21 December 2011

Mr Michael Sutton
CO2 Emissions Standards
Vehicle Emissions and Environment Section
Surface Transport Policy
Department of Infrastructure and Transport
GPO Box 594
CANBERRA ACT 2601

Dear Michael,

Re: CO2 Standards for Light Vehicles Discussion Paper

GM Holden Ltd (Holden) welcomes the opportunity to provide a submission in response to the Discussion Paper prepared by the Department of Infrastructure and Transport (2011) on a mandatory CO2 emissions standard for light vehicles. Holden is committed to reducing emissions in our vehicles and has already made substantial moves in this direction through our Ecoline strategy that offers consumers cars that are more fuel efficient and produce fewer emissions. Holden supports the introduction of a CO2 emissions standard for light vehicles and we look forward to working constructively with the Government and the Department of Infrastructure and Transport on the design and implementation of a standard.

Our submission focuses on:

- Emissions reduction targets;
- The costs of an aggressive (in too short a period of time) CO2 emissions reduction target;
- How the standard should be set;
- Flexibility mechanisms; and
- Credit mechanisms.

In this submission, Holden recommends a comprehensive suite of measures that should be adopted in their totality:

- The adoption of a fleet wide target of 190 grams of CO2 per km for light vehicles (less than 3.5 tonnes) in 2015m, falling to 155 grams in 2024 as per the 2010 election commitment.
- The adoption of an attribute-based standard using vehicle footprint as the attribute; as it does not discourage the use of lightweighting, it is less easy to manipulate than mass, and has safety benefits.
- The inclusion of fleet averaging and pooling as part of the CO₂ emissions standard in order to minimise compliance costs.
- To further reduce compliance costs, a CO₂ emissions standard should also incorporate banking and borrowing.
- The adoption of credit mechanisms to encourage the uptake of CO₂ emissions reduction technology.
- The adoption of credits for vehicles that can run on E85 and for electric vehicles and plug-in hybrid electric vehicles consistent with best international practice.
- The provision of credits for the use of lower greenhouse gas emitting refrigerants in vehicle air conditioners.
- The adoption of the FCAI recommendation on the provision of credits.

**Government’s Election Commitment**

On 24 July 2010 the Government announced its election commitment for the implementation of a CO₂ emissions standard for light vehicles (Australian Labor Party, 2010). According to that policy:

Average mandatory emission standards of 190 g/km by 2015 and 155 g/km by 2024 would represent cuts of 14 per cent and 30 per cent on 2008 levels respectively. These targets will be the starting point for further consultation.

This will allow industry to plan vehicle production with certainty about the future direction of Australia’s emissions targets.

All of the benefits cited, such as reducing CO₂ emissions by 2.6 million tonnes per annum and fuel savings of around 1.1 billion litres of fuel worth $1.8 billion every year by 2024, are predicated on the emission standards enunciated by the Government during the election campaign.¹

**Department of Infrastructure and Transport Discussion Paper**

Table 4 of the Discussion Paper outlines a number of possible scenarios for a mandatory CO₂ emissions standard for light vehicles (Department of Infrastructure and Transport, 2011, p. 14). Aside from the indicative emissions standard announced in the Government’s election commitment provided by scenario 1, Holden is extremely concerned that the Discussion Paper canvasses a range of other scenarios (scenarios 2 to 6) which in every case seeks to increase the annual emissions reduction target beyond 2015. Despite assurances they do not represent a Government position, the presentation of a series of more stringent standards would appear to indicate a clear preference for a much tighter emissions standard than was previously announced.

From Holden’s perspective, there are a number of concerns with enacting a more stringent emissions standard than contained in the Government’s election commitment.

Holden hopes the development of scenarios 2 to 6 is not a reaction to criticism last year that the Government’s election commitment was not tough enough when compared with

¹ See Department of Infrastructure, Transport, Regional Development and Local Government & ACIL Tasman (2010).
mandatory CO₂ emissions reduction targets announced by the European Union.² Comparisons with the European Union are misleading and invalid for several reasons:

- The proposed Australian emissions standard covers light commercial vehicles (LCVs) which are covered by a separate standard altogether in the European Union.
- The European passenger vehicle fleet has a significantly higher proportion of diesels than the Australian passenger vehicle fleet.
- Unlike Europe, the Australian vehicle market has been dominated by large passenger cars and variants such as the Holden Commodore and has a high penetration of sport utility vehicles (SUVs) and LCVs. (Bracks, Harcourt, Upton, Webster, & Apple, 2008, p. 10).

Comparisons between Australia and the European Union need to take account of differences in both classification and consumer preferences which result from fuel prices, urban density and other factors.

An increase in the annual emissions reduction target will break the Government’s election commitment. Such a radical policy shift would cause enormous difficulties for the automotive industry where planning certainty is critical given the long development, investment and production cycles. The automotive industry is inherently more risky than other industries due to high levels of investment required and the long lead times from product commitment to launching into the market (Ernst & Young, 2008, p. 7). This has been recognised by the Government. According to the Prime Minister and the former Minister for Innovation, Industry, Science and Research (and now Minister for Manufacturing):

... the Government understands the need for certainty and the long lead times for investment in the highly competitive automotive industry. (Gillard & Carr, 2011)

According to the former Minister for Innovation, Industry, Science and Research (and now Minister for Manufacturing):

The Government is very aware of the need for investment certainty, especially given the long lead times for new model cycles. (Carr, 2011)

If implemented, the new scenarios presented by the Department of Infrastructure and Transport in its Discussion Paper would inject enormous disruption as well as uncertainty into Holden’s planning process that could have serious repercussions for future investment. Planning for Holden’s suite of new vehicle models is already well advanced leading up to 2020, and scenarios 2 to 6 will impose enormous technical challenges as well as compliance costs.

The development of a new vehicle model is a significant investment and can cost in the order of $1 billion. For instance, the development of the VE Commodore model line cost $1.2 billion. The adoption of new technology to reduce CO₂ emissions or improve fuel economy cannot be undertaken quickly without exposing automotive manufacturers to further significant cost as well as risk. According to the Committee on the Assessment of Technologies for Improving Light-Duty Vehicle Fuel Economy (2011, p. 109) convened by the National Research Council in the US:

The timing for introducing new fuel consumption technologies can significantly influence cost and risk. The maturity of a technology affects its cost and reliability.

