REPORT

Reducing greenhouse emissions from light vehicles

Compulsory standards and other policy options

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Australian Automobile Association

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THE CENTRE FOR INTERNATIONAL ECONOMICS
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Summary

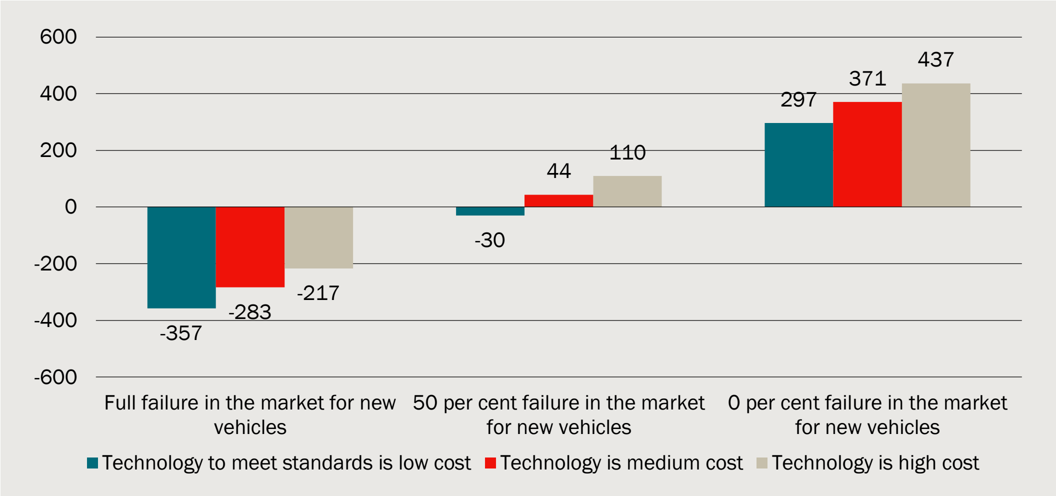
This report presents a discussion of light vehicle greenhouse emissions standards as a policy designed to reduce greenhouse emissions from light vehicles. The discussion is not designed to promote or reject these standards as an appropriate regulatory measure. Rather, it sets out to explore the nature of standards within the overall context of greenhouse policies; to understand the precise nature of the problem standards are designed to solve; and to point out how both costs and benefits could arise from the adoption of standards.

Like all regulatory policies, fuel efficiency or emissions standards involve both benefits and costs. The benefit side is generally well understood: a reduction in greenhouse emissions along with potential fuel cost savings for motorists (by driving more fuel efficient vehicles). But in the spirit of good regulatory impact analysis, the report seeks to put these benefits in context and to understand the implicit assumptions that underlie them. Again, in line with good regulatory analysis, the report also considers the sorts of costs that may arise from the adoption of standards which need to be set against the benefits when captured in a cost-benefit analysis.

- **Light vehicles are an important source of greenhouse emissions.**
  - **The transport sector accounts for around 16 per cent of Australia's total greenhouse emissions, with light vehicles accounting for around 60 per cent of this.**
- **Greenhouse emissions from vehicles are driven by 4 key factors**
  - **fuel efficiency**
  - **vehicle efficiency**
  - **driving efficiency**
  - **distance travelled**
- **Overall, emissions intensity (emissions per km travelled) has fallen in recent years, but total kilometres travelled has increased.**
- **The ideal emissions policy for vehicles should target each of these drivers of emissions to take advantage of all the possible margins for adjustment. This potentially ensures the lowest cost of abatement from within the light vehicles sector.**
- **One option for abatement in the light vehicles sector is to mandate greenhouse emissions standards (effectively the same as fuel efficiency standards) for new light vehicles. The key idea is that, over time, all new vehicles purchased would not emit more than a specified amount of greenhouse gases per kilometre travelled.**

- **In an important sense, emissions standards are inefficient as they only affect one margin for adjustment of overall vehicle emissions; they only affect emissions from new vehicles, and do not affect other aspects of driving behaviour.**
- **There are two potential benefits from compulsory greenhouse emissions standards: the public benefits arising from emissions reduction; and private benefits arising through better fuel economy and therefore lower fuel costs.**
- **How to account for these two major benefits in an evaluation of the net effects of standards depends on views about what determines vehicle choices in the first place.**
  - **If, on the one hand, current choices are rational and taken in full knowledge in a well working vehicle market, then the private benefits will, by definition, be offset by costs elsewhere and so should not be counted as a benefit.**
  - **But if, on the other hand, consumers are myopic, make irrational decisions without the best information and are subject to failures in the vehicle market, then private benefits should be counted.**
  - **The evidence on these alternatives is mixed, although it is difficult to build a very strong case that current vehicle choices do not represent the preferences of consumers or that consumers do not account for fuel economy when making vehicle choices.**
- **Standards will also impose costs, as more fuel efficient vehicles are generally more costly for a given vehicle class.**
- **Using a range of cost estimates, and a range of assumptions about including private benefits, we estimate that cost per tonne of abatement as a result of compulsory greenhouse emissions standards could range from -$357 to $437 (see chart 1).**
  - **That is, the results range from a net benefit per tonne of emissions reduction to a substantial net cost.**
  - **When private benefits are not included, then standards are a very costly form of abatement.**

1 Emission standards: cost of abatement, by cost scenario and market failure assumption ($cost per ton of CO_2 abatement)



Note: These results assume that technology is additive (the 'best case' scenario for technology costs)

Data source: The CIE

- **These estimates should be considered as illustrative, and are not intended to be definitive.**
- **They illustrate that by far the most important factor determining the cost of abatement under emissions standards is the way in which the private benefits (lower fuel costs) are treated.**
  - **The difference in outcomes from different assumptions about market failure in vehicle markets is much greater than differences in outcomes arising from different cost assumptions.**
  - **A 'negative cost of abatement' only arises if there is a significant market failure in the market for new vehicles or if consumers make irrational choices.**
  - **At the other extreme, in the absence of irrational or myopic consumer behaviour, the imposed standards may be costly per tonne of abatement.**
- **A careful regulatory impact analysis will be required to further understand which of these is most appropriate**
- **In terms of alternative policies, our illustrative analysis suggests that eco-driving training (targeting the driving behaviour associated with all light vehicles) could yield net benefits of $22 billion between now and 2040.**

1 Introduction

This report considers the broad costs and benefits of policies designed to reduce greenhouse gas emissions from light vehicles. A particular focus is the current proposal (Dep IRD 2016) to introduce compulsory emissions standards for new light vehicles.

All emissions policies involve considering trade-offs: the balancing of costs and benefits to ensure that the policies achieve their objectives as efficiently and as effectively as possible. Emissions standards are no exception. This report seeks in particular to draw out some of the trade-offs involved with compulsory standards in comparison with other control measures.

This report

This report presents a discussion of light vehicle greenhouse emissions standards as a policy designed to reduce greenhouse emissions from light vehicles. The discussion is not designed to promote or reject these standards as an appropriate regulatory measure. Rather, it sets out to explore the nature of standards within the overall context of greenhouse policies; to understand the precise nature of the problem standards are designed to solve; and to point out how both costs and benefits could arise from the adoption of standards.

Like all regulatory policies, fuel efficiency or emissions standards involve both benefits and costs. The benefit side is generally well understood: a reduction in greenhouse emissions along with potential fuel cost savings for motorists (by driving more fuel efficient vehicles). But in the spirit of good regulatory impact analysis, the report seeks to put these benefits in context and to understand the implicit assumptions that underlie them. Again, in line with good regulatory analysis, the report also considers the sorts of costs that may arise from the adoption of standards which need to be set against the benefits when captured in a cost-benefit analysis.

Background

Transport is a key source of emissions…

The transport sector (light vehicles, trucks, aviation, etc) produced 90 Mt of CO_2 emissions in 2012, or 16 per cent of Australia's total emissions. Within transport, the 'light vehicles' sector (which includes passenger vehicles, SUVs, light commercial vehicles likes utes, and small trucks and buses) is the largest. It accounted for 57 Mt of CO_2 emissions in 2012 (63 per cent of emissions from the transport sector).

…mostly growing because of distance travelled

ABS data suggests that total litres of petrol consumed by all light vehicles – a proxy for CO_2 emissions generated by light vehicles – grew by 1.1 per cent per year between 2006 and 2014. This was due to growth in total kilometres driven of 1.9 per cent year, which was partially offset by a decline in fuel consumption (measured with litres consumed per 100 km) of 0.8 per cent per year. It seems likely that growth in total kilometres is driven largely by population growth.

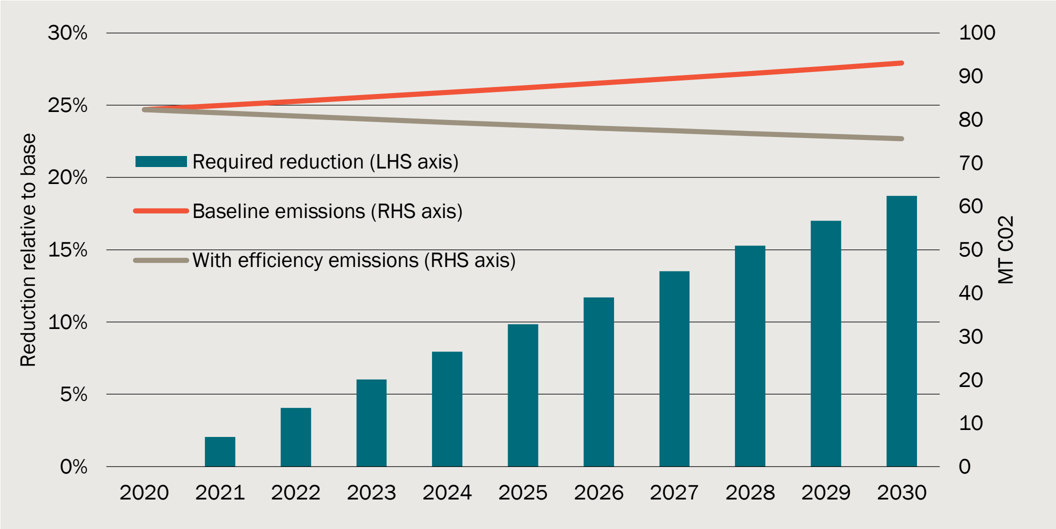
Government policy effectively proposes a 20% reduction in emissions relative to BAU

Over the period to 2030, the government intends to reduce cumulative emissions from vehicles by 92Mt, with 72Mt of this coming from light vehicles.

While the Government has not yet published full details of baseline emissions to 2030, (only to 2020), it is possible to infer the required annual rate of reduction in emissions (relative to business as usual).

- Using the rates of growth implied in projections to 2020 and assuming the 92Mt reduction applies across all road transport categories (private vehicles, light commercial vehicles, and trucks and buses), we can calculate the implied reduction in emissions relative to business as usual.
- By assumption, this reduction applies to each of the components of road transport, with 72Mt applied to light vehicles.
- Chart 1.1 illustrates the magnitude of the emissions reduction implied by the 92 Mt target. By 2030, it reaches just under 20 per cent relative to BAU by 2030.
- That is, that by 2030, the Government expects that emissions from private vehicles could fall by 20 per cent relative to BAU by 2030.

1.1 Baseline and with efficiency targets, and percentage reduction relative to baseline



Data source: CIE estimates based on Dept of Environment data

The key policy question

Given the need to reduce emissions from the transport sector in general, and light vehicles in particular, the question becomes what are the most effective and efficient policies to achieve this reduction. There are a wide variety of options, although a major option under consideration is mandatory emissions standards for light vehicles.

The main rationale for government intervention to reduce greenhouse gas emissions is that the *private* choices to burn fossil fuels in particular ways (including through transport choices) do not account for the *public* cost of the emissions generated. Policies to reduce emissions effectively seek to create incentives to recognise this *public cost* through changes in *private* choices.

In general, policies to reduce emissions create costs and benefits, and thus involve 'trade-offs'. Usually, policies that aim to reduce CO_2 emissions create private costs: heavy users of fossil fuels, or individuals with little opportunity to reduce their use of fossil fuels, will be obliged to pay more for this use or be provided with other incentives to reduce emissions. On the other hand, these policies, via emissions reduction and the avoidance of climate risks are designed to create public benefits. The goal of government is to implement climate policies that minimise costs, given the benefits created, or to maximise net benefits.

Emissions standards are an interesting policy area because it is often claimed that as a policy they create private net *benefits* (through fuel cost savings), rather than private net costs. When these private benefits are included in a benefit-cost analysis of standards, the outcome generally seems overwhelmingly positive.

One of the key tasks for this report is to understand the conditions under which these claims are true.

Structure of this report

The rest of this report is organised as follows:

- Chapter 2 considers the various ways in which emissions from vehicles can be reduced along with the properties of the key policies to go about achieving this.;
- Chapter 3 discusses emissions standards, including their costs and benefits;
- Chapter 4 discusses alternative policies to emissions standards.

2 *Efficient and effective emissions policies*

There are a variety of factors that determine emissions from vehicles; some technical and some determined by behavioural choices, but all subject to influence from policy interventions. Different policies to reduce emissions target these factors in different ways with each having a different combination of costs and benefits.

Effective and efficient policy

For a policy that seeks to reduce emissions to be effective (that is, achieve substantial reductions in emissions) and efficient (that is, achieve reductions in emissions for minimum cost), it is necessary for it to be one of two policy types. Either:

- The policy should be a broadly focused policy that incentivises behavioural change across multiple (or, ideally, all) relevant margins of adjustment. Further, it should allow individuals and businesses to decide for themselves where their behaviour should change the most. This means the policy should provide consistent incentives across margins, and not favour particular choices over others; or
- If the policy is not broadly focused, it should be a narrowly focused policy that solves or alleviates a specific, identifiable problem that is preventing behavioural change that would reduce emissions.

A policy that prompts behaviour change across multiple margins for adjustment will be effective, because total emissions reductions are likely to be higher.

Further, a policy that prompts behavioural change in different areas, but does not favour particular changes over others, will be efficient because consumers will identify and pursue the emissions reduction strategies that suit them as individuals. Changing behaviour in some ways is very costly, while changing it in others it is not, and this varies across individuals and across businesses.

The corollary of this is that policies that favour (only) certain types of behavioural change risk being inefficient or ineffective (or both), especially if they prompt behavioural change that is costly or does little to reduce total emissions.

There may be some markets where individuals are prevented from changing their behaviour in a way that reduces emissions and is efficient, because there exists a particular market failure or particular blocker. These market failures or blockers should be solved or alleviated with targeted policies that deal with them specifically. Such policies are complementary to broadly focused policies as they act to increase the choices individuals have over behaviour they can change to reduce emissions.

Vehicle emission drivers

In broadest terms, vehicle emissions are a function of:

- fuel efficiency
- vehicle efficiency
- driving efficiency
- distance travelled

Each of these are described in table 2.1

2.1 Factors determining vehicle emissions

Emissions determined by:	Description
Fuel efficiency	Energy density of fuel per unit of emission. The more dense the fuel, the further distance can be travelled for a given amount of emissions.
Vehicle efficiency	The nature of the engine system (for example, internal combustion in petrol or diesel forms, fuel cell, hybrid) determines emissions from travel of a given distance. The non-propulsion features of a vehicle (weight, size, construction materials, aerodynamics of the vehicle design, tyres) also have major influence on the energy required to propel the vehicle and therefore on emissions per distance travelled. These aspects of vehicle efficiency are in turn affected by technical choices in construction and design as well as purchasing choices by consumers.
Driving efficiency	In part, driving efficiency is determined by particular driver choices: driving habits, knowledge of good driving techniques, driving speed and style (including accelerating and braking), tyre pressure, vehicle loading. Driving efficiency is also determined by road system factors: infrastructure and design of road system, congestions, road materials.
Distance travelled	This is in large part determined by personal choices: the need to satisfy family and work requirements, the relative cost of alternatives. It is also determined by systemic factors including infrastructure and design of road system, availability of public transport.

