 2 shows this target within brackets as there was no mechanism for enforcement (voluntary targets).

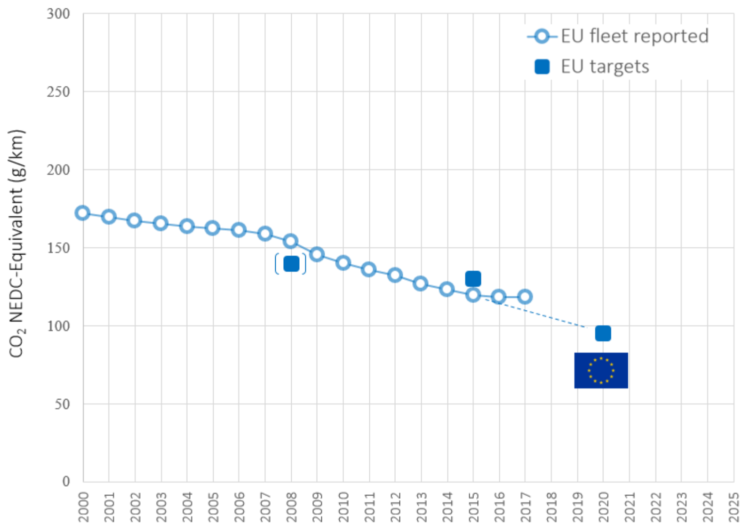

Figure 2 – Vehicle CO_2 emission targets for passenger cars in the EU.

The automotive industry did not meet this target. Subsequently, the EU set mandatory targets in 2009, i.e. (passenger car) fleet average CO_2 emissions at 130 g CO_2/km (2015) and 95 g CO_2/km (2020).[10] The targets are shown in Figure 2 as blue squares.

The EU CO_2 standards are currently regarded as the most stringent in the World. Manufacturers that fail to comply with these targets face hefty fines. Indeed, manufactures appear to have achieved the 2015 target [10], as is shown in Figure 2 (blue dots). However, Figure 2 also shows that progress has stalled over the last two reporting years. Reported CO_2 fleet average emission rates are flatlining in 2016 and 2017, which is a concerning development.

An even more significant issue is that the laboratory (NEDC) emissions test to verify this, significantly and increasingly underestimates CO_2 emissions in the real world by about 10% in 2005 to about 40% in 2015.[10] So in reality, the reduction in CO_2 emissions is not as large as one may be led to believe when examining the (official) laboratory results. This issue is well known, and often referred to as the 'gap'.[13]

There are multiple reasons for this so-called ‘gap’, such as the test protocol itself and strategies used by car manufacturers (and allowed by the test) to achieve lower emissions in laboratory conditions – as compared with real-world performance. Examples are a gentle drive cycle (NEDC), use of low-resistance tyres during the test, air conditioning switched off during the test and reduced vehicle weight during the test.

To address the gap issue, at least to some extent, the EU adopted a new test procedure in 2017 called the Worldwide harmonized Light-duty Test Procedure (WLTP). However, CO_2 targets will still be assessed using the NEDC test up to 2020, after which new WLTP based targets will be developed and used.

A related issue is that fuel consumption and CO_2 labelling of new cars is increasingly inaccurate, because of the gap. It is likely that new vehicle buyers will increasingly undervalue fuel savings, relative to other aspects such as size and performance, due to imperfect and uncertain fuel use information.[6]

On 17/12/2018, the EU set binding CO_2 emission targets for new passenger cars and light-commercial vehicles for 2025 and 2030. The agreed-upon targets aim to reduce the average emissions from new cars by 15% in 2025 and by 37.5% in 2030. For light-commercial vehicles, a 15% target for 2025 and a 31% target for 2030 were agreed. Both reductions make reference to the WLTP measured CO_2 values of MY 2020-21.

On 19/2/2019, the EU institutions agreed on a compromise for setting CO_2 emission standards for new heavy-duty vehicles (HDVs) for the first time in the European Union. The targets will reduce the average CO_2 emissions from the highest-emitting HDV segments by 15% in 2025 and by 30% in 2030. The baseline value will be defined based on the certified CO_2 emissions of new trucks collected under a separate monitoring and reporting regulation, which entered into force in January 2019.