² See Davies (2010)
Automobile companies have sophisticated product and process validation procedures that must be adhered to before products can be scaled up for mass production, or they expose themselves to large warranty or product liability concerns.\(^3\)

The Committee on the Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards (2002, p. 5) convened by the National Research Council in the US has warned that the introduction of new technology in vehicles in order to improve fuel economy takes a very long time:

Technology changes require very long lead times to be introduced into the manufacturers’ product lines. Any policy that is implemented too aggressively (that is, in too short a period of time) has the potential to adversely affect manufacturers, their suppliers, their employees, and consumers. Little can be done to improve the fuel economy of the new vehicle fleet for several years because production plans already are in place. The widespread penetration of even existing technologies will probably require 4 to 8 years. For emerging technologies that require additional research and development, this time lag can be considerably longer.

John German (2009, pp. 95-96), a senior fellow and program director for the International Council on Clean Transportation (ICCT), has warned of the business risks involved in increasing fuel economy standards:

Large annual increases in fuel economy require aggressive changes to every aspect of the vehicle. The industry does not have the resources to handle this level of change all at once. Even if it did, it would be too risky to implement the changes all at once.

...Aggressive fuel economy standards require a lot of choices be made in a short period of time. A company that rapidly implements advanced technologies and spreads them across its fleet is betting the choices are the right ones. If these choices turn out not to be optimal and other manufacturers develop solutions that work better at lower cost, the company could well be out of business.

According to John German (2009, p. 99):

... normal development and redesign cycles cannot handle annual fuel economy increases of more than 2 percent per year. This is supported by the rate of fuel economy increases in Japan and Europe.

Steven Plotkin (2009, p. 3850), of the Argonne National Laboratory at Washington DC, has provided the following views on an appropriate timeline for the introduction of stringent fuel economy standards:

...it appears that regulators should allow about 10-12 years for a standard with targets based on technology already introduced into the commercial marketplace, with more time allocated for rigorous targets requiring redesigns that might strongly test consumer preferences...

In scenarios 2 to 6, the Department of Infrastructure and Transport is suggesting an emissions reduction or fuel economy target of either of 4 or 5% per annum on average to

\(^3\) Italics in original.
apply from 2015 until 2020. Regulatory risk reflects the uncertainty behind new or changing regulation over time (Strauz, 2011, p. 740). Scenarios 2 to 6 entail enormous regulatory risk for Holden as well as other Australian automotive manufacturers and runs the very real danger of choking off future investment in the Australian automotive industry altogether.

Recommendations on the Target

Holden strongly supports the Government’s election commitment for the introduction of a CO₂ emissions standard with a fleet wide target of 190 grams of CO₂ per km for light vehicles in 2015, falling to 155 grams of CO₂ in 2024. Any attempt to set more ambitious emissions reduction targets would put in jeopardy the future of the Australian automotive industry.

- Holden recommends the adoption of a fleet wide target of 190 grams of CO₂ per km for light vehicles in 2015, falling to 155 grams of CO₂ per km in 2024.

The Future of Australian Manufacturing

The Australian automotive industry is one of the largest parts of the country’s manufacturing sector. Australia is one of only 13 countries with the capability of building a car from design through to production. In 2010, Australian automotive manufacturers produced around $6.2 billion worth of passenger motor vehicles with $473,103 worth of product generated by every employee working in the Australian automotive industry (Department of Innovation, Industry, Science and Research, 2011).

Any producer who sells their goods or services at a profit undeniably enjoys a competitive advantage with those customers who chose to buy from them instead of from their competitors (Coyne, 1986, p. 55). While a competitive advantage for a firm is vital to maintain immediate profitability, unless the firm can maintain its competitive advantage over some period it is unlikely to remain profitable and continue in business.

The ability to maintain a competitive advantage over time leads to the concept of sustainable competitive advantage. Professor Jay B. Barney of the Fisher College of Business at the Ohio State University has defined competitive advantage and sustainable competitive advantage in the following terms:

... a firm is said to have a competitive advantage when it is implementing a value creating strategy not simultaneously being implemented by any current or potential competitors. A firm is said to have a sustained competitive advantage when it is implementing a value creating strategy not simultaneously being implemented by any current or potential competitors and when these other firms are unable to duplicate the benefits of this strategy. (Barney, 1991, p. 102)

Australia has traditionally manufactured larger passenger motor vehicles such as the Holden Commodore. This is the segment of the passenger motor vehicle market in which Australia has developed a market niche.

However, Australian motor vehicle manufacturers are already facing serious challenges to remain competitive in the face of rising cost pressures resulting from rising raw material

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4 Regulatory risk has been defined as the possibility that an actor’s behaviour will be subject to state regulation and that out of compliance behaviour will result in negative consequences that impact the actor (Galt, 2007, p. 379).

5 Italics in original.
costs, rising transport costs, falling levels of financial support from the Government’s Automotive Transformation Scheme (ATS) and changes in consumer preferences towards smaller vehicles and sports utility vehicles.

The longer term movements in exchange rates also place additional challenges on local manufacturing. Previously, average exchange rates of $0.65 to the US dollar provided incentive for local sourcing of components and manufacture of vehicles. At rates approaching parity to the US dollar, importing from alternative overseas source plants becomes more cost competitive.

Additional cost pressures will be imposed by the Government’s carbon pricing mechanism from 1 July 2012. Cost pressures on the industry will be further exacerbated if the Government decides on a CO₂ emissions reduction target consistent with scenarios 2 to 6.

Not all types of vehicle present the same profit opportunity for local production. If the introduction of an emission standard forces the type of vehicle that can be produced in Australia, the Australian automotive industry will be put at significant risk and the emission standards need to be seen in the broader context of the future of Australian manufacturing.