Source: CIE. See also King (2007)

'Market failures' associated with these drivers

Each of these behavioural and other choices that determine emissions may themselves be associated with a range of 'market failures' and 'externalities' that mean consumers do not necessarily account for the full costs (or benefits) of their choices.

In the greenhouse context, the largest market failure is the failure to account for the collective, and cumulative, effect of individual emissions on the global climate. That is, the failure in individual decisions to account for the wider cost of greenhouse emissions.

However, this is not the only market failure that features in discussions of climate and related polices. Other issues are captured in the general notion of an 'efficiency gap' — the fact that individual agents to not necessarily adopt the most energy efficient technologies and behaviours, even when it appears that it would be in their own interest to do so.

Other failures include policy failures that create perverse incentives, or incentives that move against the overall objective of lowering emissions. This includes, for example, some tax policies as well as planning, road policies and so on.

Driving itself is also associated with a range of ‘externalities’, the two most significant being congestion and traffic accidents. These are called ‘other driving externalities’.

Table 2.2 provides an indication of the potential association between a market failure and the overall determinants of emissions.

2.2 Potential ‘market failures’ associated with factors determining vehicle emissions

Emissions determined by:	Potential market and policy failures
Fuel efficiency	Carbon externality: failure to account for the full cost of carbon emissions.
Vehicle efficiency	Carbon externality: failure to account for the full cost of carbon emissions Ignorance about the energy and emissions efficiency of different vehicles and vehicle types Myopia: not accounting for long term efficiency benefits (lower fuel costs) Failures in availability of efficient options in particular markets (through the choices of importers or retailers, for example). Policies which discourage purchase of particular new vehicles (eg tariffs, car taxes)
Driving efficiency	Carbon externality: failure to account for the full cost of carbon emissions Ignorance of good driving techniques. Poor habits. Congestion externalities: effect on drivers of congestion in urban areas leading to less efficiency
Distance travelled	Carbon externality: failure to account for the full cost of carbon emissions Factors indirectly encouraging vehicle travel including absence of alternative transport options

Source: CIE.

Policies to address emissions drivers

With an understanding of different emissions drivers, it is possible to consider the ways in which various new policies (or changes to existing policies) can influence different aspects of vehicle choices, and therefore different aspects of the overall emissions drivers.

Table 2.3 summarises the ways in which 5 illustrative and broad policy alternatives affect emissions associated with different emissions drivers. The policies examined include:

- a broad carbon price, applied to the carbon content of fuels
- a new vehicle emissions standard specifying allowed greenhouse emissions per km travelled

- changes in tariffs and taxes on vehicles (including the luxury car tax) or other restrictions on imported vehicle purchase
- training for drivers in efficient driving
- provision of additional infrastructure to alleviate congestion and provide a range of transport alternatives.

This list of policies is not exhaustive, but designed to illustrate some of the trade-offs involved in policy choice.

2.3 Effects of various policies: do they create incentives to reduce emissions from relevant factors?

Effect of policy on:	Carbon price	New vehicle emissions standard	Tariffs and taxes	Eco-driving training	Infrastructure
Does the policy reduce emissions from the following drivers?					
Vehicle efficiency: new vehicles	Yes	Yes	Yes	No	No
Vehicle efficiency: existing vehicles	No	No	No	No	No
Driving efficiency: new vehicles	Yes	No	No	Yes	Yes
Driving efficiency: existing vehicles	Yes	No	No	Yes	Yes
Distance travelled: new vehicles	Yes	No, possible rebound effect	No, possible rebound effect	No, possible rebound effect	Yes
Distance travelled: existing vehicles	Yes	No	No	No	Yes
Does the policy have potential to lower driving related externalities?					
New vehicles	Yes	No, may increase with rebound effect	No, may increase with rebound effect	No, may increase with rebound effect	Yes - congestion
Existing vehicles	Yes	No	No	No, may increase with rebound effect	Yes - congestion

Source: CIE

A number of key points emerge from table 2.3.

- A carbon price creates incentives to change all of the drivers of light vehicle greenhouse emissions (with the exception of vehicle efficiency from *existing* vehicles). A carbon price will also have the tendency to reduce other driving related externalities.
- New vehicle emissions standards only affect one of the drivers of emissions: the efficiency of new vehicles. By itself it does not create any incentive to alter other drivers of emissions. In some cases, the standard may indirectly create an incentive to increase some of the drivers such as distance travelled.

- Reducing tariffs and taxes, by reducing the costs of new vehicles, creates some incentive to purchase more efficient newer vehicles, but does not affect any of the other drivers.
- Efficient driving training has the potential to reduce emission from both existing and new vehicles, but may also create rebound effects.
- Improved infrastructure has the potential to reduce emissions from a number of drivers.

3 Greenhouse emissions standards

This chapter considers the broad ways in which greenhouse emissions standards work and presents some illustrative quantification of the costs and benefits of standards. An important finding is that views about costs and benefits depend on a clear understanding of the rationale for standards in the first place.

Overview

Emissions standards (for new vehicles) are a policy instrument that effectively targets the fuel economy of new vehicles. Carbon emissions per kilometre (gCO_2/km) are closely related to fuel economy, and the new emissions standard is usually expressed as an average target (across the fleet of new vehicles) in terms of gCO_2/km.

For example, the Climate Change Authority's (CCA) preferred policy for emissions standards ('strict standards') would see average emissions intensity of new vehicles fall by 5 per cent per year out to 2025, whereas the 'no policy' or 'business as usual' (BAU) policy would see average emissions intensity fall by around 2 per cent per year.

- According to data in NTC (2016), the average emissions intensity of new light vehicles sold in Australia in 2015 was 184 g CO_2/km.
- Under BAU, the average emissions intensity of new light vehicles sold in Australia would fall to 151 g CO_2/km by 2025. Under CCA's preferred, strict, standards, average emissions intensity would fall to 105 g CO_2/km by 2025.[1]

There is a variety of options for the particular ways in which standards could be implemented. The most common approach is to envisage a target for overall emissions intensity that is allowed to vary by vehicle size, but that achieves a particular target average emissions intensity. Manufacturers or importers are then required to achieve this average for the vehicles they sell within a particular time frame.

Emissions standards seek to target the direction of technical change in vehicles, or to target vehicle purchase patterns, to achieve greater fuel economy (or lower emissions intensity) than would otherwise be the case without standards. In effect, given the averaging described above, this target applies within particular classes of vehicle.

1 CCA 2014 pg 49. Note that CCA's preferred policy is for standards to be implemented from 2018, and for these standards to see emissions intensity fall to 105 gCO2/km by 2025. We have compared this target to current emissions intensity (184 gCO2/km in 2015), which was published after CCA's report. The 'BAU scenario' – falls in emissions intensity of around 2 per cent per year (in the absence of government intervention) – is based on general discussion CCA's report of current and future trends in emissions intensity.

Properties of standards

Chart 3.1 and 3.2 illustrate one way of thinking about the trade-offs inherent in emissions standards. The first panel of chart 3.1 shows the potential combinations of fuel efficiency and other characteristics that are available for a given vehicle type (for a given vehicle size, for example). As the panel indicates, the potential combinations are improving over time, but as drawn, there is a trade-off between fuel efficiency (emissions intensity) and other vehicle characteristics (even within a given class of vehicles). These other characteristics could include factors such as carrying capacity, acceleration, ride comfort and so on.

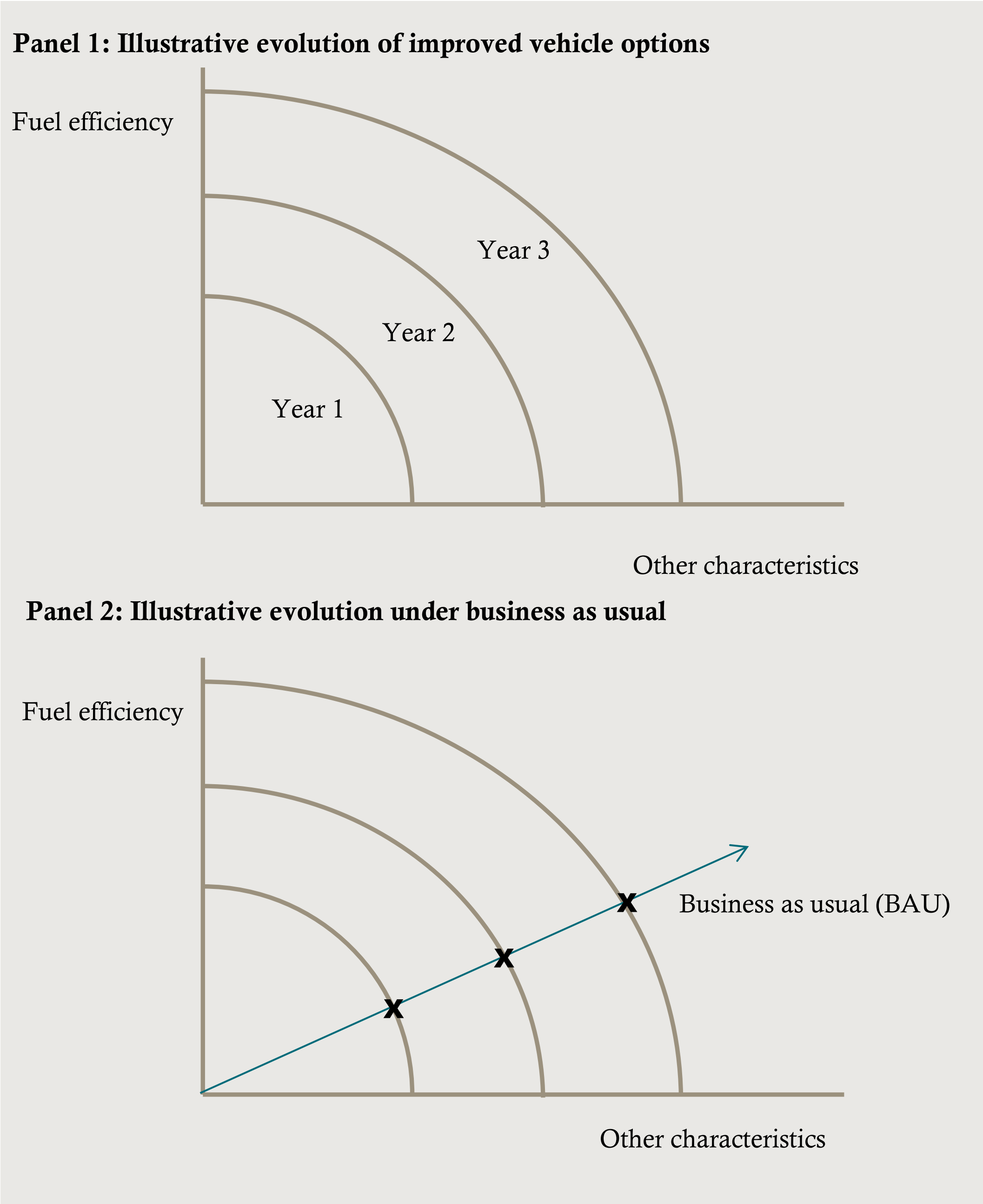
The second panel of chart 3.1 shows the evolution of fuel efficiency and other characteristics over time under ‘business as usual’ (BAU); that is, in the absence of standards. As drawn, both fuel efficiency and other characteristics are improving, but other characteristics are improving more rapidly. This reflects recent history. The BAU line is determined by a variety of factors including consumer preferences, technical constraints, and other market outcomes. As noted above, this may be associated with market failures of various kinds.

Chart 3.2 shows the implications of imposing a fuel efficiency standard. The pathway with the fuel efficiency standard in place shows more rapid improvement in fuel efficiency than under BAU, and a consequent decline in the rate of improvement in other characteristics. Other characteristics are still improving, but at a slower rate than otherwise. By definition, the ‘with standard’ line must lie above the BAU line, otherwise there would be no point in implementing the standard.

The second panel of chart 3.2 shows the gains and losses; an increase in fuel efficiency relative to BAU, and a decline in other characteristics relative to BAU.

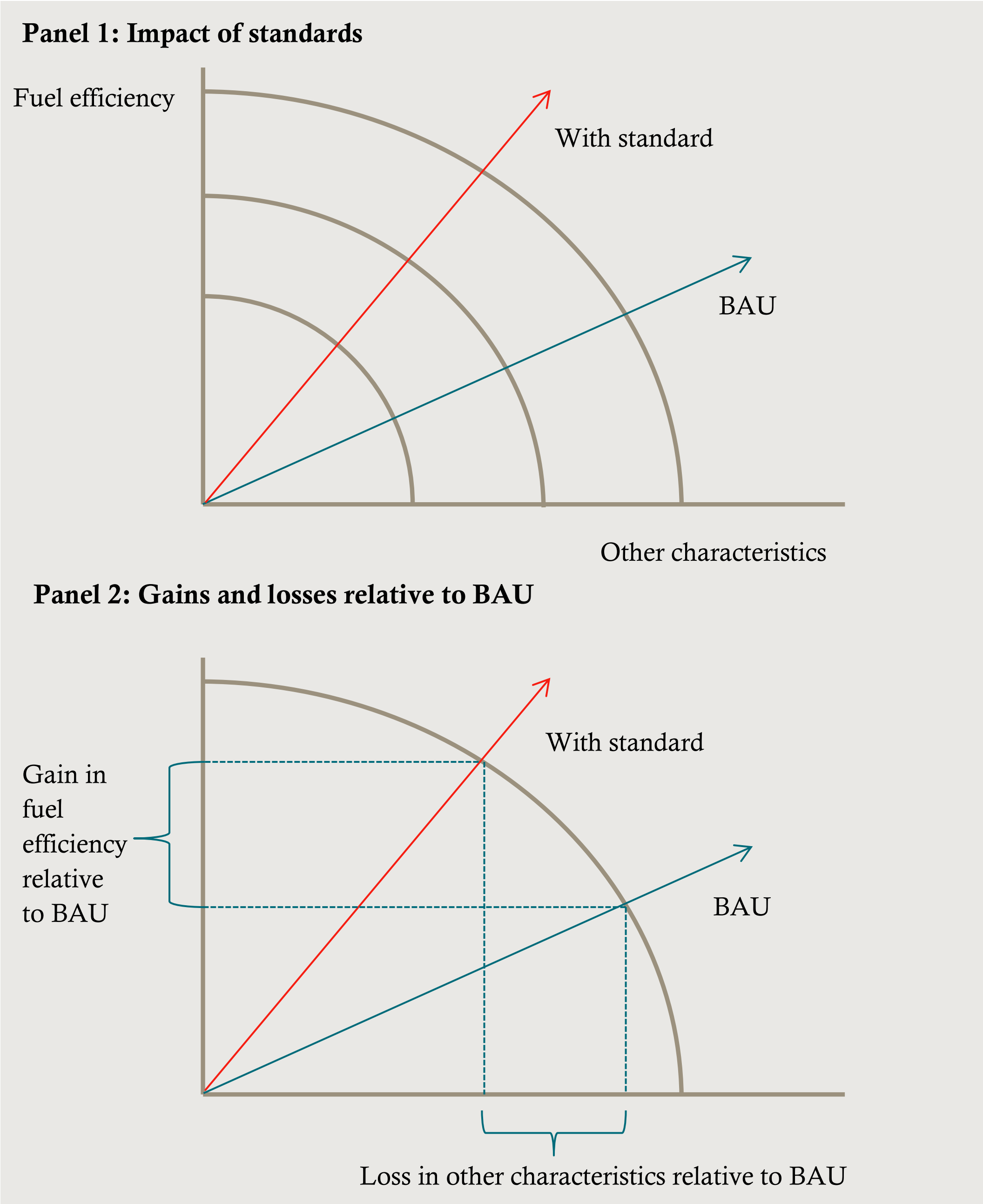
The challenge in evaluating standards as a policy measure is in putting appropriate values to these gains and losses, and understanding which of these is greater. While the improvement in fuel efficiency is relatively easy to observe, the decline in other characteristics is much harder to evaluate. The recent discussion by Walton and Drake (2012) provides some orders of magnitude in the context of US standards.