In addition to the above the EU has introduced compulsory application of on board fuel monitoring systems (OBFCM) with the aim of also monitoring the real world fuel consumption of the fleet in the future. The latter comes as a response to the continuously increasing CO_2 gap in the EU.

4.2 United States of America

Already in 1975 Corporate Average Fuel Economy (CAFE) standards were established for passenger cars and light-duty trucks in the US.[12] However, penalties for non-compliance were small and manufacturers have been willing to pay these penalties in the past, instead of improving fuel economy.[2]

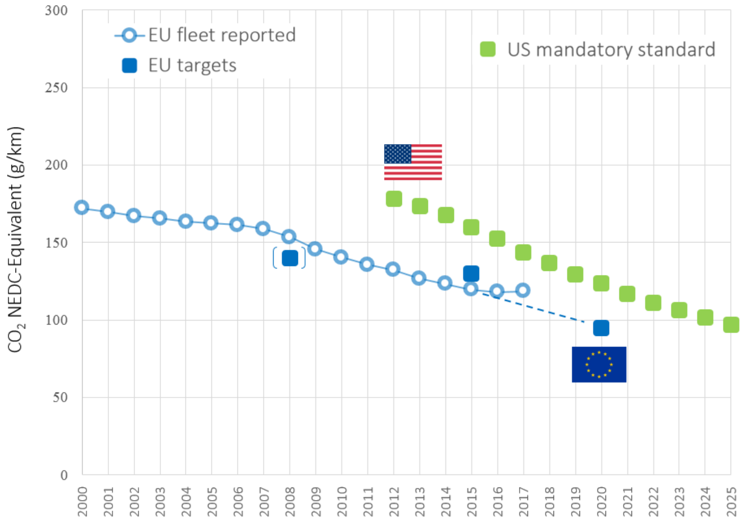

Figure 3 – Vehicle CO_2 emission standards for passenger cars in the US.

In more recent years, concerns about energy security and climate change have resulted in a change in US policies. Beginning with the 2012 model year, the Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA) have jointly regulated vehicle emissions and fuel economy. The EPA standards require that each manufacturer attain a specific overall average rate of CO_2 emissions per mile across all its vehicles. The NHTSA standards set minimum fuel economy requirements. Because a vehicle's fuel economy is closely linked to its GHG emissions, the two agencies have attempted to harmonise their standards.[14]

The new CO_2/fuel economy standards tighten by roughly 3% per year, whereas the previous (CAFE) standards had been largely unchanged for two decades.[14] The penalty for violating the CO_2 standard is severe (potential revocation of the license to sell vehicles in the US), whereas the penalty for violating the CAFE standard has been relatively mild.[2]

CO_2/fuel economy standards in the US also link to (laboratory) dynamometer testing, but they are based on a different test procedure than Europe. Before the 2008 model year (light duty vehicles), fuel economy testing took place using the Federal test Procedure (FTP) and the Highway Fuel Economy Test (HWFET). However, it was clear at the time that these tests also underestimated real world CO_2 emissions (or rather overestimated real-world fuel economy).

Changes were therefore made to the test procedure and more drive cycles (cold FTP, US06, SC03) with e.g. high speeds and aggressive driving were added, thus obtaining better real-world representative results in the tests. It has been reported that the US test procedure now appears to slightly underestimate (on average) rated real world fuel economy, and thus slightly overestimate real-world CO_2 emissions.[28]

Nevertheless, the US still uses the 2-cycle FTP/HWFET procedure to test for compliance with CO_2 and fuel efficiency standards. Data from the US EPA[29] suggests that the gap between the official compliance test and real-world emissions also exists in the US and that it is about 50% for model years 2017 and 2018.

5. The Australian Story

5.1 A brief history of CO_2 targets and standards in Australia

Over the last 20 years there have been four important documents released by the Australian Government for public consultation [6,8,15,18], as is shown in Figure 4.

Figure 4 – Relevant public consultation documents in Australia.

These documents were released over a period of 8 years and contain detailed information and discussion regarding CO_2 emissions from (light-duty) motor vehicles in Australia.