There is currently a policy debate going on regarding the future of Australian manufacturing. In March 2011, the Australian Manufacturing Workers’ Union launched a national television and online advertising campaign on the future of Australian manufacturing. In late July, Shell announced the closure of the Clyde oil refinery in Sydney. In August, steel makers OneSteel and BlueScope Steel announced large job losses. At the Future Jobs Forum in October, the Prime Minister observed:

> There are pressures in manufacturing. The long-term trend in manufacturing has been one of decline in employment ... but we have seen some sharp changes in the last 12 months. Manufacturing employs around 950,000 Australians. We saw a net fall of more than 53,000 jobs in the year through to the September quarter. (Gillard, 2011)

More recently, the Prime Minister has acknowledged the rising level of community anxiety regarding the future of Australian manufacturing:

> ... many Australians are concerned about the future of manufacturing and we have been responding to that... (Gillard, 2011a)

In late October, the Prime Minister and the former Minister for Innovation, Industry, Science and Research (and now Minister for Manufacturing) announced the creation of a new high-level taskforce in order to map out a shared vision for the future of Australia’s manufacturing sector and to help strengthen local firms as they adapt to changes in the economy (Gillard & Carr, 2011a). The Chairman of Holden, Mr Mike Devereux, serves as a member of this taskforce.

**The Costs of an Aggressive CO₂ Emissions Standard**

Holden is deeply concerned that the Discussion Paper takes an unrealistic view on what is feasible in terms of CO₂ emission reductions and the associated cost implications:

> The international literature ... suggests a 30% reduction on the average current CO₂ emission levels should be achievable in most countries by 2020, using proven, cost-
effective and available technology and without any significant change in the model or fuel mix. (Department of Infrastructure and Transport, 2011, p. 10)

Holden would point out that some of the estimated fuel efficiency savings associated with the King report (2007) have already been incorporated in new Holden vehicles or are in the process of being incorporated into new Holden vehicles.

The US Environmental Protection Agency (US EPA) and the US National Highway Traffic Safety Administration (NHTSA) (2010, p. 3.1) has warned that:

Technology assumptions, i.e., assumptions about their availability, cost, effectiveness, and the rate at which they can be incorporated into new vehicles, are often very controversial as they have a significant impact on the levels of the standards. Agencies must, therefore, take great care in developing and justifying these assumptions.

Paul Portney, Ian Parry, Howard Gruenspecht, and Winston Harrington (2003, p. 209) from the Washington DC based think tank Resources for the Future have warned that engineering studies underestimate the costs arising from increasing fuel economy standards:

Engineering studies alone may give a very unreliable guide to the actual costs of mandated increases in fuel-economy. They may not capture many important costs of actually implementing a new technology, such as marketing, maintenance, consumer unfamiliarity, and retraining of mechanics.

In regard to the adoption of aggressive fuel economy targets, John German (2009, p. 99) has warned:

Technology cost estimates are usually applied without proper consideration of leadtime... More aggressive requirements require accelerated implementation of technology, with exponential increases in development costs, tooling costs, and risks of quality or safety problems. Certainly annual increases greater than 2 percent are feasible, but the rapid increases in cost and risk with larger annual fuel economy increases need to be assessed and balanced against the need of the nation to conserve energy and reduce greenhouse gas emissions.

In order to reduce CO₂ emissions, automotive manufacturers will inevitably face rising marginal costs of supply (Department of Infrastructure, Transport, Regional Development and Local Government & ACIL Tasman, 2010, p. 48). In other words, the technology used to implement further CO₂ emission reductions will become progressively more expensive. On the other hand, over time, manufacturers’ marginal cost schedules would gradually shift down as a result of research and development (R&D)⁶ and “learning by doing”⁷ activities, but manufacturers would still face rising marginal costs as they reduced emissions further at each point of time (Department of Infrastructure, Transport, Regional Development and

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⁶ Firms undertake innovation through R&D to improve their competitiveness. R&D can help a firm lower its costs of production and/or produce better products giving it a competitive advantage over its rivals in the market place.

⁷ It is generally accepted that labour learns through experience in the production process, thereby leading to higher productivity over time which has become known as learning by doing. It was first observed by aeronautical engineers that the number of labour-hours expended in the production of an airplane body without engines is a decreasing function of the total number of airframes of the same type previously produced, with the existence of similar types of learning curves observed in relation to other industries (Arrow, 1963).
Local Government & ACIL Tasman, 2010, p. 48). A critical issue is whether the rate at which manufacturers’ marginal cost schedules shift down offsets the effect of rising marginal costs of supply of CO₂ emissions reductions in response to the imposition and periodic tightening of CO₂ emissions standards.

In its consideration of this issue, the US EPA and the NHTSA (2010, p. 3.17) have made some aggressive assumptions regarding “learning by doing effects” that would more than offset the effects of rising marginal costs of supply of CO₂ emissions reductions in response to the imposition and periodic tightening of CO₂ emissions standards in the US:

The ‘learning curve’ or ‘experience curve’ describes the reduction in unit production costs as a function of accumulated production volume. In theory, the cost behaviour it describes applies to cumulative production volume measured at the level of an individual manufacturer, although it is often assumed — as both agencies have done in past regulatory analyses — to apply at the industry-wide level, particularly in industries that utilise many common technologies and component supply sources. Both agencies believe there are indeed many factors that cause costs to decrease over time. Research in the costs of manufacturing has consistently shown that, as manufacturers gain experience in production, they are able to apply innovations to simplify machining and assembly operations, use lower cost materials, and reduce the number or complexity of component parts. All of these factors allow manufacturers to lower the per-unit cost of production (i.e., the manufacturing learning curve).

The Committee on the Assessment of Technologies for Improving Light-Duty Vehicle Fuel Economy (2011, pp. 27-28) has criticised the approach taken by the US EPA and the NHTSA, observing there is no rigorous method for determining how much and how rapidly a technology’s costs can be reduced by learning by doing, and has suggested that learning curves should be applied cautiously and should reflect average rates of learning based on empirical evidence from the motor vehicle industry.

While unit costs associated with new technologies are likely to decline over time due to “learning effects”, the US EPA and the NHTSA may have been far too optimistic in applying cost reductions. In discussing the implications of a CO₂ emissions standard for the European Union, the Institute for European Environmental Policy (2007, p. 29) has concluded:

A further consideration for the development of any target value is that the trajectory towards an ambitious longer-term target may not be expected to be linear. Costs per g/km will increase supra-linearly and incremental reductions due to new technologies may be expected to diminish over time.