3.1 BAU evolution of vehicle characteristics



Source: CIE

3.2 Standards target changes in favour of fuel efficiency



Source: CIE

How will standards achieve their objective?

The precise mechanism by which standards achieve the appropriate reduction in emissions intensity depends very much on the regulatory specifics of the standard. However, in principle, because the standard seeks to change purchase patterns relative to what they would otherwise have been, standards actually work by creating an *implicit price incentive*. For the retailer (for example) to achieve the required average emissions intensity, by definition they must move purchases away from the current pattern — or from the pattern where they would otherwise be under BAU (otherwise there would be no need for the standard). To do this, they will need to offer a series of discounts or premiums in order to shift consumer purchases. These will be largely invisible within the market.

The net effect is that standards will look like a tax on relatively high emissions vehicles, and a subsidy to relatively low emissions vehicles. The administrative and compliance challenge is for fleet managers to encourage consumers to change the composition of their demand so that the average emissions intensity of the fleet sold satisfies the standard.

The overall cost to the economy relative to business as usual of the more efficient fleet (the fleet that satisfies the standard) is difficult to predict, so in the analysis presented below we use a range of cost estimates.

Emissions standards do not impact all margins of adjustment

As noted in table 2.3, emissions standards are a narrowly focused policy. It effectively only targets one margin for adjustment.

In any year, new vehicles make up around 7 per cent of the vehicles on the road. The emissions reductions achieved by emissions standards are therefore relatively modest (though they grow over time). Under the CCA's preferred, strict standards, CO_2 emissions from vehicles in 2025 are around 8 Mt lower than they otherwise would be. CCA note that over the lifetime of vehicles sold between 2018 and 2025, strong standards reduce CO_2 emissions by 79 Mt. This should be compared to total emissions over the lifetime of these vehicles.[2]

As emissions standards are a narrowly focused policy, unless they are solving a specific, identifiable problem in the market for new vehicles that requires their implementation, they are unlikely to be an efficient policy.

The specific problem targeted by emissions standards

It is generally assumed that manufacturers will meet vehicle emissions standards by introducing technology or vehicle types that improve the fuel economy of vehicles. All advocates of emissions standards argue that this technology creates a 'net saving': the fuel savings created for drivers offsets the cost of the new technology (or the higher price of the more efficient models). If this is true, then why isn't this new technology being introduced anyway? Why are standards necessary?

Broadly, there are three potential answers to these questions. Each has different implications for the desirability of emissions standards.

First, there could be some failure in the market for new vehicles. Importers may not offer the full range of efficient models, and drivers of new vehicles may be 'disempowered' in

2 CCA 2014 pg 52

some sense. They are forced to purchase non-preferred, higher emitting vehicles from retailers, who for some reason prefer to supply these vehicles to the market. In this case, emissions standards would force suppliers to supply preferred, lower emitting vehicles.

Second, it could be that drivers are choosing vehicles that have sub-optimal fuel efficiency because they have insufficient information to make a better choice, or because they do not understand the information that has been provided to them, or because they are myopic in their vehicle choices.

Third, it could be that that drivers are reasonably well informed and are able to choose vehicles that reflect their preferences. In fact, they are choosing vehicles that have less than maximum fuel efficiency because these vehicles better meet some of their other criteria (like size, style, etc). These drivers potentially include tradesmen, families, and 'performance drivers'. If these drivers exist in significant numbers in the market, the argument that there is a problem that needs to be solved by emissions standards becomes much weaker. The question becomes what is the most efficient way to change the preferences of these drivers? Table 3.3 summarises these arguments.

3.3 Types of new vehicle buyers, and the existence of a problem that requires emissions standards

Type of buyer	Example of the most fuel efficient vehicle they could choose	Example of vehicle they might actually buy	Reason why the less efficient vehicle is bought	Is there a problem for emissions standards to solve
'Disempowered' buyer	Low emissions European model	High emissions Aus. model	Efficient model is withheld from Aus. market by manufacturers/retailer s	Yes
Information poor or myopic buyers	Small, highly efficient car (e.g. Yaris)	Vehicle that is advertised heavily (e.g. Camry)	Inability to interpret implications of fuel economy	Possibly (though problem may be better solved by other means)
Tradesman	Small ute	Large ute	Chooses larger ute as unsure of future requirements	Not necessarily
Family	Family sedan (e.g. Camry)	People mover (e.g. Carnival)	Chooses larger vehicle as unsure of future requirements	Not necessarily
'Performance driver'	Small performance vehicle (e.g. Mini)	Larger sports car	Sports car better meets style, performance requirements	Not necessarily

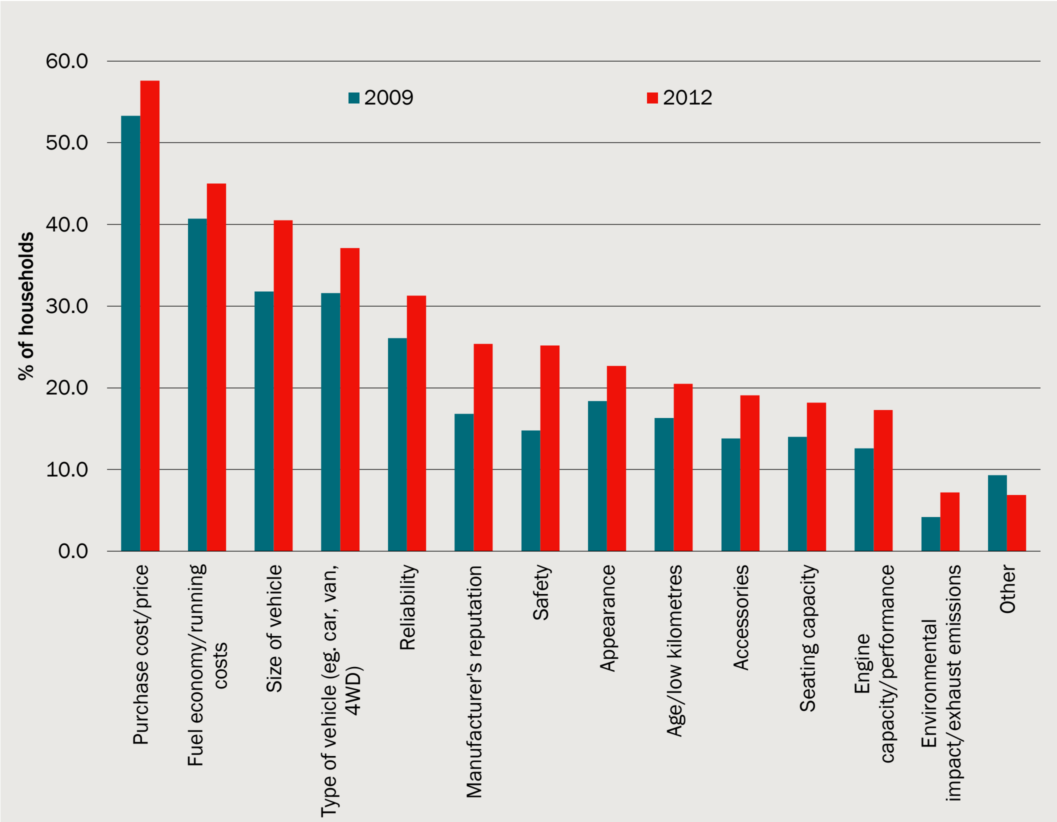
Source: The CIE

There is mixed evidence on the existence of this problem

Australian and international studies have considered the question of whether there is a market failure that prevents drivers from buying their preferred, optimally fuel efficient vehicle. Evidence on the existence of this problem is mixed.

By way of background, it is worth noting that according to survey data from the ABS, the fuel efficiency of vehicles is the second most important factor driving purchase decisions (and the importance has been increasing, see Chart 3.4).

3.4 Factors in vehicle choice



Data source: Australian Bureau of Statistics. *Environmental Issues: Waste Management, Transport and Motor Vehicle Usage* March 2009 and 2012, Catalogue Number 4602.0.55.002.

Further, a recent comprehensive analysis for the US (Busse et all 2013) concludes that there is no evidence that consumers are myopic when considering vehicle purchases.

Brief literature review of evidence

Department of ITRDLG

In a 2010 working paper, the Department of ITRDLG considers whether there is evidence of perceived market, behavioural or policy failures that impede the offering and acquisition of new light vehicles incorporating fuel-economy-improving and CO_2 emissions reducing technologies. The result of this was not conclusive. According to the Department 'the analysis was able to identify a range of **potential** [our emphasis] market failures that could justify direct regulatory action but was not able to identify definitive arguments for introducing mandated CO_2 emissions standards for light vehicles as an effective means to address these failures.' (Dep ITRDLG 2010 pg. 22).

CCA (2014) and Productivity Commission (2005)

Discussion in CCA (2014) suggests CCA is of the view that market failures that would justify the introduction emissions standards are present.

CCA presents evidence[3] that across many makes and models, vehicles sold in Australia are less efficient than equivalent vehicles sold in the UK. However, as this could reflect preferences in Australia for other characteristics in cars (for example Australian drivers could prefer larger engines that are less fuel efficient compared to drivers in the UK), this is not necessarily evidence of a market failure.

CCA notes that manufacturers have more information on the fuel economy of cars than their customers[4]. However, as noted, it is generally argued that emissions reducing technologies create overall savings for drivers. Given this, if manufacturers were to provide better information on fuel economy to drivers, it is possible this action would cause their sales and profits to increase. It is not clear why information asymmetries constitute a market failure that requires emissions standards.

CCA notes that behavioural, cultural and organisational barriers can lead drivers to purchase vehicles that are privately sub-optimal (i.e. they undervalue the fuel savings of emissions reducing technology)[5]. The Productivity Commission (PC) considered these barriers in a 2005 Inquiry Report *The Private Cost Effectiveness of Improving Energy Efficiency*. This report is cited by CCA. PC does not find evidence that these barriers justify an intervention like emissions standards.[6]

- PC discusses ‘behavioural and cultural norms’ (the way we value energy use) as inhibitors to Australians doing things like purchasing more fuel efficient cars. Clearly, these ‘norms’ could simply be ‘preferences’. If this is true, the question becomes the best way to alter our preferences. This is discussed below, where we consider the efficiency of various policy options.
- PC discusses ‘bounded rationality’ – which is essentially individuals making optimal decisions, but only on the basis of their abilities and available information. Because their abilities and available information are limited, their final decision is different to the optimal decision that would be made in the (theoretical) ideal case. PC concludes: ‘The Commission considers that bounded rationality of consumers is an insufficient ground for justifying intrusive measures such as minimum standards’[7].
- PC discusses ‘organisational barriers’ to the adoption of energy efficient technologies. These are varied, from factors like ‘risk aversion’ (which could apply to changing technologies so as to lower emissions) to ‘decentralisation’ (which is the idea that decentralised firms are less likely to pursue large-scale, enterprise wide projects, which presumably include projects that increase efficiency). PC concludes: ‘In the

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3 CCA 2014 Figure 3.1

4 CCA 2014 pg. 30

5 CCA 2014 pg. 30-31

6 PC 2005 pg. 54-60

7 Id pg. 57

> Commission's view there is no clear case for government intervention to address internal organisational issues'[8].

PC conclude their discussion by stating 'behavioural, cultural and organisational barriers do not of themselves provide a rationale for government intervention. Understanding these barriers may, however, be helpful in designing efficiency programs that address environmental externalities, information failures and other sources of market failure'[9].

CCA notes other papers that discuss these issues. In some cases, the CIE was not able to follow-up these other references (in one case, it appears the reference has been removed). However, CCA's discussion of the points made in these other reports suggest PC's discussion – which concludes these issues do not necessarily justify interventions like emissions standards – broadly covers off on the key issues raised.

International literature

The broader international literature has similarly mixed views about the presence of market failures, or decision failures, leading to the need for standards in order to achieve private benefits.

Indeed, considerable research effort has been put into understanding the so-called 'efficiency gap' or 'energy paradox' — the observation that there are apparently profitable efficiency opportunities that are nevertheless not taken up by consumers.

For example, in considering possible explanations for the efficiency gap Krupnick et al (2014) point to recent studies (Busse et al 2013 and Alcott and Wozny 2012) that suggest that consumers are not in fact, myopic, and do not undervalue fuel economy benefits.

Rather, the efficiency gap may be related to hidden costs of adopting higher fuel efficiency vehicles (see discussion below) or to the high level of heterogeneity amongst consumers.

On hidden costs, van Dender and Crist (2011) note that consumers appear to have very short pay-back requirements (2 to 3 years) for investments in fuel economy. While this could be caused by 'myopia' or other behaviour anomalies, it could also be the result of fully rational decisions that account for 'hidden amenities'; features of the decision process that are hidden to analysts but that matter to household.

> For example, consumers might prefer that technological potential be used for improved comfort or performance instead of better fuel economy….If decisions just reflect hidden amenity values, then the short payback period is the socially relevant one and there is no market failure[10].

In a comprehensive analysis of the energy efficiency gap, Gerarden et al 2015 provide a taxonomy of potential explanations for the gap and consider empirical evidence for each of these. Table 3.5 summarises their main explanations

8 Id pg. 60

9 Ibid

10 van Dender and Crist 2011 p 9

3.5 Explanations for the 'efficiency gap'

Category of explanation	Detail
Market failures (failures in the market for energy efficiency)	Information problems Energy market failures Capital market failures Innovation market failures
Behavioural effects (particulars of consumer behaviour)	Inattentiveness and salience (fuel efficiency not important) Myopia and short sightedness Bounded rationality and heuristic decision making
Modelling flaws (flaws in models that suggest an efficiency gap in the first place)	Unobserved or understated costs of adoption Ignored product attributes Heterogeneity in benefits and costs of adoption across potential adopters Uncertainty, irreversibility and option value

Source: Based on Gerarden et al 2015

They find that while each explanation is theoretically sound, the empirical evidence is mixed and that further research is needed to further pin down understanding of consumer responses as well as optimal policy measures.

Overall, the CIE's assessment is that the evidence on the existence of market or information failures that requires or justifies emissions standards is not strong. While it may be the case that lesser problems exist (such as information failures), emissions standards may not necessarily be the best policy response.

Emissions standards and private benefits

The extent to which emissions standards create private versus public benefits crucially depends on whether or not they are solving a problem in the market for new vehicles.

As emission standards force manufacturers to supply (and thus drivers to buy) more fuel-efficient cars than they otherwise would have (on average), standards reduce CO_2 emissions and thus create public benefits. This is independent of whether emission standards are solving a specific problem in the market for new vehicles.

Extra fuel efficiency, of course, creates fuel savings for drivers. This is a private benefit. If emission standards *allow* drivers to access these fuel savings by solving a problem (such as manufacturers withholding better technology from the market, or consumer myopia) then fuel standards create this benefit for drivers for (probably) very little or no opportunity cost.

However, if emission standards *impose* fuel savings on drivers – that is, the standards force drivers to purchase efficient vehicles they would not otherwise buy – then we cannot simply assume the standards create straight (net) private benefits. While the standards create fuel savings, they also impose opportunity costs on drivers, such as a loss of utility, by forcing them to switch to vehicles with characteristics that are not necessarily preferred.

Potential opportunity costs imposed on drivers by emission standards

If drivers can access the vehicle they prefer, the opportunity costs imposed on them by standards are illustrated by considering two extremes.

First, we could assume (as is generally done in analyses of emission standards) that manufacturers meet emission standards by changing the evolution of vehicle characteristics. Manufacturers could increase their R&D expenditure on fuel economy improving technologies. All other things equal, manufacturers may pay for this extra R&D on fuel economy improving technologies by *decreasing* R&D expenditure on other vehicle characteristics. If drivers value the benefits that are created by R&D on these other characteristics then reducing this R&D expenditure will impose an opportunity cost on consumers.

Second, we could assume that manufacturers meet emission standards by changing the composition of their fleet. In terms of Australian standards, this is more likely as Australian standards alone may not be sufficient to alter global R&D behaviour (given that Australia will soon have no domestic manufacturing). That is, they could increase the price of larger, less fuel-efficient vehicles and decrease the price of smaller, more fuel-efficient vehicles to prompt drivers to switch towards the latter. This would impose opportunity costs on drivers, as those who desire or need larger, less fuel-efficient vehicles (such as tradespersons, large families, etc.) would need to pay more for these vehicles. The 'opportunity cost' is the benefits they lose from not being able to spend these resource on other vehicle characteristics.