Relevant aspects in relation to CO_2 vehicle emission standards are show in Figure 5, as well as the EU and US data discussed in the previous sections. One thing that is immediately clear in the chart is that reported CO_2 values regarding the Australian fleet (red dots) are significantly higher as compared with the EU fleet (about 30% in the period 2005-2017).

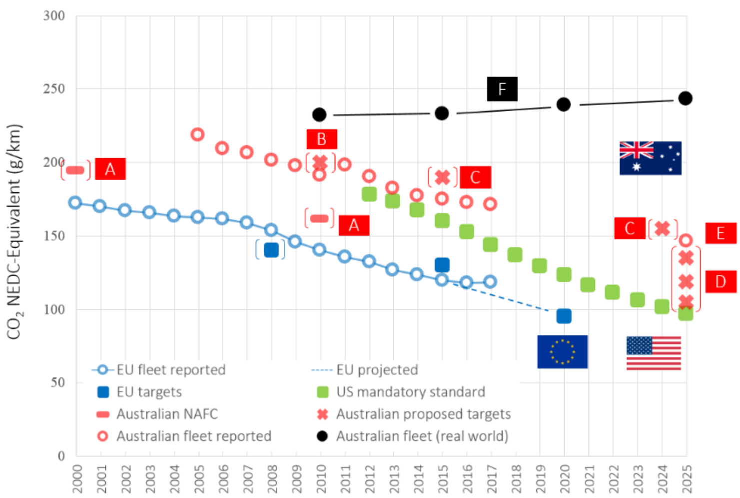

Figure 5 – (Proposed) vehicle CO_2 emission standards for passenger cars in Australia and comparison with international best practice.

Interestingly, the values are also (increasingly) higher than the US fleet, which has a more similar fleet make up with a large (and growing) portion of large petrol cars/SUVs.[29] Australian reported values are about 5% higher than the US fleet in 2012, but growing to 20% in 2017 and anticipated to be 50% higher in 2025.

To some extent this is caused by the type of vehicles used in Australia. Australian consumers purchase a higher proportion of large and heavy passenger vehicles, with more powerful engines, larger engine capacities and automatic transmissions (and hence higher emissions) than consumers in Europe.

For instance, the majority (about 75%) of the Australian car fleet had an engine capacity of more than 2 litres, whereas this was about 10% in European countries like the United Kingdom and the Netherlands.[16] The growing and substantial difference in reported CO_2 emissions with the US is, however, more difficult to explain.

It has been reported that the most efficient variants of vehicle models offered in Australia are considerably less efficient than the most efficient variants of the same model offered in other markets. For example, the most efficient variants of top selling models offered in Australia were on average 27% per cent worse than the most efficient model variants offered in the UK.[6]

This suggests that vehicle manufacturers use the lack of mandatory standards in Australia to sell less fuel efficient vehicles as compared with countries where CO_2 emission standards are in place such as Europe and the US. Further research is required to better understand the technological reasons behind this. For instance, are Australian cars using less state-of-the art and less efficient engine technology, are they heavier and larger than cars sold overseas (including US), are they not fully optimised for fuel efficiency, etc.?

Importantly, the efficiency issue also suggests that Australian motorists are paying about 30% more for fuel than they should – from a technological perspective. In the absence of CO_2 standards in Australia it is likely that Australian consumers will not be offered the efficient cars available to consumers in markets with fuel efficiency/CO_2 standards.

Returning to Australian CO_2 targets. No mandatory targets have ever been adopted in Australia, but voluntary targets have been used. Several mandatory target options have been debated and proposed over time. In the chart Australian targets are shown within brackets as they have either not eventuated or have no mechanism for enforcement (voluntary targets).

Similar to the US CAFE standards, Australia has had voluntary fuel-economy targets in place for new petrol fuelled passenger cars since 1978, with specific targets for specific years, including 2000 (8.2 litre/100 km) and 2010 (6.8 litre/100 km).[6] In Figure 5 these voluntary fuel economy targets are converted to CO_2 emission rates using fuel density (0.73 kg/l) and CO_2 fuel intensity (3.17 kg CO_2/kg fuel). NEDC-equivalency was computed using past Australian vehicle emission measurements.[17] The corresponding voluntary targets are 195 g CO_2/km (2000) and 161 g CO_2/km (2010). They are shown in the chart (denoted with 'A'). The voluntary fuel-economy targets were not achieved. The figure shows that the reported CO_2 emission rate (red dots) was about 20% higher than the fuel economy target for 2010.