In other words, the rising marginal costs of supply of CO₂ emissions reductions in response to the imposition and periodic tightening of CO₂ emissions standards would outweigh the rate at which manufacturers’ marginal cost schedules shift down.

There is also the hidden opportunity cost of using emerging engine technologies to enhance fuel economy or CO₂ emissions reductions at the expense of competing vehicle attributes, such as horsepower or additional energy-using devices, that consumers may value more highly (Anderson, Parry, Sallee, & Fischer, 2011). This issue has been recognised in the previous assessment of a CO₂ emissions standard for Australia:

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8 Opportunity cost is the cost of any activity measured in terms of the best alternative foregone.
...if it was assumed that manufacturers sacrificed planned improvements in
performance and other features to reduce CO₂ emissions, the value of features
foregone by vehicle users would have to be treated as an opportunity cost of
standards. This cost should be added to the additional cost of vehicles associated with
allocation of the cheapest available technologies to improve fuel-economy and reduce
emissions. (Department of Infrastructure, Transport, Regional Development and Local

The US EPA and the NHTSA (2009, p. 4.2) have articulated this concern in the following terms:

An important concern is whether achieving the fuel economy improvements required
by alternative fuel economy or CO₂ emissions standards would require manufacturers
to compromise the performance, carrying capacity, safety, or comfort of their vehicle
models. If it did so, the resulting sacrifice in the value of these attributes to
consumers would represent an additional cost of achieving the required
improvements in fuel economy, and thus of manufacturers’ compliance with stricter
standards. Although the exact values that vehicle buyers attach to vehicle attributes
such as fuel economy, performance, passenger- and cargo-carrying capacity, and
other dimensions of vehicle utility are difficult to infer from their purchasing
decisions and vehicle prices, changing vehicle attributes can significantly affect the
overall utility that vehicles provide to their owners, and thus their value to potential
buyers.

It is noted that the Discussion Paper, in discussing a 30% improvement in fuel economy, has
sort to downplay the opportunity cost in the following terms:

The fuel efficiency improvements necessary to meet such standards can be generally
made without impinging on consumer preferences for vehicle attributes (such as
acceleration and safety features) in each main vehicle class. (Department of
Infrastructure and Transport, 2011, p. 12)

The US EPA and NHTSA (2009, p. 4.2) dealt with the opportunity cost problem by developing
cost estimates for fuel economy-improving technologies that included any additional
manufacturing costs that would be necessary to maintain the reference fleet levels of
performance, comfort, capacity, or safety of the vehicle model to which those technologies
were applied. The previous Australian assessment adopted a similar approach (Department
of Infrastructure, Transport, Regional Development and Local Government & ACIL Tasman,
2010, p. 47). However, Steven Plotkin (2009, p. 3844) of the Argonne National Laboratory at
Washington DC has warned of the problems with adopting this approach:

... the method treats the analysis as if it had only two variables, technology cost and
fuel savings. In this formulation, both the vehicle designer and purchaser are simply
deciding whether adding fuel economy technology to a vehicle is worth the cost in
fuel savings. In reality, however, all fuel-saving technologies are dual purpose – they
can be used to save fuel, or they can be used to gain something else – better
performance, larger size, more luxury, or even greater safety — without having to use
more fuel. Thus, an engine improvement that allows more power to be squeezed out
of an engine can lead to a more powerful vehicle without increasing engine size, or a
more fuel efficient vehicle with a smaller engine and the same power. Or the vehicle
designer can compromise and get some of each — more power and better fuel
economy, but less than the maximum possible for each... Vehicle purchasers attach
real value to the attributes that “compete” with greater fuel economy for the
benefits of efficiency technology. Consequently, asking them to forgo improvements
in these attributes in favour of higher fuel economy would not be “free” even though fuel savings may outweigh the technology costs.

The opportunity cost problem is real and cannot simply be assumed away.

**Attribute-Based Standard**

Holden supports the implementation of an attribute-based standard.

Holden agrees with the conclusion reached in the Discussion Paper that the international evidence appears to favour the development of “attribute” or “utility” based standards linked to a target based on the average emissions level of vehicles produced or sold in a given year (Department of Infrastructure and Transport, 2011, p. 19). The primary advantage with an attribute-based standard is that it allows the vehicle fleet to remain diverse in terms of shape, size, and functionality (German & Lutsey, 2011, p. 4). In other words, it will not unfairly discriminate against larger vehicles such as those manufactured by Holden.

On the other hand, Holden strongly opposes the implementation of a uniform fixed standard (UFT) that all vehicles must not exceed. This is on the basis that a UFT would unfairly discriminate against heavier and more fuel-intensive vehicles in favour of lighter and less fuel-intensive vehicles. According to the European Commission (2007, p. 37):

... the consequence of using a uniform target is that manufacturers of relatively smaller cars would find it substantially easier to comply with the future legislation than manufacturers of relatively bigger cars. Using a uniform target raises concerns as to the respect of the diversity of European car manufacturers and does not meet the requirement of competitive neutrality for the European car market, as it would penalise manufacturers of larger cars while not providing sufficient incentive for manufacturers of smaller cars to continue reducing their CO₂ emissions...

Holden concurs with the conclusions reached in the previous assessment of a CO₂ emissions standard for light vehicles:

The adoption of a UFT could also have severe ramifications for domestic vehicle manufacturers, which traditionally have specialised in production of passenger vehicles in large and medium passenger vehicle market segments ... The imposition of a UFT may adversely affect domestic vehicle manufacturers, even to the point of eliminating their competitive niche and threatening their existence. (Department of Infrastructure, Transport, Regional Development and Local Government & ACIL Tasman, 2010, pp. C.3-C.4)

An alternative to the UFT is using a uniform percentage increase (UPI) approach which works through requiring each vehicle manufacturer to achieve a fixed percentage improvement in fuel-economy from its fleet economy in a base year. According to the Committee on the Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards (2002, p. 93) in the US, the peer-reviewed literature on environmental economics has consistently opposed this form of regulation and has cited many drawbacks including:

- it is generally the most costly way to meet an environmental standard;
- it locks manufacturers into their relative positions, thus inhibiting competition;
- it rewards those who have been slow to comply with regulations;
- it punishes those manufacturers who have done the most to help reduce energy consumption by imposing a relatively higher burden; and
it seems to convey a moral lesson that it is better to lag than to lead.