In practice, it is possible that manufacturers will meet emissions standards by following some combination of the above strategies, and the opportunity costs imposed on drivers by the standards will be some combination of the costs described.

EPA (2012) touches on this issue; it notes it uses technology packages that maintain 'utility and acceleration performance' compared to baseline.[11] However, 'maintaining utility and acceleration performance' does not mean that emissions standards do not impose opportunity costs on consumers — as illustrated in chart 3.2.

Walton and Drake (2012) in the US context estimate that the value of lost amenities from other vehicle characteristics as a consequence of standards at between US$1 400 and US$2 200 per vehicle.

How to treat the fuel savings and opportunity costs created by standards

As noted, if emissions standards solve a problem that is preventing drivers from purchasing preferred, lower emitting vehicles, then the opportunity costs created by standards are likely to be very low or zero. The standards allow drivers to *access* the fuel savings created by the more fuel efficient vehicles, which are supplied because of the standard and which are preferred. These fuel savings that standards allow access to can be treated as a straight (net) benefit, which is added to the public benefit of emissions reduction.

11 EPA 2012 Pg. 1-22

However, if emissions standards are not solving a problem and are simply *imposing* fuel savings on drivers by forcing them to switch to vehicles that would otherwise be not preferred, then the standards create fuel savings and impose opportunity costs on drivers. Given the premise that vehicles that meet emissions standards are not being chosen to begin with, these costs must be at least as big as the fuel savings. In the absence of more information, the only reasonable assumption is that the opportunity costs of imposing standards on drivers offset the fuel savings created, which means we should ignore the fuel saving created. That is, for benefits created by fuel standards, we only count the public benefit of emissions reduction.

In the absence of hard data, our experience tells us the answer probably lies somewhere in the middle. Standards will allow some drivers to access fuel savings, but will impose savings and opportunity costs on others. This means, for evaluating emissions standards, we count some percentage (between 0 and 100 per cent) of the fuel savings created by the standards as a private benefit. This percentage reflects our view of the percentage of drivers who would not be able to access their preferred vehicle if the emission standards did not exist. Of course, we count 100 per cent of the public benefit: the emissions reduction generated by the standards.

Costs of emissions standards

Analysts usually assume that manufacturers meet emission standards by introducing new technology that improves the fuel efficiency of vehicles. They incur a cost to develop and implement this technology, which is the cost (called the 'technology cost') created by emission standards. By assumption, this cost is passed onto drivers. The literature is not settled onto the magnitude of this technology cost.

Australian estimates of the cost of reducing average emissions intensity

CCA (2014) view their preferred 'strong' emissions standard as close to US standards. On this basis, they claim this standard will impose a technology cost of around $1 500 per vehicle by 2025, and cite NHSTA (2012) for this. This standard begins in 2018, which makes using this data potentially problematic for our purposes (our scenarios start in 2015). Therefore, we use data from the Department of Infrastructure, Transport, Regional Development and Local Government (2010), discussed next.

While the relationship between achieved emissions reduction and technology cost may not be linear, analysts accept that as the intensity of vehicle emissions (gCO_2/km) is reduced further, the cost of the reduction increases. Given this, Dep ITRDLG has compiled a range of data for the incremental cost of reducing emissions intensity by 1g/CO_2 from various pieces of literature (see Dep ITRDLG 2010 Table 4). The data presented in Dep ITRDLG's report are reproduced in Table 3.6.

3.6 Cost of reducing vehicle emissions intensity (gCO_2/km) by 1 gCO_2/km

Lowest cost					Highest cost
US EPA	US EPA adjusted	King report, low-point	King report, high-point	IEA mid-point	TNO science and industry
27.47	35.75	41.69	52.10	61.40	135.48

Source: Reproduced from Dep ITRDLG Table 4

Dep ITRDLG present arguments which suggest the two lowest estimates (US EPA and US EPA adjusted) and the highest estimate (TNO science and industry) may not be appropriate for Australia. For its analysis, Dep ITRDLG settle on the King report, low point estimate: a cost of $41.69 for reducing emissions intensity by 1 gCO_2/km.

In our illustrative cost benefit analysis of emission standards, we consider three separate scenarios for the technology cost required to meet the standards: 'low cost', 'medium cost' and 'high cost'. To develop these scenarios, we use the three cost estimates in Table 3.6 that Dep ITRDLG do not explicitly argue against (costs of $41.69, $52.10 and $61.40 for reducing emissions intensity by 1 gCO_2/km), plus a further assumption for the extent to which technology is additive, which is developed below.

International estimates of the cost of reducing emissions intensity

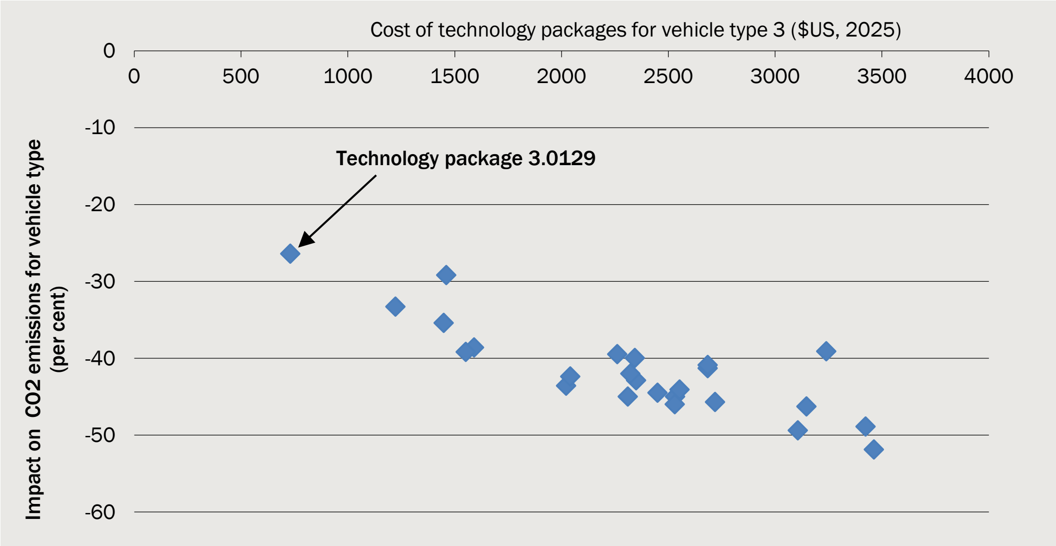
NHSTA (2012) and EPA (2012) use a complicated, model-based approach to estimate technology costs. In simple terms, the data and steps they use include the following.

- Data on initial fleet and initial fleet characteristics (including existing take-up of available technologies).
- Engineering data on specific technologies: the costs and effectiveness of individual emissions reducing technologies, including learning (costs fall over time as engineers 'learn' how to implement them).
- Technology path selection: given initial fleet characteristics, technology costs and effectiveness, and emissions targets, a mathematical model determines the 'least cost' combination of technologies that achieves emission targets.
- Technology paths can be incorporated into financial and economic cost-benefit analysis.

The advantage of this approach is that the authors are trying to directly model the sorts of decisions car manufacturers will make in trying to meet emission standards, assuming they meet standards with technology upgrades alone. If the authors use accurate estimates of fleet characteristics, technology costs and technology effectiveness, their estimates are likely to be relatively accurate. On the other hand, the disadvantage of this approach is that it is difficult for other analysts to follow and break-down their results, or re-use their data. For this reason, we do not use these US data in our study.

EPA (2012) provide raw cost estimates for a sub-set of technology packages that could be applied to (their) vehicle type 3 (midsized/large car, e.g. Honda Accord) in Table 1.3-4. 25 of these cost-emissions reduction combinations randomly selected by the CIE, have been reproduced in Chart 3.7. For example, EPA's technology package 3.0129 costs US$733 and reduces emissions of CO_2 in type 3 vehicles by 26.4 per cent

3.7 Technology packages for vehicle type 3 (EPA 2012) in 2025



Data source: EPA (2012); The CIE

Our illustrative estimates for the cost of meeting standards

We start with the information that average emissions intensity for new vehicles is set to fall by 2 per cent per year under the BAU scenario (without standards). We assume that manufacturers have already begun to undertake the R&D that leads to this BAU reduction, so the cost of this reduction is essentially sunk. From this point, there are two alternative assumptions on how emissions standards create technology costs for manufacturers.

- We could assume that technology is additive. Manufacturers are able to invest in R&D that creates reductions in emissions intensity that is additional to the reductions experienced in BAU. Under our emissions standards, emissions intensity is required to fall by 5.5 per cent per year. As BAU sees a fall of 2 per cent per year, emissions standards only require manufacturers to invest in R&D that sees emissions intensity fall by a further 3.5 per cent year. Therefore, the cost of vehicles only increases in line with costs for the technology required to reduce emissions intensity by 3.5 per cent per year. This scenario, where technology is 'additive', is probably the 'best case' scenario for technology costs.
- Alternatively, we could assume that technology is not additive. This means that under emissions standards, manufacturers are forced to go back to the drawing board and invest (fully) in new lines of R&D that will deliver the required fall in emissions intensity: 5.5 per cent per year. As technology is not additive, they are not able to simply invest in new technology that creates falls in emissions intensity that is additional to BAU. The costs of vehicles will increase in line with the costs of technology that generate falls in emissions intensity of 5.5 per cent per year. This scenario, where technology is not additive, is probably the 'worst case' scenario for technology costs.

NHSTA (2012) and EPA (2012) discuss that vehicle manufacturers have numerous options ('technology packages') available to them to reduce emissions intensity. They can adjust the size of vehicles, they can make the engine and transmission (and other parts) run more efficiently, they can change the type of engine, etc.; and they can introduce these changes in packages. This probably means, in broad terms, emissions reducing technology is 'additive' (given our simple framework). Thus, our assumption that technology is additive (the 'best case scenario' for technology costs) probably best captures how emission standards will lead to technology costs that will increase the price of vehicles.

Table 3.3.8 summarises this discussion of costs. There are three estimates of the incremental cost of reducing average emissions intensity by 1 gCO_2/km, taken from Dep ITRDLG, and two assumptions as to whether technology is additive.

3.8 Extra cost per vehicle in 2025 due to emissions standard[a] (lowest to highest)

Underlying cost	Assumption on whether technology is additive	Extra cost per vehicle due to emissions standard in 2025 [a]
		$A
CCA estimate [b]	-	1500
Dep ITRDLG – low ($41.69 to reduce emissions intensity by 1 gCO_2/km)	Technology is additive so only changes in vehicle emissions intensity that are additional to BAU incur a cost (best case scenario:	1897
Dep ITRDLG – medium ($52.10)		2371
Dep ITRDLG – high ($61.40)		2794
Dep ITRDLG – low	Technology is not additive: all changes in vehicle emissions intensity incur a cost, which is added to vehicle cost (worst case scenario)	3302
Dep ITRDLG – medium		4126
Dep ITRDLG – high		4863

[a] As noted, this report examines scenarios where the average emissions intensity of new vehicles sold in Australia falls from 184 gCO_2/km in 2015 to 151 gCO_2/km in 2025 under BAU and to 105 gCO_2/km in 2025 under emission standards

[b] The CCA's standards begin in 2018; CCA's estimate is based on its observation that its proposed Australian standard is similar to US standards

Source: Dep ITRDLG (2010); CCA (2014); The CIE

Net benefits of emissions standards

The CIE has performed simple cost-benefit analysis of emissions standards to demonstrate that the net benefits created are extremely sensitive to the assumptions made. Appendix B provides a detailed explanation of the methodology and assumptions that are used in this analysis. In the scenarios, average emissions intensity for new vehicles falls from 184 gCO_2/km in 2015 to 151 gCO_2/km by 2025 under BAU (where no standards are applied) and to 105 gCO_2/km by 2025 if standards are applied.

Impact of the technology cost assumption

Here, we assume there exists full failure in the market for new vehicles, and that this problem is solved by emissions standards. This means we count 100 per cent of the fuel savings created by the emissions standards as a straight (net) benefit. We also assume the 'best case' scenario in terms of how manufacturers incur costs – technology is additive, so they only incur costs for reducing emissions intensity beyond BAU.

We make assumptions for the cost of the technology that is required to meet the standards: low, medium and high. Under these assumptions, emissions standards create net benefits, in NPV terms, of $12.2 billion, $9.8 billion and $7.7 billion respectively (see Table 3.9).

3.9 Costs, benefits and net benefits of emissions standards, by scenario, compared to 'BAU' scenario (billions $, 2015, NPV terms)

Cost or benefit	Value created by emission standards, where technology to meet standards is:		
	Low cost	Medium cost	High cost
Benefit: fuel savings	20.8	20.8	20.8
Benefit: value of emissions reduction	0.8	0.8	0.8
Cost: additional cost of new vehicles	-9.4	-11.8	-13.9
Other benefits and costs	0.0	0.0	0.0
Policy: net benefit	12.2	9.8	7.7

Note: NPV results assume 100 per cent failure in market for new vehicles and that technology is additive ('best case' scenario for technology costs).

Source: The CIE

Impact of whether technology is additive

We continue to assume there is full failure in the market for new vehicles. However, we vary our assumption as to whether technology is additive or not. As expected, due to increased technology costs, the net benefits created by emissions standards drop sharply if we change our assumption from additive technology (the best case scenario for technology costs) to non-additive technology (the worst case scenario). In fact, if technology costs are high, and technology is not additive emissions standards impose a net cost on the economy of $1.6 billion (see Table 3.10).

3.10 Costs, benefits and net benefits of emissions standards, by scenario, compared to 'BAU' scenario (billions $, 2015, NPV terms)

Cost or benefit	Value created by emission standards, where technology to meet standards is:		
	Low cost	Medium cost	High cost
Best case scenario: technology is additive	12.2	9.8	7.7
Worst case scenario: technology is not additive	5.8	1.9	-1.6

Note: NPV results assume 100 per cent failure in market for new vehicles

Source: The CIE

Impact of the assumption for market failure

The extent to which we count the fuel savings created by standards as a net benefit depends on whether or not there is a failure in the market for new vehicles. Here, we vary the extent to which we assume such a market failure exists, as follows.

- First we assume there is 'full' or 100 per cent market failure (which reproduces the results in Tables 3.9 and 3.10). This is consistent with assuming that 100 per cent of drivers who are trying to buy a new vehicle are disenfranchised or 'weak' and cannot buy their preferred vehicle (which has lower emissions intensity than vehicles available in Australia).
- Second we assume there is 50 per cent market failure.
- Third we assume there is 0 per cent market failure. This is consistent with the idea that the preferred model of all drivers (in terms of emissions intensity) is available in the market.

For now, we revert back to the assumption that technology is additive (the best case scenario for technology costs). Table 3.11 shows how net benefits (in NPV terms) of emissions standards vary with these assumptions.

- If we assume there is full market failure and low technology costs, emissions standards create net benefits of $12.2 billion in NPV terms.
- On the other hand, if we assume there is no market failure and high technology costs, emission standards impose $13.1 billion of net costs on the economy in NPV terms.
- If we make medium assumptions: medium (50 per cent) market failure and medium technology costs, emissions standards impose a net cost on the economy of $0.6 billion.

3.11 Costs, benefits and net benefit of emissions standards, by scenario, compared to 'BAU' scenario (billions $, 2015, NPV terms)

Cost or benefit	Value created by emission standards, where technology to meet standards is:		
	Low cost	Medium cost	High cost
Assumption: 100 per cent of fuel savings are attributable to emissions standards			
Benefit: reduced spend on fuel	20.8	20.8	20.8
Policy: net benefit	12.2	9.8	7.7
Assumption: 50 per cent of fuel savings are attributable to emissions standards			
Benefit: reduced spend on fuel	10.4	10.4	10.4
Policy: net benefit	1.8	-0.6	-2.7
Assumption: 0 per cent of fuel savings are attributable to emissions standards			
Benefit: reduced spend on fuel	0.0	0.0	0.0
Policy: net benefit	-8.6	-11.0	-13.1

Note: These results assume that technology is additive (the best case scenario for technology costs).