In 2005, the Federal Chamber of Automotive Industries (FCAI) set a voluntary but unambitious industry target for 2010 of 222 g CO_2/km for new light-duty vehicles, or LDVs, labelled the National Average Carbon Emissions target. This target applied to passenger cars and light-commercial vehicles combined. The LDV target was achieved in 2008.[6] The reported CO_2 emission rate for passenger cars is about 90% of the reported CO_2 emission rate for LDVs.[11] A corresponding industry target for passenger cars only would therefore be 200 g CO_2/km ('B' in the chart). The reported CO_2 emission rate was about 5% lower than this CO_2 target for 2010. Nevertheless, the voluntary industry arrangement did not achieve the original goal of 6.8 l/100 km and the corresponding CO_2 target of 161 g CO_2/km, and was not renewed.

Australia came close to adopting mandatory vehicle CO_2 emission standards. In late 2007, the Australian Government (labour) committed Australia to cutting greenhouse gas emissions by 60% from 2000 levels by 2050 to give effect to Australia's obligations under the Kyoto Protocol. Following earlier work, the then Prime Minister Kevin Rudd instructed the Vehicle Efficiency Working Group to "develop jointly a package of vehicle fuel efficiency measures designed to move Australia towards international best practice", which led to the 2008 public discussion paper.[15]

In 2010, the Australian Government (labour) decided that mandatory CO_2 emissions standards would apply to new light vehicles from 2015, i.e. a national fleet wide average of 190 g/km in 2015 and 155 g/km in 2024 ('C' in the chart).[8] However, a change in Government in 2013 meant the standards would not see the light of day.

In 2015 the Australian Government established a Ministerial Forum to coordinate a whole-of-government approach to addressing emissions from motor vehicles.[6] This included fuel efficiency and/or CO_2 emission standards. A Vehicle Emissions Discussion Paper was released in 2016 and discussed a wide range of initiatives and measures to reduce motor vehicle emissions.[18] This was followed by a draft Regulation Impact Statement (RIS) in the same year.[6]

The targets for 2025 considered in the draft RIS were denoted as 'strong', 'medium' and 'mild', corresponding to 105, 119 and 135 CO_2 g/km in 2025, respectively ('D' in the chart). Under all three targets, the draft RIS concluded that there are significant net cost savings. However, no further action has been taken by the Federal Government since 2016. At the time of writing this report, the Forum is still ongoing, but without clear timelines or further communication.

5.2 The issue of real-world CO_2 emissions in Australia

Getting back to the issue of 'real-world' emissions, i.e. the growing discrepancy between officially reported CO_2 emission rates used in (US and EU[1]) vehicle emissions legislation and those that actually occur on the road.[10,13,29] As mentioned before, real world CO_2 emission rates of vehicles in the EU were underestimated by about 10% in 2005 growing to about 40% in 2015.[10] The US also suffers from the gap issue with values of about 50% for 2017 and 2018 model years, as was discussed before.

The 2016 draft RIS estimates that without mandatory standards the Australian LDV fleet will reach 157 g CO_2/km in 2025, which corresponds to 146 g/km for passenger cars ('E' in chart), simply due to ongoing technological improvements in vehicle efficiency.[6] This is an estimated reduction of about 25% as compared with the reported CO_2 emission rate in 2010 of 191 g/km.

TER conducted preliminary modelling of real-world CO_2 emissions, which shows a different picture ("F', black dots in the chart, note: not corrected for NEDC as this represents actual on-road emission rates).

[1] Note that EU legislation is relevant for Australia as the Euro vehicle emission standards (air pollutants) have been adopted in Australia since 2003. Before 2003, US vehicle emission standards (air pollutants) were used in Australia.

The COPERT Australia software was used in combination with AFM (Australian Fleet Model) to predict average CO_2 levels in real-world conditions. COPERT Australia predicts emissions for 226 Australian vehicle classes and accounts for the effects of e.g. driving behaviour, meteorology and fuel quality.[3] A description of the software is provided in Attachment A. AFM simulates turnover of the Australian fleet and takes into account vehicle sales data and information regarding vehicle population and vehicle use. A description of the tool is provided in Attachment B.