Eliminating a UFT and UPI leaves open the option of choosing an attribute-based standard. There are essentially two main attribute-based standards in operation today: mass (or weight) and footprint\(^9\). Under an attribute-based standard, vehicles are indexed to either mass or footprint, setting less stringent targets for heavier or larger vehicles so as to reduce competitive impacts and promote efficiency improvements across the entire vehicle fleet (German & Lutsey, 2011, p. 2).

An attribute-based standard should maximize the range of strategies available to automotive manufacturers for deploying more efficient vehicles while indexing efficiency requirements to characteristics that best reflect the range of vehicle features — passenger capacity, cargo capability, etc. — a vehicle is designed for (German & Lutsey, 2011, p. 4). As the attribute of a vehicle class increases, the emissions or fuel economy requirements decrease, with the goal being to improve efficiency without compromising vehicle functionality (German & Lutsey, 2011, p. 4).

The advantage of using either mass or footprint is that they can both be measured and they both correlate substantially with CO\(_2\) emissions and fuel consumption (German & Lutsey, 2011, p. 4). However, it is the case that mass is much better correlated with CO\(_2\) emissions and fuel consumption than is footprint. It is this fact that renders mass as unsuitable for use as an attribute-based standard in the design of a CO\(_2\) emissions standard for Australia.

Emission standards should be technology neutral in that they do not require manufacturers to use specific technologies (German & Lutsey, 2011, p. 2). This has the advantage of ensuring that there is a full range of options available in order to reduce CO\(_2\) emissions (German & Lutsey, 2011, p. 2). The intent is to promote the full range of approaches to making vehicles more efficient — improved engine combustion, increased transmission efficiency, lightweighting, advanced drivetrains, etc. — and, indeed, to create incentives to come up with new solutions (German & Lutsey, 2011, p. 2).

The fundamental flaw with using mass as an attribute-based standard is that it actively discourages the use of lightweighting as an option for reducing emissions. Indeed, using mass as a standard may even create perverse incentives for automotive manufacturers to increase the mass of their vehicles in order to improve compliance. According to the Institute for European Environmental Policy (2007, p. 56):

> Vehicle weight is a strong determinant of a vehicle’s CO\(_2\) emissions and as such weight reduction is an important technical option for reducing CO\(_2\) emissions from passenger cars. Choosing weight as utility parameter thus reduces or even cancels the potential of weight reduction as an option for contributing towards meeting any utility-based limit or target. With weight as utility parameter, reducing the weight of a vehicle also leads to a lower CO\(_2\) limit value for that vehicle, thus reducing the incentive to cut weight.

The NHTSA (2006, p. 108) adopted the introduction of footprint as a standard for light trucks because it overcame the discouragement of lightweighting as an option to improve fuel efficiency:

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\(^9\) The vehicle footprint is a product of the average track width (the distance between the centreline of the tyres) and the wheelbase (the distance between the centres of the axles). (Department of Infrastructure, Transport, Regional Development and Local Government & ACIL Tasman, 2010, p. 17)
A footprint-based system does not encourage manufacturers to add weight to move vehicles to a higher footprint category. Nor would the system penalise manufacturers for making limited weight reductions. By using vehicle footprint in lieu of a weight-based metric, we are facilitating the use of promising lightweight materials that, although perhaps not cost-effective in mass production today, may ultimately achieve wider use in the fleet, become less expensive, and enhance both vehicle safety and fuel economy.

According to a recent paper from the ICCT:

... only size-based standards also fully encourage and capture lightweight technology deployment. Deploying technologies such as component-level lightweight material substitution (high-strength steel, aluminum, and composites) and using more comprehensive mass-optimized vehicle structural designs that integrate parts and employ more advanced lightweight bonding and forming techniques can reduce vehicle mass by up to 30% without any compromise in vehicle size or function... (German & Lutsey, 2011, p. 7)

Concern has been expressed that the use of mass as a standard could be subject to gaming.\textsuperscript{10} The NHTSA (2006, p. 104) has previously expressed concern that mass could be more easily tailored for the sole purpose of subjecting a vehicle to a less stringent target. Similarly, according to a recent report published by the ICCT:

Vehicle weight is not visible to the customer, does not create value for the customer, and therefore generally is not part of the purchase decision. Curb weight therefore is not a proxy for utility from a customer’s perspective. More importantly, this disinterest of consumers toward the weight of their vehicle allows for gaming: manufacturers can, at relatively low cost, increase the curb weight of a vehicle (within certain boundaries) without the customer noticing it, resulting in a higher target for this now heavier vehicle. (Mock, 2011, p. 14)\textsuperscript{11}

On the other hand, it has been recognised that it is much more difficult to game a footprint-based standard:

Using the “footprint” system as a basis for fuel efficiency regulation is believed to be more difficult for manufacturers to manipulate. The footprint of a car is largely driven by consumer preferences. Manufacturers report that consumers are very sensitive to the size of a car and that slight changes in truck size can have significant impacts on demand for a particular truck model. In addition, changing vehicle size is especially costly to manufacturers because it often requires significant changes to the weight and design of a vehicle. (Langton, 2006, p. 27)

... as it is difficult to increase track width much without changing overall width, and as increasing the wheelbase increases the turning radius and makes the vehicle more difficult to manoeuvre in urban settings, the potential for gaming is also sufficiently limited in a footprint-based emission target system. (Mock, 2011, p. 17)

\textsuperscript{10} Gaming is where manufacturers make changes to the characteristics of their vehicle for the purposes of meeting their targets while emissions stay constant or even increase (Mock, 2011, p. 1).