Source: The CIE

Cost of carbon abatement

Many studies in the literature calculate an average cost per tonne of CO_2 abatement. Here, we calculate this average cost as the net benefits created in each scenario, less the value of carbon abatement, divided by the total reduction in CO_2 emissions (measured in NPV terms). In each scenario, the value of carbon abatement is $0.8 billion. Table 3.12 shows the net benefits created by emissions standards in each scenario, excluding this benefit, varying all assumptions possible.

3.12 Net benefit of emissions standards, excluding benefit of 'carbon abatement', compared to 'BAU' scenario (billions $, 2015, NPV terms)

Assumption for market failure	Value created by emission standards, where technology to meet standards is:		
	Low cost	Medium cost	High cost
Assumption: technology is additive (best case scenario for technology costs)			
100 per cent failure in the market for new vehicles	11.4	9.0	6.9
50 per cent market failure	1.0	-1.4	-3.5
0 per cent market failure	-9.4	-11.8	-13.9
Assumption: technology not additive (worst case scenario for technology costs)			
100 per cent failure in the market for new vehicles	5.0	1.1	-2.4
50 per cent market failure	-5.4	-9.3	-12.9
0 per cent market failure	-15.8	-19.7	-23.3

Source: The CIE

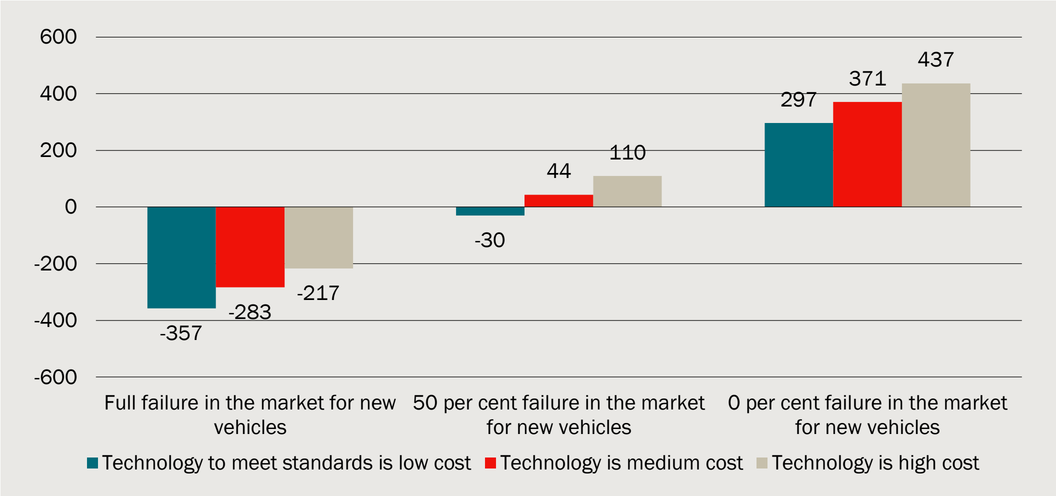
In each scenario, the total reduction in CO_2 emissions is 32 Mt (in NPV terms). Without discounting to convert to NPV terms, total carbon abatement is 85 Mt. To calculate the average cost of abatement, we treat net costs in Table 3.12 as positive (and net benefits as negative) and divide by 32 Mt.

First we assume technology is additive (the best case scenario for technology costs). Under this assumption, data on the average cost of abatement for emissions standards, are shown in Chart 3.3.13.

- If technology costs are low, and there is full (or 100 per cent) failure in the market for new vehicles, emission standards create a net benefit (a negative net cost) of $357 per tonne of abatement. This is less positive than CCA's estimate of the average benefit per tonne of reduction for its emissions standards: $580 per tonne[12]. This partially reflects our higher assumption for technology costs.
- If technology costs are high, and there is no (0 per cent) failure in the market for new vehicles, emissions standards impose a net cost on the economy of $437 per tonne of abatement.
- If intermediate assumptions are made: 50 per cent market failure and medium technology costs, emissions standards still impose a net cost on the economy of $44 per tonne of abatement.

12 CCA 2014 pg 53

3.13 Emission standards: cost of abatement, by cost scenario and market failure assumption ($cost per ton of CO_2 abated)



Note: These results assume that technology is additive (the best case scenario for technology costs)

Data source: The CIE

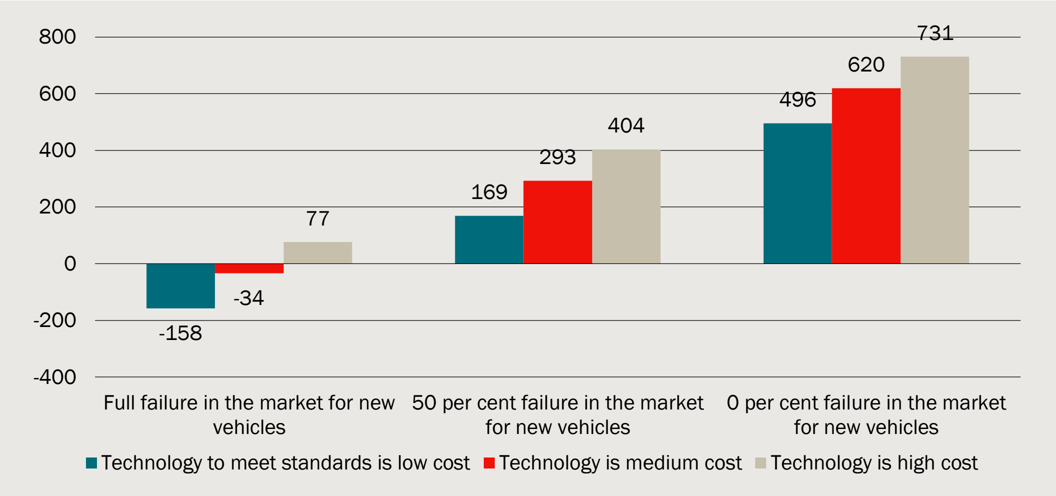
Next we assume technology is not additive (the worst case scenario for technology costs). Under this assumption, data on the average cost of abatement for emissions standards, are shown in Chart 3.14.

- If technology costs are low, and there is full (or 100 per cent) failure in the market for new vehicles, emission standards create a net benefit (a negative net cost) of $158 per tonne of abatement.
- If technology costs are high and there is no failure in the market for new vehicles, emissions standards create a net cost of $731 per tonne of abatement.
- If medium assumptions are made: 50 per cent market failure and medium technology costs, emissions standards are still a relatively costly way of reducing emissions: $293 per tonne of abatement.

Implications

The results illustrated in charts 3.13 and 3.14 indicate that assumptions about market or behavioural failures (amongst consumers) are much more important in determining the measured net cost of abatement than are assumptions about the technology cost of vehicles that meet the imposed standards.

3.14 Emission standards: cost of abatement, by cost scenario and market failure assumption ($cost per ton of CO_2 abated)



Note: These results assume that technology is not additive (the worst case scenario for technology costs)

Data source: The CIE

Emissions standards vs more efficient policies

If emissions standards create negative net benefits (net costs), they are less desirable than alternative abatement policies.

- They are less desirable than the policy of 'doing nothing' (i.e. not implementing standards), which creates net benefits of zero;
- They appear to be less desirable than teaching Australians 'eco-driving' which, as outlined in Chapter 4, could create significant net benefits; and
- They would be less desirable than a 'carbon-price' if it was established that the public benefits created by such a tax outweighed the private costs.

Further insights on emission standards

Jacobsen (2013) evaluates the emissions standards policy in the US using a model. The question of whether or not there exists a problem in the market for new vehicles that requires standards is not addressed. Rather, the author (implicitly) assumes such a problem does not exist and examines various impacts of forcing drivers towards more fuel efficient vehicles (in general: towards smaller, less powerful vehicles).

The two key insights from Jacobsen that are relevant in Australia are as follows.

- Achieving a reduction in fuel use (and CO_2 emissions) with a fuel tax imposes a much lower welfare cost on the economy than achieving a reduction in fuel use with emissions standards. This is because the fuel tax prompts drivers to reduce their fuel use by driving less and by choosing a more fuel-efficient vehicle when they buy a new one, whereas the emissions standards only prompt drivers to do the latter. (The logic behind this argument is explained in Chapter 2). Even allowing for technology changes (which reduces the welfare losses created by emissions standards), Jacobsen calculates that welfare loss per ton of CO_2 emissions avoided is $67 and $222 for the fuel tax and emissions standards (respectively).[13]

- Jacobsen finds that over the long-run (he uses a 10 year period), emission standards are regressive. Emission standards force up the price of new vehicles, which mainly reduces the welfare of higher income drivers. This price increase pulls up the price of used vehicles (as new vehicles and used vehicles are substitutes), and this reduces the welfare of lower income drivers. Measured as a percentage of income, the welfare loss is larger for lower income earners than it is for higher income earners, which implies the policy of emissions standards is regressive.[14]

The rebound effect

If individuals buy more fuel efficient cars, they will use less fuel for their standard travel tasks. The fuel savings could be banked. However, it is also possible that drivers could respond by increasing their driving (this is called the 'rebound' effect in the literature). A fuel tax or a carbon tax would have no such effect.

Rebound effects are a very common finding in the analysis of fuel efficiency policies, and there is a large literature looking at their importance and magnitude. Recent studies include the UK Energy Research Centre[15] and the International Transport Forum[16]. The US Environmental Protection Agency uses a rebound effect of 10 per cent in their analyses.

Next steps for emissions standards

The costs, benefits and impacts of emissions standards are far more complicated than parts of the existing literature acknowledge.

Emission standards should be subject to a RIS

The actual net benefits that will be created by the policy, if it is implemented, will depend substantially on whether or not the standards are solving a specific problem in the market for new vehicles. They will also depend on technology costs and whether technology is additive. If emissions standards are to be introduced in Australia, they should be subject to a thorough Regulation Impact Statement (RIS), that considers these issues. The RIS should also compare emissions standards to alternative policies. If the government finds that emissions standards are solving a specific problem in the market for new vehicles, it

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13 Jacobsen 2013, Table 9 pp 177

14 Jacobsen 2013, Table 8 pp 176

15 UK ERC 2007 The Rebound Effect UK Energy Research Centre, October. Available at http://www.ukerc.ac.uk/asset/3B43125E-EEBD-4AB3-B06EA914C30F7B3E/.

16 See van Dender K, and Crist P 2011 *What does improved fuel economy cost consumers and what does it cost taxpayers? Some illustrations*. International Transport Forum, Discussion Paper 2011 16.

is unlikely there will be many genuine policy alternatives to emissions standards. If the government does not find there is a specific problem, emission standards should be compared to other carbon abatement policies including fuel taxes and carbon taxes.

Table 3.15 sets out the key cost and benefit factors that need to be included in a RIS.

3.15 Factors to include in a RIS of emissions standards

Factor	Description
Benefits	
Private value of fuel savings	The treatment of these benefits in the CBA underlying the RIS depends crucially on the understanding of the original rationale for the standard. In the absence of clearly identified fuel efficiency market failures, it is not appropriate to include private benefits. In the presence of market failures, at least some of the private benefits should be included.
Value of emissions reduction	This needs to be understood in the wider context of emissions policy and includes both CO_2 and other emissions. Emissions reductions should be valued at the economy wide cost of emissions reductions, accounting for the fact that there may be other low cost abatement options available.
Technology cost or cost of fleet mix change	There are a wide range of technology cost estimates available. The analysis should allow for sensitivity around estimates. As Australia is a technology-taker (technological options are likely to be driven by other markets), the standard may also involve costs (from the Australian import perspective) in terms of upgrading the efficiency of the fleet, compared with what would otherwise have been the case.
Opportunity cost	This factor is often excluded from explicit consideration. However, focus on fuel efficiency characteristics of vehicles must involve some opportunity cost in terms of other characteristics that consumers value.
Rebound effect	It is widely understood that energy efficiency measures involve a ‘rebound effect’. In the case of a vehicle efficiency standard, there is an increase in kilometres travelled due to the effective reduction in the cost of vehicle travel brought about by increased fuel efficiency.
Other implications of the rebound effect	Increased kilometres travelled will have other implications, including increased congestion, increased non-CO_2 emissions, etc.
Indirect implications for fuel prices	Fuel efficiency from standards may require improvements in fuel quality. This will have indirect implications for fuel prices that need to be included in the analysis. Note that changes in fuel prices will affect all vehicles, not just new vehicles.
Compliance costs	Complying with the standard will involve compliance costs for fleet importers and managers.
Administrative costs	Administering the standard will involve government administration costs
Cost of taxation (to cover administration costs)	Administration costs will involve the use of tax revenue, which has an opportunity cost.

Source: The CIE

Fuel standards may interact with emissions standards. If this is the case, consideration of fuel standards will need to be included in a RIS on emissions standards.

The design of emission standards should be subject to a RIS

If the government decides to introduce emissions standards, the strength of the standard (the extent to which emissions are required to fall) should be based on the extent to which this creates net benefits. This will be based on the issues raised above.

- If the government finds there is a market failure that requires emissions standards and assumes low technology costs, then it will likely implement a strong standard. CCA (2014) considered three separate standards and preferred the strongest one, essentially on this basis.
- If the government finds limited or no market failure, includes opportunity costs, and assumes high technology costs, it is likely it will implement a weak standard. In this case, careful consideration should be given as to whether or not the standard is justified in the first place.

4 Eco-driving and other policies

There are a number of alternatives, or complements, to compulsory emissions standards. This chapter considers in particular the potential net benefits of a program to train drivers in 'eco-driving'. This sort of program has an advantage in that it affects all drivers, and all vehicles, not just new vehicles which are the target of standards.

Eco-driving: results of cost-benefit analysis and discussion

The CIE has performed a simple cost-benefit analysis of teaching Australians 'eco-driving'. The main purpose of this analysis is to demonstrate that policies that have a broad focus (like eco-driving, which focuses on all drivers and all vehicles) and/or which solve a specific problem (like educating against bad habits) could achieve substantial reductions in CO_2 emissions at relatively low cost. The analysis is based on the results of a study undertaken by Graves et al (2012) for the RACQ.

Table 4.1 presents costs, benefits and net benefits of teaching all Australian drivers 'eco-driving' via an online module (RACQ option 1). This reduces fuel consumption by 4.5 per cent. Overall, this policy creates net benefits of $22.1 billion, including $23.4 billion of fuel savings. We attribute these savings to eco-driving, because eco-driving is alleviating a specific problem (bad habits) that prevents these savings from being realised (see discussion below). The policy results in an (undiscounted) abatement of 76 of CO_2 between 2015 and 2040.

4.1 Costs, benefits and net benefits of teaching drivers 'eco-driving', relative to 'BAU' scenario (billions $, 2015 dollars, NPV terms)

Cost or benefit	Eco-driving options
	RACQ option 1
Cost: DWL of taxation that is levied to pay for program	-0.5
Cost of program participants time	-1.7
Benefit: fuel expenditure savings	23.4
Benefit: value of reduced emissions	0.9
NPV	22.1

Notes: There is a direct financial cost to government of providing eco-driving training. However, as this is a transfer, this direct financial cost is not included (or included as zero cost) in the economic cost-benefit analysis. The dead weight loss that is created by this transfer is included as an economic cost. The cost of program includes updated training every 10 years.

Source: The CIE

The problem 'eco-driving' is trying to solve

The logic behind eco-driving is that drivers have developed bad driving habits that increase the amount of fuel they use for set driving tasks. Eliminating these bad habits, by teaching them better habits in 'eco-driving', will reduce their fuel use.