This preliminary modelling by TER shows two main issues.

1. Average CO_2 emission rates of the on road Australian car fleet (including SUVs) is about 20% higher in 2010 and 65% higher in 2025, as compared with reported or estimated (NEDC based) Australian CO_2 values for new cars. [2]
2. Real-world CO_2 emission rates are not expected to go down, but are in fact expected to *increase* by about 5% in the period 2010-2025. The main reasons for this are a) limited reduction in mean real-world vehicle CO_2 emission rates (previous point), and b) a strong and sustained growth in SUV sales that has increased the proportion of larger and heavier vehicles in the on-road fleet. Large vehicles require more fuel per kilometer of driving and emit significantly more CO_2 than smaller cars.

To make matters worse, the impact of an increase in the real-world CO_2 emission rates on total CO_2 emissions[3], is compounded by the ongoing growth in total travel. The Australian Bureau of Statistics (ABS) reported that total travel by passenger vehicles in Australia was 142 billion kilometres in 2000. This has been growing to 176 billion kilometres in 2016, an increase of 24%.[19]

This means that average CO_2 emission rates of new passenger cars actually need to be reduced significantly[4] only to offset the growth in kilometres travelled and just to prevent an increase in total CO_2 emissions from road transport.

At this stage, there are neither CO_2 emission standards nor other supportive (harmonised) measures that promote the uptake of zero/lower emission vehicles (e.g. electric vehicles) at a national level in Australia.[20,21] As a consequence, Australia is increasingly lagging behind international best practice. This also carries a reputational risk where Australia may be internationally regarded as a 'climate villain' in the transport arena, and is not doing its bit to address climate change.

[2] This reflects the increasing 'gap' that is observed worldwide, and was discussed earlier. However, it is emphasized that this study is comparing the on-road fleet (including *older vehicles*) with reported *new vehicle* emissions performance based on the NEDC, rather than comparing reported *new* vehicle emissions performance with on road and real world emission measurements of the same *new* vehicles. The latter cannot be done as there are currently no emission test programs in Australia that collect these data, which is in stark contrast with e.g. Europe and the US.

[3] Total CO_2 emissions (g) are computed by mutiplying mean CO_2 emission rate (g/km) with total travel (vehicle kilometres).

[4] This would likely require a reduction that is significantly larger than 24%, as new passenger cars make up only a minor portion of the on-road fleet, which includes other vehicle types (light commercial vehicles, trucks, buses, motorcycles), as well as older passenger cars that are not affected by current CO_2 emissions regulation.

6. Conclusions

Australia has attempted to impose CO_2 or fuel efficiency standards on light-duty vehicles a number of times over the past 20 years or so, but without success. At this stage it is unclear if, and if so, when mandatory CO_2 emission standards will be adopted in Australia.

Although the general expectation appears to be that mean CO_2 emission rates of the Australian new car fleet will autonomously reduce over time, due to technological improvements enforced by overseas emission legislation, this may in fact not be the case.

Preliminary modelling by TER suggests that on-road CO_2 emission rates of new cars in Australia:

- are actually increasing over time (2010-2025),
- are much higher than reported using the official emissions test, and
- that this gap with the official test is expected to grow to 65% in 2025.

The large and increasing difference between official and on-road CO_2 emissions, the ongoing growth in total travel and the lack of effective greenhouse gas emission reduction policies for road transport is of concern.

With ongoing growth in population and associated road ransport travel (VKT or vehicle kilometres travelled), the pressure to reduce average real-world CO_2 emission rates (g/km) becomes ever stronger, even for unambitious targets to just stabilise total CO_2 emissions from road transport.

Given the slow fleet-turnover, the benefits from stricter emission standards, if they were adopted in Australia, will only start to have a significant effect several years into the future.

There are also cost implications for consumers, as the sale of less efficient vehicles in Australia mean higher weekly fuel costs for car owners that could have been prevented with internationally harmonised emissions legislation.

Australia is increasingly lagging behind international best practice. This carries a reputational risk where Australia may be seen as not pulling its weight in addressing climate change and reducing greenhouse gas emissions.