\textsuperscript{11} Curb weight is the total weight of a vehicle with standard equipment, all necessary operating consumables, a full tank of fuel, while not loaded with either passengers or cargo.
Even though the European Union adopted a mass-based standard, Malgorzata Golebiewska (2011) from the European Commission Directorate-General on Climate Action has acknowledged the shortcomings of using mass:

- easy to manipulate, e.g. increase to obtain a more lenient target; and
- in longer term may limit usage of light weight materials.

It would appear that a major contributing factor in the European Union decision to adopt a mass-based standard rather than a footprint-based standard had to do with a lack of data availability on vehicle footprint with the European Parliament recommending the adoption of a footprint-based CO\textsubscript{2} emissions standard in October 2007 (Commission of the European Communities, 2007, p. 8). However, the lack of footprint data is now being addressed in the European Union (Mock, 2011, p. 17).

Another advantage of a footprint attribute-based standard is there is evidence that size-based standards may reduce vehicle and pedestrian crash fatalities compared to mass-based standards (German & Lutsey, 2011, p. 10). According to the European Federation for Transport and Environment (EFTE) (2007, p. 4):

> It is obvious, though important, that policies designed to cut CO\textsubscript{2} emissions from cars should not compromise vehicle safety.

Weight-based CO\textsubscript{2} standards would do just that as they remove the incentive to car makers to reduce vehicle weight: lighter cars would get a tougher CO\textsubscript{2} standard. There is compelling evidence that heavier cars lead to more fatalities. Cars with a larger footprint do not. Studies have consistently shown up to four times higher levels of severe injury and death for pedestrians in collisions with SUVs. SUVs distinguish themselves from normal cars primarily through their additional weight and height – not their footprint.

A report by Dynamic Research Inc. (DRI), which formed an important basis for US regulation ... , showed that, if larger vehicles are safer for their occupants, it is not their weight but their size, more specifically their footprint, that makes them safer.\textsuperscript{12} The summary of this report even states that “weight reduction would be expected to decrease the overall number of fatalities” – in other words: heavier cars are more dangerous. So CO\textsubscript{2} standards that are easier on heavier cars can be expected to lead to more fatalities than CO\textsubscript{2} standards that are easier for cars with a larger footprint.

Steven Plotkin (2009, p. 3850) has summed up the benefits of using a footprint-based standard in the following terms:

> ... footprint is attractive as the basis of a standard because it preserves the incentive to reduce weight; it resists distortion- any tendency to increase either track width or wheelbase will be limited by the need to essentially redesign the vehicle (not the case with weight); and because increasing either of these dimensions would tend to be beneficial to vehicle safety. Wider track width will reduce a vehicle’s potential to roll over, and a longer wheelbase may provide more space for crash management and improve directional stability.

\textsuperscript{12} See Van Auken & Zellner (2004)
John German (2009a) of the ICCT has recommended that footprint should be used as the template for any future attribute-based system. According to EFTE (2007, p. 7), footprint does not have the drawbacks of weight and is therefore strongly preferable.

According to the Committee on the Assessment of Technologies for Improving Light-Duty Vehicle Fuel Economy (2011, p. 116), reductions of mass offer the greatest potential to reduce vehicle fuel consumption. On this basis, it would be counter-productive to use an attribute-based standard that discourages reductions in mass.

The balance of expert opinion favours the adoption of footprint over mass for an attribute-based standard. There are clear benefits for using footprint as it does not discourage the use of lightweighting, it is less easy to manipulate than mass, and has safety benefits. Consistent with expert opinion, Holden strongly supports the use of footprint for an attribute-based standard and strongly opposes the use of mass.

- Holden recommends the adoption of an attribute-based standard.
- Holden recommends the adoption of a footprint-based standard as it does not discourage the use of lightweighting, it is less easy to manipulate than mass, and has safety benefits.
- Holden recommends the rejection of a mass-based standard.

**Flexibility Mechanisms**

While it may have been an oversight, Holden is concerned that the Discussion Paper did not explicitly refer to an emissions standard that allowed for fleet averaging. Fleet averaging enables automotive manufacturers to average their CO₂ emissions across their entire fleet rather than having to meet a target in relation to each specific model. Pooling is where manufacturers belonging to the same group do the same as fleet averaging across the entire group.

The main benefit arising from fleet averaging and pooling is that it allows automotive manufacturers to choose for themselves as to how best to comply with emissions reduction targets. According to the European Commission (2007, p. 38):

> Applying the target to manufacturers’ average fleet rather than individual vehicles would allow manufacturers to decide for themselves how and in which segments to reduce their average emissions. Reduction of average emissions may be achieved by reducing the emissions of the models where such reductions cost the least although manufacturers are also likely to take portfolio and market considerations into account.

Holden strongly supports fleet averaging and pooling for emissions reduction targets and would be extremely concerned if such flexibility mechanisms were denied to automotive manufacturers in an attribute-based standard as it offers the opportunity for the lowest cost reduction of CO₂ emissions.

Further options to lower the compliance cost of an emissions reduction target include:

- banking whereby a manufacturer banks a credit for overachievement in order to use at some future point in time; and
- borrowing whereby a manufacturer borrows a credit now that will be paid back in the future through overachievement.
Net banking is likely to occur when the future price of CO\(_2\) abatement is expected to be higher than the current price of abatement. On the other hand, net borrowing is likely to occur when the current price of CO\(_2\) abatement is expected to be higher than the future price of CO\(_2\) abatement. Banking and borrowing are both measures designed to provide intertemporal flexibility.\(^{13}\) The White Paper on the former Carbon Pollution Reduction Scheme identified the following benefits associated with intertemporal flexibility:

> In general, intertemporal flexibility will improve allocative efficiency by allowing abatement to occur at the time that imposes the lowest relative cost on the economy. It will also have the effect of smoothing prices over time. (Australian Government, 2008, p. 8.9)


Holden strongly supports the adoption of additional flexibility mechanisms and is extremely disappointed that the Discussion Paper has sort to downplay the possibility of providing additional flexibility mechanisms on the basis of administrative complexity in that it is not possible to provide a system of credit banking in a scheme that does not set annual targets (Department of Infrastructure and Transport, 2011, p. 24).