The evidence that there is a problem of 'bad habits' and that 'eco-driving' is a solution to this problem is simply that, as documented in RACQ (2012), the fuel use of drivers declined once they were provided with the eco-driving training. The key point is that after they have been provided with eco-driving training, the drivers have the option of using the knowledge they learned (or not). The fact that it appears they choose to use this knowledge to reduce their fuel use suggests there was an underlying problem (like 'bad habits') and this problem is solved with 'eco-driving'.

If it turned out that fuel use did not decline after eco-driving lessons, our interpretation would (of course) have to change.

Therefore, as shown in Table 4.1, we attribute the private benefits (fuel savings) to the eco-driving training.

Opportunity costs

The opportunity cost created by eco-driving training are the dead-weight loss of the taxes that are raised to pay for the program and the cost of the time required for individuals to participate in the program. As shown in Table 4.1, we have included these opportunity costs.

Other policies

As noted, if the government wishes to consider introducing emissions standards, it should subject the policy to a proper RIS, which should include detailed analysis of alternative policy options.

While it is beyond the scope of this report to consider alternative policy options in detail, this chapter provides some high level comments on other policy options. The issues raised here will need to be considered in a RIS.

Roads infrastructure

Generally, the primary goal of roads infrastructure projects is to tackle problems like congestion and long commute times. Where roads infrastructure projects alleviate these problems, it is also possible that carbon emissions (from driving) will reduce. However, these savings in carbon emissions can be relatively small. For example, according to the updated Strategic Business Case for WestConnex (November 2015), Australia's largest infrastructure project, the project will create $22.2 billion worth of benefits (or $24.3 billion if 'wider economic impacts' are included), including $12.9 billion worth of 'travel time savings' and $832 million of carbon emission savings.

Other types of infrastructure projects – like public transport projects – could create larger emissions abatement.

Fuel standards

Standards for fuel could be used to oblige fuel retailers to sell higher quality fuels that, when burned in car engines, release less emissions.

While detailed analysis of such a proposal would be required, the CIE understands from the AAA that such a policy could create relatively small carbon abatement benefits yet impose considerable cost on drivers. It is possible the 'benefit-cost' ratio of such a policy would be very low.

- It is likely that higher quality fuel would only reduce emissions in relatively new cars. Carbon abatement could therefore be relatively small.
- Higher fuel standards would likely increase the price of petrol for all drivers, whether or not they drive a car that benefits from the better quality fuel (and which emits less emissions as a result). The policy could therefore create significant, widespread costs.

Fuel standards may interact with emissions standards. If this is the case, consideration of fuel standards will need to be included in a RIS on emissions standards.

Changes to taxes on new vehicles

Tax changes could be used to alter driver decisions on the purchase of new vehicles so as to reduce carbon emissions (taxes could be lowered on relatively efficient vehicles, and increased on relatively inefficient vehicles).

Similar to emissions standards, this policy is likely to create relatively small emissions abatement as it only impacts one aspect of behaviour, the purchasing of vehicles. Broader policy measures, like carbon and fuel taxes, should create more substantial abatement, as they impact all aspects of driver behaviour (including purchasing but also how and by how much vehicles are used).

Further, as taxes only make up some share of purchase price, or impact a certain subset of vehicles, relatively substantial changes will be required to have a meaningful impact on emissions.

Once domestic vehicle production ceases, import tariffs will theoretically apply to all new vehicles sold in Australia. However, where they apply they are only small (5 per cent). Further, under recent bilateral agreements, these tariffs no longer apply to vehicles imported from Japan and South Korea.

The 'luxury vehicle tax' is levied on more expensive vehicles: the tax equals 33 per cent of the vehicle price above the set threshold. The tax already has a carbon abatement aspect to it, as the threshold is $75 375 if the fuel consumption is below 7L/100km and $63 184 otherwise. Changes to the luxury car tax would only have a small impact on carbon emissions, as vehicle purchases that attract the tax make up only a small share of vehicle purchases.

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A Background data

All vehicles in Australia

Table A.1 shows data published by the ABS on the stock of light vehicles in Australia. To estimate the total stock of 'light vehicles', the stock of 'passenger vehicles' is added to the stock of 'light commercial vehicles': the data suggests there 16.2 million 'light vehicles' in Australia in 2014. These vehicles travelled 222.3 billion km and consumed 24.4 million litres of fuel (at 11.0 L/100km).

A.1 Data on all light vehicles in Australia

Year	Number of vehicles	KM travelled	Litres of fuel consumed	Vehicle usage	Fuel consumption
	Million	Billion	Million	Km/vehicle	L/100km
2006	13.4	191.4	22.4	14 331	11.7
2007	13.7	195.3	23.0	14 254	11.8
2010	14.8	206.1	24.0	13 940	11.6
2012	15.3	211.2	24.0	13 825	11.4
2014	16.2	222.3	24.4	13 689	11.0
Growth (per cent) [a]	*2.5*	*1.9*	*1.1*	*-0.6*	*-0.8*

[a] *Cumulative average annual growth rate between 2006 and 2014*

Note: From the underlying ABS data, the displayed data on 'light vehicles' are the sum of 'passenger vehicles' and 'light commercial vehicles'. According to the ABS data, in 2014, there were 13.4 million passenger vehicles that travelled 176.8 billion kilometres with an average fuel consumption of 10.7L per 100km and 2.8 million light commercial vehicle vehicles that travelled 45.5 billion km with an average fuel consumption of 12.1L per 100km.

Source: ABS 9208.0

The ABS does not report emissions intensity (measured with g CO_2 per km travelled). However, emissions intensity is very closely related to fuel consumption. Using this relationship (specifically, the regression equation estimated below), we estimate that emissions intensity of the whole Australian light vehicle fleet in 2014 was 256.1 gCO_2/km (given fuel consumption of 11.0L/100km).

Between 2006 and 2014, average annual growth for total kilometres driven (km), vehicle usage (km/vehicle) and fuel consumption (L/100km) were 1.9 per cent per year, -0.6 per cent per year and -0.8 per cent per year. These historical growth rates are used to project forward in our scenario analysis.

New vehicles sold in Australia

VFACTs data, published by the FCAI, measure sales of new vehicles. There were 1 123 224 new light vehicles sold in Australia in 2015, up from 1 081 899 in 2014.

(For this, 'heavy commercial' vehicles have been excluded from the total). Data for the 2014 year in Tables A.1 and A.2 suggest that sales of new light vehicles make up around 7 per cent of the total vehicle fleet in any year.

A.2 Sales of new vehicles (2015)

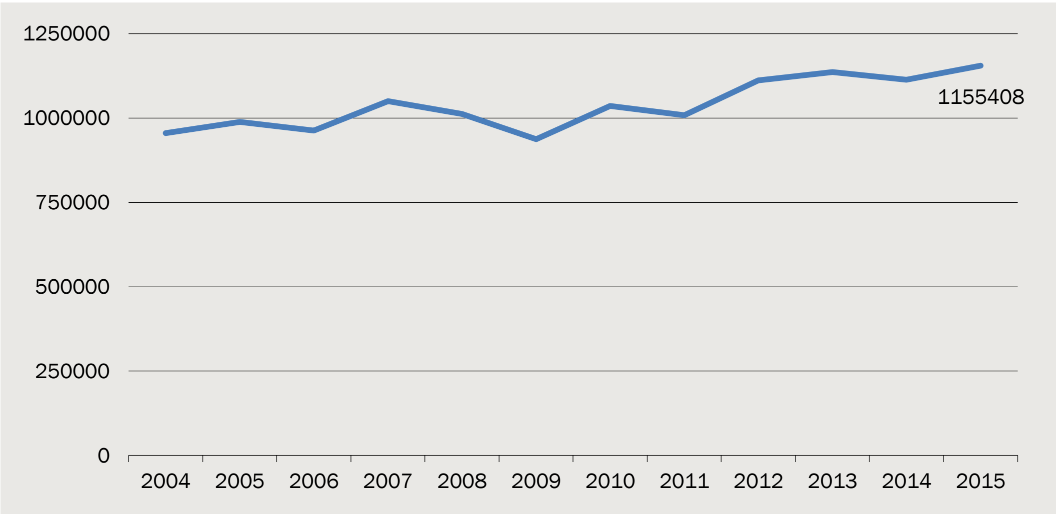
	Light vehicles [a]	Heavy commercial vehicles	Total vehicles
	Number	Number	Number
2014	1 081 899	31 325	1 113 224
2015	1 123 224	32 184	1 155 408

Note:

Source: VFACTs (FCAI)

According to historical data published on VFACTs website, sales of new vehicles grew on average by 1.7 per cent per year between 2004 and 2015 (to reach 1 155 408 in 2015).

A.3 Sales of new vehicles (2002 to 2015)



Source: VFACTs (FCAI)

Characteristics of new vehicles

CO_2 emissions of new vehicles

The National Transport Commission (NTC 2016, Table 6) publish data on emissions for new vehicles. These data show that average emissions have been declining over-time, reaching 184.2 g/CO_2 in 2015.

A.4 Average emissions of new vehicles sold (gCO_2/km)

Data source: NTC (2016) Table 6; The CIE

Fuel consumption and price

New vehicles sold are classified into 18 different classes (micro, light, small, etc.). The CIE has picked the most popular make and model in each class and, using data from manufacturers websites and the Green Vehicle Guide[17], calculated the weighted average emissions intensity, fuel consumption and price. For each make and model, we have picked the basic or standard model. Table A.5 shows the weighted average data, which are used in the scenario analysis. Tables A.6 and A.7 contain the underlying data across classes. The relationship between fuel economy and emissions intensity is discussed below.

A.5 Estimated average characteristics for the new vehicle fleet in Australia (2015)

Characteristic	Unit	Estimate
Emissions intensity	gCO_2/km	183.8 [a]
Fuel economy	L/100km	7.8
Recent price	$	35 171

[a] The CIE's calculated weighted average for emissions intensity 183.8 matches closely with reported NTC data (184.2, noted here as '184', above)

Source: The CIE; Vehicle manufacturer's websites; Green Vehicle Guide; VFACTs (FCAI)

Fuel economy and emissions intensity

Using data for the vehicles in Table A.7 (below), we use OLS regression to estimate the numerical relationship between fuel economy and emissions intensity (equation 1). These estimates allow us to easily convert between the fuel economy and emission intensity. This is done in a few places in this analysis.

17 https://www.greenvehicleguide.gov.au/

$$Fuel\ econonomy\ \left(\frac{L}{100km}\right) = -0.18084 + 0.043593 * Emissions\ intensity\ (\frac{gCO2}{km})$$

Because these two variable are directly related, this estimated relationship has an adjusted R-squared of 0.99.

Detailed data on new vehicles sold

Table A.6 shows detailed data on types of new vehicles sold. The 2015 sales data (at the class levels) are used to calculated the weighted average variables in the last line of Table A.7. In table A.7 we have selected the most popular make and model from each class and used manufacturers website and the Green Vehicle Guide to compile data on emission intensity, fuel economy and prices. For each make and model, we have used the basic or standard model.

A.6 Composition of new vehicle sales in Australia, 2015

Type of vehicle	2015 sales	Most popular make and model
Micro	10 717	Mitsubishi mirage
Light	111 954	Mazda 2
Small	233 122	Toyota Corolla
Medium	78 123	Toyota Camry (4 cyl)
Large	43 940	Holden Commodore
Upper large	2 976	Holden Caprice
People movers	11 946	KIA Carnival
Sports	22 905	Toyota 86
SUV small	111 275	Mitsubishi ASX
SUV medium	144 937	Mazda CX-5
SUV large	139 734	Toyota Prado
SUV upper large	12 525	Toyota Landcruiser Wagon
Light buses < 20 seats	2 811	Toyota Hiace bus
Light buses > 20 seats	606	Mitsubishi Rosa bus
Vans/CC < 2.5t	3 899	Volkswagon Caddy van
Vans/CC 2.5t-3.5t	17 094	Toyota Hiace van
PU/CC 4*2	40 657	Toyota Hilux 4*2
PU/CC4*4	134 003	Toyota Hilux 4*4
Heavy commercial vehicles	32 184	Isuzu N-Series
Total new vehicle sales	1 155 408	-

Source: FCAI VFACTs

A.7 Fleet of new light vehicles sold in Australia: most popular, standard models (2015)

Type	Most popular	Standard Aus. model	Engine size	Fuel type	Emissions intensity	Fuel consumption	Recent price
	Make and model				gCO_2/km	L/100km	$
Micro	Mitsubishi mirage	ES 4 door hatch	1.2	Petrol	109	4.6	13490
Light	Mazda 2	Hatch Neo	1.5	Petrol	126	5.4	16990
Small	Toyota Corolla	Ascent hatch	1.8	Petrol	156	6.7	23189
Medium	Toyota Camry (4 cyl)	Altise	2.5	Petrol	183	7.8	30100
Large	Holden Commodore	Evoke sedan	3.0	Petrol	198	8.3	39000
Upper large	Holden Caprice	Caprice-V	6.2	Petrol	300	12.9	65300
People movers	KIA Carnival	S	3.3	Petrol	271	11.6	45608
Sports	Toyota 86	86 Manual	2.0	Petrol	180	7.8	34178
SUV small	Mitsubishi ASX	LS	2.0	Petrol	176	7.6	25000
SUV medium	Mazda CX-5	Maxx	2.0	Petrol	149	6.4	30823
SUV large	Toyota Prado	GXL	4.0	Petrol	266	11.6	65708
SUV upper large	Toyota Landcruiser Wagon	GXL	4.6	Petrol	309	13.4	90251
Light buses [a]	Toyota Hiace bus	HiACE SLWB commuter bus	2.7	Petrol	263	11.3	57964
Vans/CC 2.5t-3.5t	Toyota Hiace van	HiACE Long wheelbase van	2.7	Petrol	237	10.1	36812
PU/CC 4*2	Toyota Hilux 4*2	Workmate double cab pickup	2.7	Petrol	248	10.7	35004

Type	Most popular	Standard Aus. model	Engine size	Fuel type	Emissions intensity	Fuel consumption	Recent price
	Make and model				gCO_2/km	L/100km	$
PU/CC4*4	Toyota Hilux 4*4	Workmate double cab pickup	2.4	Diesel	191	7.3	48733
Weighted average					184	7.8	35171

a < 20 seats

Note: The weights are based on the sales in each vehicle class in Table A.6. Two types have been excluded from this analysis and the calculation of the weighted average: Light buses > 20 seats and Vans/CC < 2.5t due to a lack of available information.

Note: 'Recent' prices are prices in February and March 2016

Source: VFACTs; Manufacturers websites; Green Vehicle Guide; The CIE

Financial costs and benefits of other emissions abatement policies

In a study published in 2012, RACQ investigated the cost effectiveness of teaching drivers 'eco-driving'. The logic behind eco-driving is that drivers have or have developed bad driving habits that increase the amount of fuel they use for set driving tasks. Eliminating these bad habits, by teaching them better habits ('eco-driving'), will reduce their fuel use. Eco-driving includes: shifting gears as early as possible, skipping gears where appropriate, using the highest gear possible, avoiding heavy braking and accelerating, etc.[18]

The mooted bad habits that eco-driving is designed to correct are the potential problem that prevents people from optimising (reducing) their fuel use. If this problem exists, and if eco-driving lessons are an appropriate policy response, then teaching drivers eco-driving will have a significant impact on fuel use (because individuals who have learnt 'eco-driving' will choose to apply what they have learnt in their lessons).

In the RACQ study, 897 Queensland drivers were taught 'eco-driving' and a control group was not. The fuel use of both sets of drivers was compared before and after the training. RACQ use statistical analysis to judge that eco-driving training results in statistically significant reduction in fuel use while driving.[19]

RACQ used five different methods to teach eco-driving, each having a different measured impact on driving and a different financial cost (see Table A.8). RACQ notes that statistical analysis suggests there is no significant difference between the impact each of the five methods has on fuel use. They note that while the fifth impact (half-day workshop) appears to have a much bigger impact than the other methods, they suggest the significance of this difference is reduced by the small sample size for the fifth group (pg. 50).