The available evidence suggests that legislative action regarding vehicle CO_2 emissions is 1) overdue in Australia, and 2) needs urgent attention by the Federal Government to ensure total CO_2 emissions from road transport are in fact reduced.

One final remark – introduction of mandatory vehicle fuel efficiency and/or CO_2 emission standards in Australia should ideally be considered in the light of other (supplementary) policy measures such as fleet measures (e.g. zero emission vehicle policy in California, EV promotion), information campaigns, fuel/mileage taxes, and so forth. Basically, a 'whole system' approach to ensure cost-effective reduction of total CO_2 emissions from the on road fleet.[5]

[5] For instance, lower weekly fuel costs may encourage car owners to travel more, thereby reducing or offsetting reductions in CO_2 emissions (rebound effect).

7. Recommendations

- Further research to better understand the technological reasons behind the significantly reduced fuel efficiency of vehicles sold in Australia, as compared with e.g. the US and Europe. This information will assist with the development of new and effective policy measures to address the fuel efficiency issue.
- Consideration of other/supplementary policy measures in addition to mandatory vehicle fuel efficiency and/or CO_2 emission standards in Australia (a 'whole system' approach).
- Conduct a sensitivity analysis where the impact of different fleet modelling assumptions and uncertainties in real-world CO_2 emission factors is considered and calculated. This will quantify the uncertainty in the (preliminary) TER modelling results.
- Conduct on-road CO_2 emission measurements of Australian vehicles. Comprehensive in-service vehicle emissions testing programs (so-called National In-Service Emission or 'NISE studies') have been conducted in the past in Australia, but only until 2009. As a consequence, there is an urgent need to measure current 'real-world' CO_2 emissions from modern Australian vehicles.

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Attachment A – COPERT Australia

COPERT (**CO**mputer **P**rogram to calculate **E**missions from **R**oad **T**ransport) is a globally used software tool used to calculate air pollutant and greenhouse gas emissions produced by road transport. Scientific development is managed by the European Commission.

A dedicated Australian version of COPERT was developed in 2012-2013 to properly reflect the Australian fleet mix, fuel quality and driving characteristics and to provide vehicle emission estimates for the Australian situation.[22,23,24,25]

The National Pollutant Inventory (NPI) recommends COPERT Australia for motor vehicle emission inventories and it has been used to estimate motor vehicle emissions for all states and territories in Australia.[3]

The software can be obtained from https://www.emisia.com/utilities/copert-australia/.

Large vehicle emission testing programs were conducted in Australia in the period 2000-2009. These programs enabled the development of COPERT Australia. They involved chassis dynamometer testing of hundreds of Australian vehicles, often both on an aggregated ('bag'), as well as modal ('second-by-second') basis for various pollutants and over different real-world driving cycles, generating large databases with raw vehicle measurements. For instance the NISE2 studies were conducted in 2005-2009 and provided almost 2 million seconds of Australian vehicle emissions data for criteria air pollutants and CO_2. This rich measurement database was used to develop COPERT Australia, after thorough emissions data verification.[26]

From the perspective of accurate vehicle emission modelling, (public) availability of these large empirical databases is essential to adequately capture the emissions behaviour of Australian vehicles in real-world conditions. No significant vehicle emission measurement programs have been conducted in Australia since 2009, which means that emission factors used in COPERT Australia rely increasingly on overseas data for new technology vehicles.

COPERT Australia estimates emissions for 122 air pollutants and greenhouse gases, and estimates emissions of both cold start and hot running exhaust and non-exhaust pollutants. COPERT Australia predicts emissions for 226 individual vehicle categories, which are defined in terms of:

- vehicle type (e.g. small passenger car, large SUV, heavy bus, rigid truck, articulated truck)
- fuel type (petrol, E10, diesel, LPG) and
- 'emission control technology level' or ADRs (Australian Design Rules).

ADRs are the vehicle emission standards adopted in Australia, and since 2003 they have been equivalent to European standards. The vehicle classification is shown in Table 1 (next page).

The software accounts for various other factors such as driving conditions (average speed), fuel quality, impacts of ageing on emissions (deterioration of engine and catalysts over time) and meteorology (ambient temperature and humidity).

Table 1 – Vehicle classification used in COPERT Australia.