- **Holden recommends that fleet averaging and pooling should be part of any CO\(_2\) emissions standard in order to minimise compliance costs.**
- **To further reduce compliance costs, Holden recommends that a CO\(_2\) emissions standard should also incorporate banking and borrowing.**

**Credit Mechanisms**

The Department of Infrastructure and Transport (2011, p. 14) has justified increasing emissions reduction targets to 4 or 5% per annum under scenarios 2 to 6 on the basis that these rates are consistent with the range of rates of improvement being applied in both the United States and the European Union. However, in this regard it needs to be highlighted that both the United States and European Union schemes offer a number of emissions credits for improved environmental performance in a number of areas that is not part of any current Australian proposal. While the Discussion Paper on the one hand appears supportive of emission reduction targets set along the lines of the United States and the European Union, on the other hand it appears dismissive of the credit arrangements also applying in those jurisdictions:

> Such credit arrangements need to be treated with caution as their merits can in some cases be difficult to quantify accurately (particularly where the claimed benefits are based on estimates of life cycle emissions). Their inclusion is also inconsistent with the general principle of a performance based standard (where every gram of CO\(_2\) saved is treated equally, regardless of the technology). (Department of Infrastructure and Transport, 2011, p. 17)

Holden believes the credits provided under the United States and European Union schemes are an integral part of the arrangements that cannot be so easily dismissed.

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\(^{13}\) Intertemporal flexibility refers to the extent to which liable entities can shift the timing of their emissions and abatement activities to reduce their costs (Australian Government, 2008, p. 8.9).
In the United States, automotive manufacturers are able to earn credits toward the fleet-wide average CO\textsubscript{2} standards applying from 2012 to 2016 for taking the following actions:

- The introduction of Flex Fuel Vehicles and Alternative Fuel Vehicles (US Environmental Protection Agency & National Highway Traffic Safety Administration, 2010a, p. 6).\textsuperscript{14}
- The introduction of advanced technology to encourage the early commercialisation of advanced fuel economy control technologies, such as electric vehicles, plug-in hybrid electric vehicles, and fuel cell vehicles (US Environmental Protection Agency & National Highway Traffic Safety Administration, 2010a, p. 7).
- The introduction of new and innovative technologies that reduce CO\textsubscript{2} emissions, but whose CO\textsubscript{2} reducing benefits are not captured during vehicle testing (US Environmental Protection Agency & National Highway Traffic Safety Administration, 2010a, pp. 7-8).
- Improvements for air conditioning systems such as reducing both hydrofluorocarbon (HFC) refrigerant losses (i.e. system leakage) and indirect CO\textsubscript{2} emissions related to the increased load on the engine (US Environmental Protection Agency & National Highway Traffic Safety Administration, 2010a, p. 5). Included in the credits for reducing refrigerant losses are substantial credits for the use of alternative refrigerants with lower CO\textsubscript{2} equivalent potential. Earning these credits is conditional on improvements in air conditioning performance in regard to refrigerant losses and efficiency.

In fleet-wide average CO\textsubscript{2} standards applying from 2017 to 2025, incentive programs to encourage early adoption and introduction into the marketplace of advanced technologies that represent “game changing” performance improvements are being considered, including the provision of incentives for electric vehicles, plug-in hybrid electric vehicles, and fuel cell vehicles (US Environmental Protection Agency & National Highway Traffic Safety Administration, 2011, p. 2).

In the European Union, automotive manufacturers will receive credits for vehicles that can run on E85 provided there is a certain percentage of service stations able to supply E85 (Commission of the European Communities, 2011a).\textsuperscript{15} Further, automotive manufacturers will receive super-credits for producing cars with extremely low emissions (below 50 grams of CO\textsubscript{2} per km) in the first few years of the scheme (Commission of the European Communities, 2011a).

In addition, automotive manufacturers will receive credits for CO\textsubscript{2} savings achieved by fitting new cars with approved “eco-innovations” which reduce emissions (Commission of the European Communities, 2011). A technology can qualify as an eco-innovation if it is new to the market, contributes to significant CO\textsubscript{2} savings and is not otherwise taken into account in determining the level of CO\textsubscript{2} emissions from vehicles (Commission of the European Communities, 2011).

Holden strongly supports the provision of a CO\textsubscript{2} credit for vehicles that can run on E85.

Holden has introduced the Flexfuel VE Series II Commodore, the first Australian-made car capable of running on high-blend ethanol fuel. The new 3.0, 3.6 litre V6 and V8 Commodore

\textsuperscript{14} Flex Fuel Vehicles are those that can run on either petrol or a mixture of 85% ethanol and 15% petrol. Dedicated alternative fuel vehicles can run exclusively on an alternative fuel. (US Environmental Protection Agency & National Highway Traffic Safety Administration, 2010a, p. 6)

\textsuperscript{15} E85 is a blended fuel containing 85% ethanol and 15% petrol.
models all have flex-fuel capability, which will help build the market for E85 fuel. Through our partnership with Caltex, E85 is now available at 40 metro service stations by the end of 2011.

We have also announced the formation of Flex Ethanol Australia – a new company that will investigate the feasibility of creating ethanol from household rubbish in Australia. Earmarked for Victoria, this plant aims to turn approximately one million tonnes of agricultural waste and household rubbish into more than 200 million litres of ethanol every year.

Ethanol is a biofuel which in Australia is produced from either sugarcane or wheat feedstocks. Holden’s analysis shows that E85 reduces CO₂ emissions by 20-40% compared to driving with petrol. Future production processes could potentially reduce the CO₂ emissions of E85 by up to 90%, compared to petrol.

Demand for ethanol as a replacement for oil-based fuels is increasing rapidly and being encouraged in a number of countries through a range of government policies (ABARES, 2011, p. 47). These policies are being driven by concern over climate change and the need to reduce greenhouse gas emissions. According to International Energy Agency (IEA) (2011, pp. 10-11), more than 50 countries have adopted blending targets or mandates for biofuels, including the United States and the European Union.