A.8 Eco-driving: methods of teaching, costs and reduction in fuel use

Teaching method	Number of participants	Delivery cost [a]	Benefit
		$	Average per cent change in fuel use (each year), across program participants
Online learning	194	38.1	-4.52
Classroom	207	116.2	-4.73
Driving lesson	212	111.2	-4.33
Classroom and driving lesson	208	181.2	-4.02
Half-day workshop	76	246.2	-7.40

[a] Delivery cost is measured in NPV terms in the first year of the program. In the RACQ data, each method has an initial cost in year 0, and then subsequent administration costs in year 1 and 2. Using a discount rate of 7 per cent (used elsewhere in this report and recommended by OBPR), we discount all costs back to year 0 to get a single figure.

Source: RACQ (2012) pg. vi, 51 and 52

18 RACQ 2012 pg. 3

19 RACQ 2012 pg 47

Given RACQ's conclusions that: (1) teaching eco-driving has a statistically significant impact on fuel use and (2) there is no statistically significant difference between the effectiveness of the teaching methods, we undertake a simple analysis: we calculate the costs and benefits of teaching Australians eco-driving, assuming they are taught with method 1 (on-line learning) in Table A.8.

Note that in Table A.8, the cost is a 'delivery' cost, which RACQ characterises as an 'implementation cost'. RACQ does not provide much detail on what it has included in these costs. The costs presumably cover the per driver costs of providing the training, but it is not clear if and how initial costs and setup costs, such as designing and producing content (for the online course and workshop), training driving instructors (where necessary), etc., have been included this delivery cost. (RACQ does note the cost includes a 'management' cost). If these costs have not been included, RACQ's costs could underestimate the financial costs of the training. It is possible RACQ has included initial costs but has not explicitly noted this. If 'eco-driving' is well understood by driving instructors and organisations like RACQ, it is possible that the initial and setup costs of establishing a widespread 'eco-driving' program could be relatively modest (especially when measured on a per participant basis).

B Methodology for NPV analysis

For this report, the CIE has undertaken a simple cost benefit analysis of two carbon abatement policies: hypothetical emissions standards and teaching Australians 'eco-driving'. The purpose of our analysis is not to produce definitive, precise estimates of the likely costs and benefits that would be created by these policies. If the government wishes to introduce the standards, it should undertake a RIS, and this is the appropriate place for this detailed work to be done.

- For emissions standards, the purpose of our analysis is to use different scenarios to demonstrate that the cost and benefits created by standards are very sensitive to whether or not there exists a market failure that is solved by the standards, technology costs and the additivity of technology.
- For 'eco-driving' training, the purpose of our analysis is to demonstrate that broadly targeted policies (policies that target all drivers), and policies which solve specific problems, can create substantial abatement at relatively low cost, compared to narrowly focused policies like emission standards.

High-level assumptions that apply to all analysis

The CIE has made the following key assumptions for its analysis.

- Carbon price (the value of abated emissions) of $25 per ton.
- Fuel price (the value of fuel savings) of $1.50 per litre.
- These prices and other prices remain constant in real terms, and all analysis is done in real terms.
- A real interest rate of 7 per cent (consistent with OBPR guidelines).
- The time-frame is 26 years (2015 to 2040). This is consistent with Dep ITRDLG 2010.
- All population projections are based on ABS Series B projections (ABS Cat. 3222.0). Series B is middle case of the ABS projections.

Tailpipe emissions standards for new vehicles sold in Australia

Emissions standards are described and discussed in detail in Chapter 3. The basic idea is that manufacturers are forced to reduce the emissions intensity (gCO_2/km) of new vehicles more quickly than they otherwise would have. According to NTC data, the current emissions intensity of new vehicles is 184 gCO_2/km (2015).

The logic that underlies the scenarios we use to analyse emissions standards is simple. Each year a new vintage of new vehicles is sold. The price of each vintage of new vehicles increases if the vehicles include technology upgrades that are required to meet emissions standards. Then, in the year each vintage is sold and in subsequent years, the vehicles drive a number of kilometres. The fuel costs and emissions created by this driving depend on the fuel economy (L/100km) and emissions intensity (gCO_2/km) of the vehicles. These characteristics: fuel economy and emissions intensity, depend on the vintage of the vehicles (vehicles sold in later vintages have better fuel economy and lower emissions intensity) and whether emissions standards are being applied (fuel economy is better and emissions intensity is lower under the emissions standards, compared to business as usual).

In NPV terms, we calculate the net benefit of each scenario for emissions standards compared to business as usual.

As the purpose of this analysis is to demonstrate the importance of assumptions, this analysis is kept simple in two ways.

- We take estimates of technology cost directly from Dep ITRDLG 2010. We do not undertake research to produce our own estimate.
- Cost-benefit analyses of emissions standards can be quite complicated, as authors can include various factors, including a 'feedback' effect (where driving increases due to savings on fuel costs – a factor that reduces slightly the claimed benefits of the standards), impacts on congestion, impacts on vehicle turnover, impacts on taxes, etc. For our analysis we include only the main effects: fuel savings created by the standards, the technology cost required to meet the standards and the value of abated emissions of CO_2. The AAA explained to the CIE that as the technology in vehicles is upgraded, it is likely that the cost to service vehicles will increase. For simplicity, we have not included this impact.

Scenarios: business as usual and assumptions for technology costs

In each scenario, our 2015 starting point for new vehicles is: average emissions intensity of 184 gCO_2/km (NTC), average fuel consumption of 7.8 L/100km (based on the regression equation in Appendix A) and an average price of $35 171 (see Table A.5).

Business as usual scenario

Under 'business as usual' (BAU), no policy intervention (including emissions standards) is applied.

While future trends are uncertain, CCA discussion suggests that in the absence of a specific policy intervention by the government, average emissions for new vehicles will continue to fall by around 2 per cent per year over the next decade or so[20]. Therefore, under BAU we assume emissions fall from 184 gCO_2/km in 2015 to 151 gCO_2/km in 2025. Fuel consumption falls to 6.4 L/100km.

As discussed in Chapter 3, we assume the technology costs associated with emissions reduction in BAU are sunk. For simplicity, it is therefore assumed that the cost of

20 CCA 2014 pg. 32

vehicles does not change in this scenario – the average price remains constant at $35 171. As stated all analysis is done in real terms, so there is no inflation to drive a price change.

Emissions standards scenarios: technology costs including additive and non-additive technology

CCA (2014), on the basis of their cost-benefit analysis, argue that a 'strong' standard is preferred. In CCA's strong standards scenario, emissions fall to 105 gCO_2/km by 2025. We adopt this target for each of our emissions standards scenarios. In each scenario, emissions fall by 5.5 per cent per year to reach 105 gCO_2/km by 2025 (from a starting point of 184 gCO_2/km in 2015)and fuel consumption falls in-line to reach 4.4 L/100km.

The requirement that emissions intensity falls by 5.5 per cent per year creates a technology cost, as vehicles have to be upgraded to meet this requirement. This technology cost is added to the price paid by drivers of new vehicles. To generate a low cost, medium cost and high cost scenario, we take cost estimates from Table 3.6 (above). In the discussion that accompanied Table 3.6 , it was noted the three cost estimates to be used were $41.69, $52.10 and $61.40 which are estimates for the cost of reducing emissions intensity by 1 gCO_2/km.

We also vary our assumption for 'additivity' of technology.

Firstly, we assume that technology is additive. This means manufacturers only have to implement technology for reductions in emission intensity that is additional to the BAU. Therefore, only technology costs associated with reducing emissions intensity by 3.5 per cent per year (5 per cent per year less 2 per cent per year) are created and added to the price of vehicles. This is the 'best case' scenario for technology costs, and is described as such in the results (Chapter 3).

- In the low cost scenario, where a drop in emissions intensity of 1 gCO_2/km costs $41.69, the price of new cars increases by around 0.5 per cent per year to reach $37 068 in 2025. All analysis is done in real terms; there is no inflation component in this price increase.
- In the medium cost scenario, where a drop in emissions intensity of 1 gCO_2/km costs $52.10, the price of new cars rises by around 0.7 per cent per year to reach $37 542 by 2025.
- In the high cost scenario, where a drop in emissions intensity of 1 gCO_2/km costs $61.40, the price of new cars rises by around 0.8 per cent per year to reach $37 965 by 2025.

Secondly, we assume that technology is not additive. This means, under emissions standards, manufacturers have to go back to the drawing board and research and implement new technologies that reduce emissions intensity by the full 5.5 per cent per year. There is no benefit from the BAU trend. Therefore, technology costs associated with reducing emissions intensity by 5.5 per cent per year are created, and added to the price of vehicles. This is the 'worst case' scenario for technology costs, and is described as such in the results (Chapter 3).

- In the low cost scenario, where a drop in emissions intensity of 1 gCO_2/km costs $41.69, the price of new cars increases by around 0.9 per cent per year to reach

$38 473 in 2025. All analysis is done in real terms; there is no inflation component in this price increase.

- In the medium cost scenario, where a drop in emissions intensity of 1 gCO_2/km costs $52.10, the price of new cars rises by around 1.1 per cent per year to reach $39 298 by 2025.
- In the high cost scenario, where a drop in emissions intensity of 1 gCO_2/km costs $61.40, the price of new cars rises by around 1.3 per cent per year to reach $40 034 by 2025.

Other assumptions

New light vehicle sales

Our starting point for sales of new light vehicles is 1 123 224 in 2015. Sales of new light vehicles are assumed to grow by 1.7 per cent each year, in-line with the historical trend for total sales of new vehicles (see Chapter 5). New car sales reach 1 335 312 in 2025.

For this analysis we assume that new vehicles are sold from 2015 to 2025 only.

- From 2015 to 2025, in our emissions standards scenarios, there are both costs (higher prices for vehicles as more are sold) and benefits (fuel savings from more efficient cars and emissions abatement).
- From 2026 to 2040, in our emissions standards scenarios, there are only benefits. As no new cars are sold, there are no additional costs from vehicle sales. The benefits, the fuel savings and emissions abatement, continue to arise from vehicles sold before 2026.

This 2026-2040 period was added so full fuel savings and emissions abatement could be realised. If our analysis ended in 2025, vehicle purchasers would incur large costs in 2025 and receive very small benefits. We do not make any assumption for the lifetime of vehicles. Vehicles sold as new cars in 2015 continue to operate, and generate benefits, right through to 2040.

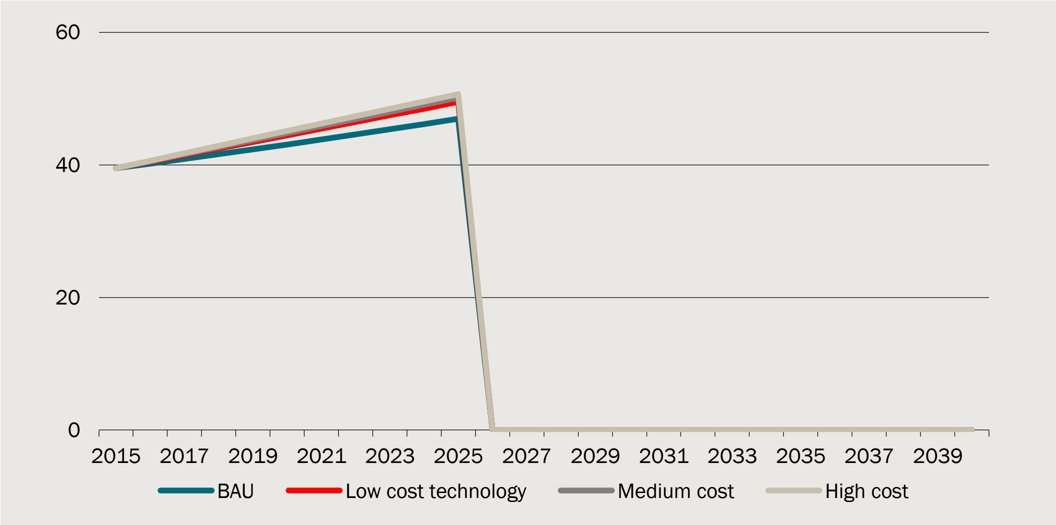
Kilometres driven per vehicle

Our starting point for kilometres per vehicle is 13 689 km/vehicle, reported by the ABS for 2014. We project this forward at its historical growth rate of -0.6 per cent per year. Kilometres per vehicle thus falls to 11 793 km/vehicle in 2040.

Results of these assumptions

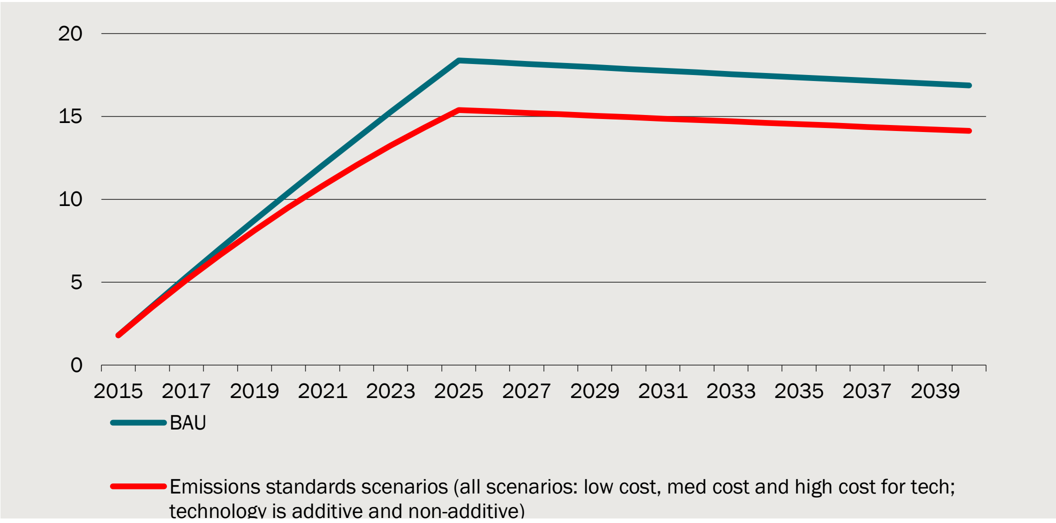
For each emissions standard scenario we calculate the additional expenditure on new vehicles (cost), fuel savings (benefit) and the value of carbon abatement (benefit) relative to the BAU scenario. These three series are a product of the assumptions just outlined. Charts B.1, B.2 and B.3 show these data.

B.1 Expenditure on new vehicles ($ billions), assuming technology is additive (best case scenario for technology costs)



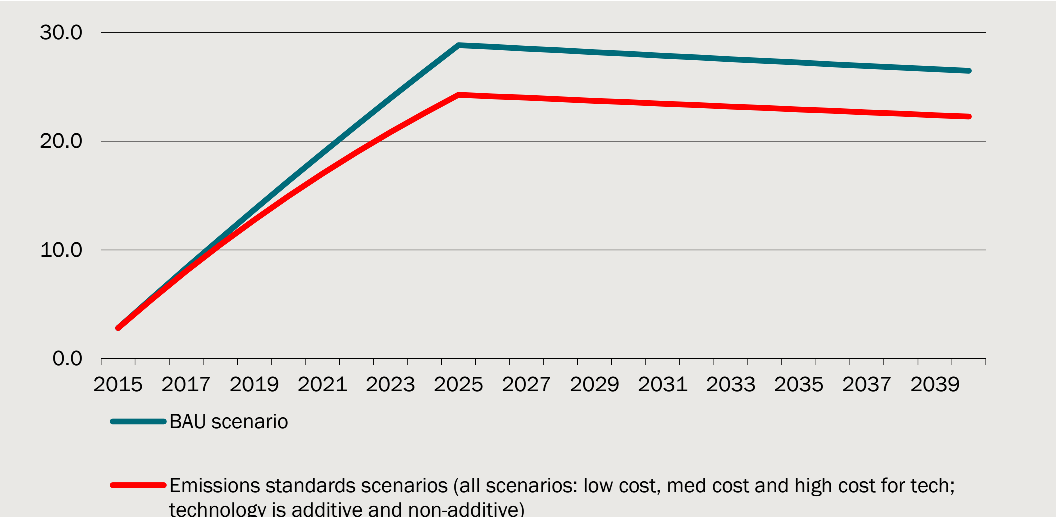
Data source: The CIE

B.2 Expenditure on fuel ($ billions)



Data source: The CIE

B.3 CO_2 emissions from vehicles sold from 2015-2025 (Mt)



Note: As noted above, to calculate the value of emissions, and thus of carbon abatement, we use a carbon price of $25 per ton.