Main Type	Sub Type	Fuel Type	Emission Standard
Passenger Car	Small (EC <2.0 l) Medium (EC 2.0-3.0 l) Large (EC ≥ 3.0 l)	Petrol Diesel LPG E10	Uncontrolled ADR27 ADR37/00-01 ADR79/00-05
SUV	Compact (EC ≤ 4.0 l) Large (EC > 4.0 l)	Petrol Diesel E10	Uncontrolled ADR27, ADR30, ADR36 ADR37/00-01 ADR79/00-05
Light Commercial Vehicle	GVM ≤ 3.5 t	Petrol Diesel	Uncontrolled ADR30, ADR36 ADR37/00-01 ADR79/00-05
Heavy Duty Truck	Medium (3.5-12 tonne GVM) Heavy (12-25 tonne GVM) Articulated (>25 tonne GVM)	Petrol Diesel LPG	Uncontrolled ADR30 ADR70 ADR80/00 ADR80/02-05
Bus	Light Bus (≤ 8.5 t GVM) Heavy Bus (>8.5 t GVM)	Diesel	
Moped	2-stroke; 4 stroke	Petrol	Conventional Euro 1-3
Motorcycle	2-Stroke; 4-S <250 cm^3 4-S 250-750 cm^3 4-S ≥750 cm^3	Petrol	

Attachment B – AFM (Australian Fleet Model)

Various engine and vehicle design factors impact on vehicle emissions and fuel consumption. Emission simulation therefore requires a detailed breakdown of the on-road fleet. For COPERT Australia the fleet mix (on-road population, annual mileage, accumulated mileage) needs to be estimated for 226 vehicle classes (Table 1).

Fleet mix modelling at this level of detail poses certain challenges and requires various assumptions. Published fleet data are often too aggregated to be useful for the high level of detail required for vehicle emissions modelling. In addition, available fleet data sets often apply different vehicle class definitions.

Changes in fleet composition have been estimated for 2010, 2015, 2020 and 2025 using a fleet mix model developed by Transport Energy/Emission Research (TER) called AFM (Australian Fleet Model). The tool estimates the on-road vehicle population and total (vehicle) kilometres travelled (VKT) for 360 vehicle categories in the different base years. The estimated kilometres travelled for a particular vehicle category (e.g. small ADR79-4 petrol passenger car) are then used to compute weighting factors for all vehicle categories that fall within a composite vehicle class (e.g. petrol car).

Figure 6 shows a schematic of the fleet mix modelling process, showing the different elements.

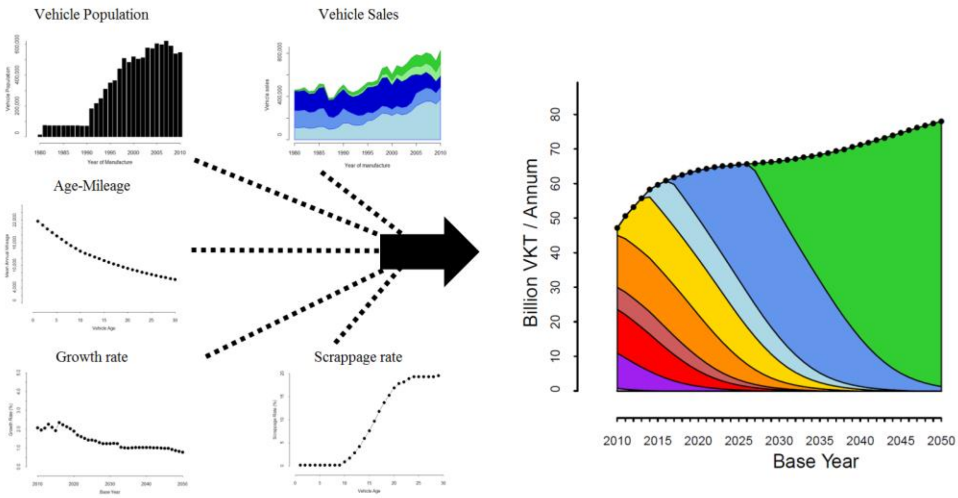

Figure 6 – AFM fleet mix modelling process.