Data source: The CIE

Teaching Australians 'Eco-Driving'

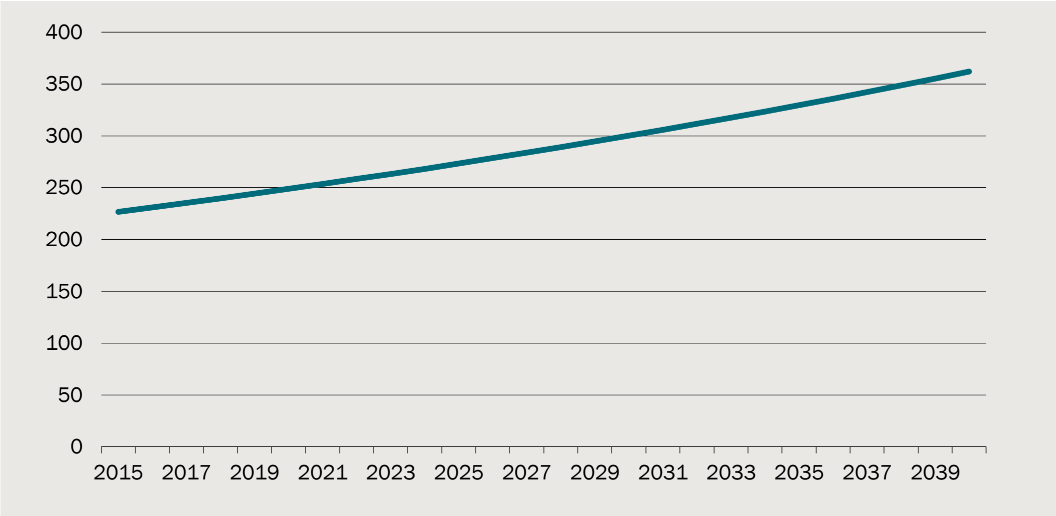
The logic behind eco-driving is that drivers have developed bad driving habits that increase the amount of fuel they use for set driving tasks. Eliminating these bad habits, by teaching them better habits in 'eco-driving', will reduce their fuel use.

Here, we analyse the costs and benefits of the government paying for all drivers in Australia (current drivers and all new drivers in subsequent years) to learn eco-driving.

Underlying assumption: total kilometres driven in Australia

Using data from Table A.1, we develop a projection for the total driving task: total kilometres driven by light vehicles in Australia, out to 2040. We start from the last piece of published data, 2014, 222.3 billion km driven, and project forward at historical annual average growth of 1.9 per cent per year.

B.4 Total kilometres driven in Australia ('driving task'), for each scenario (billion km)



Data source: The CIE

Scenarios

We develop two scenarios for the fuel consumption (L/100km) that Australian drivers use to complete this driving task.

Business as usual scenario

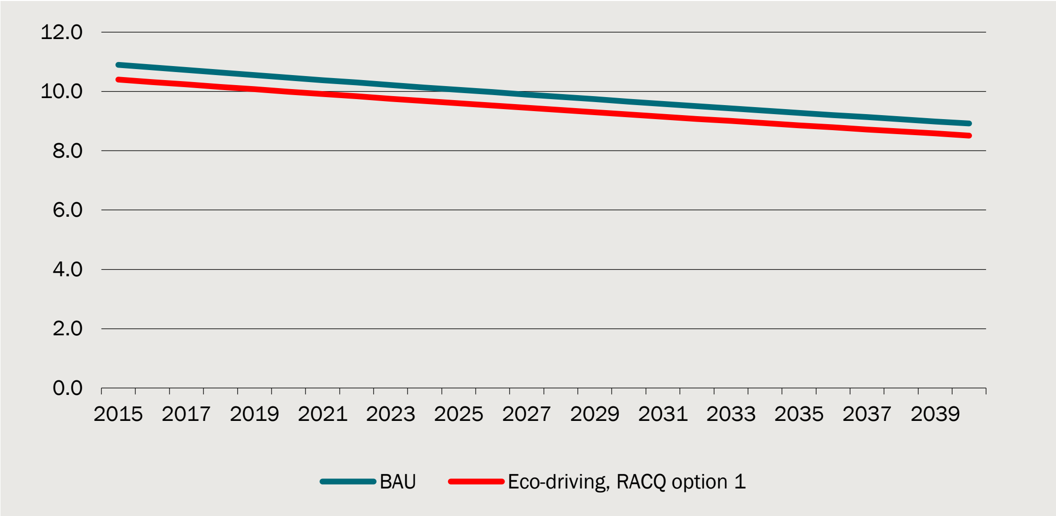
Under the 'business as usual scenario', fuel consumption is simply projected forward using historical data in Table A.1. The last piece of published data is 11.0 L/100km in 2014, and the historical trend is growth of -0.8 per cent per year. Fuel consumption thus drops from 10.9 L/100km in 2025 to 8.9 L/100km in 2040. We use the relationship specified in Appendix A to estimate the emissions intensity of driving, given these assumptions for fuel economy. Emission intensity drops from 254 gCO_2/km to 209 gCO_2/km in 2040.

Eco-driving scenario

Under the eco-driving scenarios, we assume all drivers receive eco-driving training via the on-line learning method, which means that the fuel consumption of all drivers is 4.5 per cent lower than it otherwise would be (see Table A.8). Under this scenario, fuel consumption drops from 10.4 L/100km in 2025 to 8.5 L/100km in 2040. Emissions intensity drops from 243 gCO_2/km to 199 gCO_2/km.

Chart B.5 shows these scenarios.

B.5 Fuel consumption (L/100km), by scenario



Data source: The CIE; RACQ (2012)

Benefits of the eco-driving training

We assume that all drivers receive eco-driving training via online learning, and that fuel consumption falls, for all drivers, by the average fall reported in the RACQ study: 4.5 per cent (see Table A.8). The simplification and limitation of this assumption is discussed below. The benefits of eco-driving are reduced fuel consumption and reduced emissions of CO_2.

- From total kilometres driven and the fuel consumption in each scenario, we can calculate total expenditure on fuel in each scenario using our assumption for the fuel price: $1.50. We then work out the saving created by eco-driving. Because eco-driving solves a problem (bad habits) that prevent people from driving properly and (thus) achieving these benefits, it is reasonable to count these private benefits as being created by the policy change.
- From total kilometres driven, the fuel consumption and the estimated relationship between carbon emissions intensity and fuel consumption, we calculate total emissions. We value these emissions using our assumption for the carbon price: $25 per ton, and work out the value of the saving from abatement created by eco-driving.

Costs of eco-driving training

Key cost driver: number of drivers that require eco-driving training

To estimate the costs of teaching eco-driving, we need to calculate the initial number of drivers (in 2015) that require training in eco-driving, and then the number of new drivers that require training in each subsequent year.

Number of initial drivers in 2015

For its financial cost-benefit analysis, RACQ (pg. 51) assume that each driver drives 14 400 km per year (citing ABS Cat. 9208.0). From the underlying data, this figure corresponds to the number of kilometres travelled per vehicle. That is, RACQ implicitly assume there is one driver per vehicle.

For the purposes of our simple analysis, this is probably a reasonable assumption to adopt. The data in Table A.1 (reported data for 2014, plus one year of average growth) suggests, Australia wide, kilometres per vehicle (or per driver, as assumed here) is 13 689 in 2015. Combined with a total driving task in 2015 of 226.55 billion kilometres in 2015, this implies there are 16.55 million drivers in 2015 that would need to receive training in eco-driving. This number compares to around 19.2 million residents aged 15 and over in Australia in 2015, according to ABS population projections (ABS Cat. 3222.0).

Number of new drivers each year: 2016-2040

We assume the number of new drivers in each year equals:

- the number of Australian residents aged 15; plus
- the number of immigrant adults (aged 15 and over).[21]

We take the number of residents aged 15 from ABS Series B population projections (ABS Cat. 3222.0). According to these data, the estimated number of 15 year-olds is 289 318 in 2016 and grows by 1.3 per cent each year to reach 496 378 in 2040.

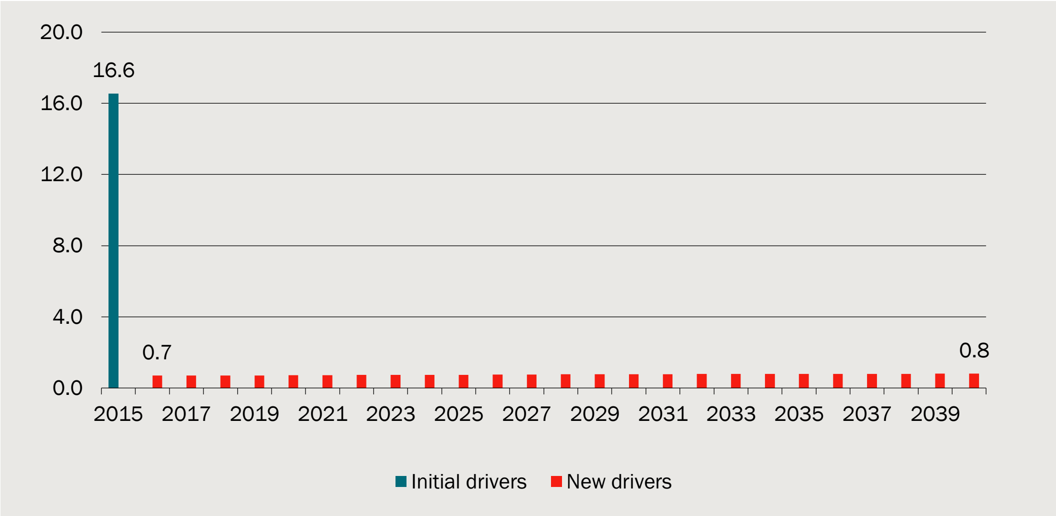
Projecting immigration patterns is very difficult. For long-term projections, forecasters usually work with flat average figures. In its Series B population projections (the middle case, which we are working from), the ABS assumes flat net overseas migration (NOM) of 240 thousand net immigrants per year. This is broadly consistent with average NOM (236 thousand) in the six years prior to the publication of the projections (2007 to 2012). In these six years, average immigration was 474 967 people per year. In 2014 (the last year of data), 85.7 per cent of immigrants were aged 15 and over. Therefore, we assume that in each year from 2016 to 2040, the number of immigrants who are aged 15 and over (and who therefore require eco-driver training) is a flat 407 105 (calculated as 85.7 per cent of 474 697).

Overall, the number of new drivers who receive eco-driver training in 2016 is 696 422. This grows and reaches 803 582 in 2040.

These results are shown in Chart B.6.

21 This method double counts immigrants who are 15 years old. Data limitations means we cannot correct for this double count. However, it is likely to be very small

B.6 Number of drivers in Australia who receive eco-driver training (millions)



Data source: The CIE

First economic cost: dead weight loss of taxation (not the financial cost of providing the training)

According to RACQ data, the direct financial costs of providing eco-driver training once is $38.1 per driver (see Table A.8).

For our analysis, we assume that teaching drivers eco-driving reduces fuel consumption from the year they receive the training right out to 2040. Given that the training is supposed to alleviate bad-habits, it is quite possible that these bad habits could creep back into driver behaviour after some period of time. RACQ do not discuss this possibility in their report, so we make a simple assumption to allow for this effect. We simply assume that all drivers would need to be retaught eco-driving 10 years and 20 years after their initial training. To include this assumption in our analysis we add to the cost of teaching each driver: $38.1 discounted over 10 years (in NPV terms) and $38.1 discounted over 20 years. With these adjustments, our estimates for the actual direct financial cost of teaching each new driver eco-driver training is $67.3 (rather than $38.1) per driver. This is an appropriate assumption for the drivers who receive the training in the early years, but it is inappropriate for drivers in the later years (because our cut-off year is 2040, we include costs that are not actually borne). This reduces the net benefits we eventually calculate.

Combined with our assumptions for the number of drivers who receive the training, we calculate the direct financial cost of providing the training to all drivers is $1.1 billion in 2015 (the cost of teaching all current drivers), $47 million in 2016, and (eventually) $54 million in 2040.

As noted, the government pays for these direct financial costs. These direct financial costs do not represent ‘economic costs’, and it is not appropriate to include them in this (economic) cost benefit analysis. To pay for programs, the government levies taxes on some activities (earning wages, earning profits, consumption, etc.) in order to pay for others (in this case, eco-driving). The simple assumption, which is standard in this type of economic analysis, is that the direct part of this transaction is simply a transfer: the taxed part of economy contracts, while the part that receives the payment expands. These direct impacts offset each other and there no change in the level of activity. This means there is no ‘economic cost’ associated with the direct financial cost of providing the scheme (eco-driver training).

While the taxes and payments directly associated with eco-driving training are assumed to be a transfer, these taxes impose indirect impacts on the economy, and these indirect impacts create economic costs that we must account for. Specifically, we assume that individuals and companies re-arrange their activities in order to minimise their tax, and this re-arrangement causes economic activity to contract. In economic jargon, this contraction in the economy is a called a ‘dead-weight-loss’ created by the tax. For the purposes of this simple analysis, we assume the dead-weight-loss of taxation is equal to 30 per cent of taxes levied.

Therefore, in each year, an economic cost that is equivalent to 30 per cent of the financial cost of teaching drivers eco-driving, is imposed on the economy. This economic cost is $334 million in 2015, $14 million in 2016 and (eventually) $16 million in 2040.

Second economic cost: the time cost of learning eco-driving

The second economic cost created by eco-driving training is the opportunity cost of the time required for drivers to participate in the training. Drivers could use the time they spend learning eco-driving to earn more income or to partake in some activity that they derive utility from. As learning eco-driving causes them to lose this opportunity, we must include this loss as an opportunity cost for eco-driving training.

RACQ note the on-line module takes 1 hour. As noted, we assume each driver receives 2 refresher courses after 10 and 20 years. Therefore, we assume the time loss taken up by the training is 1 hour, plus 1 hour discounted over 10 years, plus 1 hour discounted over 20 years. This gives a total time loss of 1.8 hours.

We assume the hourly ‘cost’ of drivers’ time is the hourly rate consistent with full-time, ordinary-time average weekly earnings for persons, reported by the ABS (Cat. 6302, for November 2015). This hourly rate is $37.5 per hour. As all of our analysis is real, this hourly rate is held constant between 2015 and 2040.

With these assumptions, the total opportunity cost of drivers time is $1.1 billion in 2015, $46 million in 2016, and grows to $53 million in 2040.

Simplifications we have made and the limitations of our results

We take the RACQ result – that eco-driving training, taught by online module, causes fuel use to fall by 4.5 per cent on average amongst program participants– and apply this as the average, economy-wide fall in fuel use across all drivers in the economy (as all drivers receive the training in our scenario). As the goals of our analysis are quite simple, this is reasonable.

The sample of drivers used by the RACQ are those who responded to RACQ's invite to participate in study. RACQ note participants were not told the study would involve eco-driving training, so there was no self-selection in for drivers who would be more likely to respond well to the training. RACQ offered an inducement of $1000 for participants. RACQ did not include this $1000 inducement in the costs of the scheme. We do not either. This means we assume that participation in the scheme will be widespread, which is reasonable for this simple analysis given the finding that the eco-driving lessons are an effective way of reducing fuel consumption. This assumption will have to be tested in a more formal RIS.

There are various methods to teach eco-driving training, and we have chosen one: online learning. We chose this method because RACQ found there was no (statistically) significant difference between the efficacy of the different methods available, and because this method was the cheapest. If the government undertakes a RIS on emissions standards, and includes eco-driving training as a policy alternative, it may have to consider whether eco-driving can be taught to all drivers via an online learning module.

Our assumption that people need to be re-taught eco-driving every 10 years is clearly a simplification. This and other assumptions will need to be tested too.