The first step creates a detailed on-road vehicle population table for current and/or past base years, using various data sets. The next step is to estimate total travel for each vehicle class, which is expressed as total vehicle kilometres travelled per year (VKT/annum). At a more detailed level, vehicle usage is reflected in mathematical relationships between vehicle age and mean annual mileage and between vehicle age and accumulated mileage.

For future years information regarding on-road vehicle population and vehicle sales is not available. Therefore, assumptions need to be made regarding the on-road fleet population and vehicle use. Fleet growth rate and fleet turnover (scrappage) are considered for each vehicle class (40 in total) to simulate the progressive changes in fleet composition over time.

The simulation result is a detailed (future) vehicle population and travel (VKT) data table for 40 vehicle classes and 31 vintage/age categories (i.e. 1,240 model classes) for each base year.

The data tables are compressed to 40 vehicle classes and 19 ADR categories. Each ADR category spans a predefined range of vehicle model years. For instance, small ADR79/02 petrol cars include model years 2010-2013.

Since not all combinations of vehicle class and ADR exist (e.g. some ADRs apply only to heavy-duty vehicles), the results are compressed VKT tables with a total of 360 model classes for each base year. These data provide a detailed breakdown of the fleet mix population and travel (VKT), which is subsequently used for vehicle emissions modelling.

As a final step, the vehicle population, annual mileage and accumulated mileage data can be converted to the COPERT Australia input file format, where an input file for is created for each base year.

Fleet averaged vehicle emission factors can now be computed. In order to do this, estimated total travel for each vehicle class is used to create weighting factors for each vehicle class that belongs to a particular composite vehicle category.

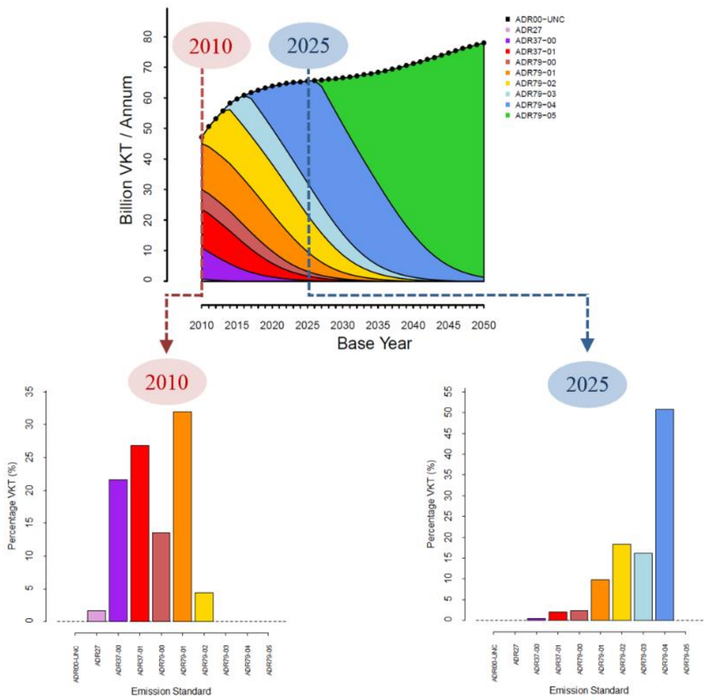

Figure 7 – Example of weighting factor calculations.

Figure 7 illustrates the process with an example. The middle chart visualises the detailed fleet mix simulation for a particular Australian vehicle class for base years 2010-2050. The different colours represent ADR categories relevant for this vehicle class. The dotted black line represents total travel (VKT) for this vehicle class for each base year. The two dashed vertical lines represent the VKT distributions across ADR categories for 2010 and 2025. These VKT distributions are normalised by dividing by total VKT (adding up to 100%), and shown on either side as VKT percentage bar plots.

These VKT percentages are subsequently combined with vehicle/ADR category specific emission factors from COPERT Australia, expressed as grams per km (g/VKT), to compute a fleet average CO_2 emission factor for this vehicle class.

It is noted that different assumptions on e.g. age-mileage or age-scrappage relationships will lead to different estimates of future on-road vehicle population, VKT and accumulated mileage. Therefore, a sensitivity analysis is generally recommended to quantify the uncertainty in predictions.