Already there are a number of government initiatives in Australia to promote the use of ethanol as a transport fuel. In September this year the New South Wales Government announced that it was raising its ethanol mandate for petrol to 6% by total volume sold from 1 November 2011 (Hartcher, 2011). In May this year the Australian Government announced that it was effectively exempting domestically produced ethanol from fuel excise. According to the former Assistant Treasurer (and now Minister for Employment and Workplace Relations):

This bill also includes a commitment that renewable fuels (ethanol, methanol and biodiesel) do not pay effective excise. This commitment reflects discussions with our crossbench colleagues and industry on these longstanding reforms. It will mean that these renewable fuels will play an important part in Australia’s transition to a low-carbon economy and future energy security. (Shorten, 2011, p. 3805)

To withhold encouragement for the domestic production of ethanol by not providing a CO₂ emissions credit for a vehicles that can operate on E85 would be incompatible with other government policies that seek to encourage the uptake of biofuels.

Through falling CO₂ emissions from electricity generators, electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs) will provide a further opportunity for significant reductions in CO₂ emissions. Holden intends to introduce an extended-range EV vehicle in 2012 – the Volt. The Volt has a total driving range of about 550 kilometres depending on driving style and conditions.

The IEA (2011a, p. 1) has warned that the time for action to encourage the take-up of electric vehicles is now:

... the next decade is a key “make or break” period for EVs and PHEVs: governments, the automobile industry, electric utilities and other stakeholders must work together to roll out vehicles and infrastructure in a coordinated fashion, and ensure that the rapidly growing consumer market is ready to purchase them.
In regard to policy action, the IEA (2011a, p. 35) suggests that governments need to do the following:

A comprehensive policy framework should be established through 2020 in order to give stakeholders a clear view of the road ahead, enable early decisions to be made, and reduce investment risks. Governments need to establish a consistent and dependable incentive framework to support the implementation of electric-drive vehicles... Overall policy goals should be established (e.g., energy security, low CO$_2$ emissions) with appropriate incentives so manufacturers can tailor their production to achieve these policy goals.

Among the policies the IEA (2011a, p. 37) suggests could play a role in incentivising electric-drive vehicles are “[a]dditional credits under regulatory systems (e.g., in EU vehicle CO$_2$ regulations, EVs/PHEVs are considered zero emissions, so automakers get an advantage for producing them; similar credits exist in the US Corporate Average Fuel Economy (CAFE) law)”.

Holden strongly supports the provision of credits for the uptake of emissions reducing technology such as EVs and PHEVs. Motor vehicle air conditioners use hydrofluorocarbons (HFCs) for refrigerants which are greenhouse gases. One kilogram of the most common refrigerant used today in vehicle air conditioners, R-134a, is equivalent 1,300 kilograms of CO$_2$. The replacement of R-134a with another refrigerant, such as HFO-1234yf, would dramatically cut CO$_2$ equivalent emissions. The CO$_2$-equivalent of 1 kilogram of HFO-1234yf is only 4 kilograms. The replacement of R-134a with HFO-1234yf would dramatically reduce CO$_2$ equivalent emissions. However, changing refrigerants is not an easy process, as automotive manufacturers must change the design of refrigeration systems and the vehicles, as well as train service technicians in the new systems (Minjares, 2011, p. 4). As in the United States, Holden believes the Australian Government should facilitate the transition to lower greenhouse gas emitting refrigerants in vehicle air conditioners through the provision of credits.

Holden understands that the Federal Chamber of Automotive Industries (FCAI) will be recommending the adoption of a number of credit mechanisms and strongly endorses these proposals.

- Holden recommends the adoption of credit mechanisms to encourage the uptake of CO$_2$ emissions reduction technology.
- Holden recommends the adoption of credits for vehicles that can run on E85 and for EVs and PHEVs consistent with best international practice.
- Holden recommends the provision of credits for the use of lower greenhouse gas emitting refrigerants in vehicle air conditioners.
- Holden supports the adoption of the FCAI recommendation on the provision of credit mechanisms.

**Conclusions**

Holden supports the introduction of a CO$_2$ emissions standard for light vehicles and the Government’s election commitment of 24 July 2010, for the average mandatory emission standards of 190 g/km by 2015 and 155 g/km by 2024.

However, Holden is extremely concerned that the Discussion Paper canvasses a range of other scenarios (scenarios 2 to 6) which seek to increase the annual emissions reduction target beyond 2015. This would appear to indicate a clear preference for more aggressive emissions standard than was previously announced by the Government in the 2010 election
campaign. There are a number of concerns with enacting a more aggressive emissions standard than contained in the Government’s election commitment.

Increasing the emissions reduction target represents a radical policy shift and would cause enormous difficulties for the automotive industry where planning certainty is critical given the long development, investment and production cycles. The new scenarios will inject enormous disruption as well as uncertainty into Holden’s planning process that could have serious repercussions for future investment. Holden’s suite of new vehicle models are already well advanced up to 2020, and scenarios 2 to 6 will impose enormous technical challenges as well as compliance costs.

The forced adoption of new technology to reduce CO\textsubscript{2} emissions or improve fuel economy will expose automotive manufacturers to significant cost as well as risk. Scenarios 2 to 6 entail enormous regulatory risk for Holden as well as other Australian automotive manufacturers and may significantly limit or prevent future investment in the Australian automotive industry.

Holden strongly supports the Government’s election commitment for the introduction of a CO\textsubscript{2} emissions standard with a fleet wide target of 190 grams of CO\textsubscript{2} per km for light vehicles in 2015, falling to 155 grams of CO\textsubscript{2} in 2024.

An aggressive CO\textsubscript{2} emissions reduction target will impose significant costs on Australian automotive manufacturers. The rising marginal costs of supply of CO\textsubscript{2} emissions reductions in response to the imposition and periodic tightening of CO\textsubscript{2} emissions standards would outweigh the rate at which manufacturers’ marginal cost schedules shift down. Furthermore, there is also the hidden opportunity cost of using emerging engine technologies to enhance fuel economy or CO\textsubscript{2} emissions reductions at the expense of competing vehicle attributes that needs to be considered. This opportunity cost cannot be simply assumed away.

Holden supports the implementation of an attribute-based standard. The fundamental flaw with using mass as an attribute-based standard is that it actively discourages the use of lightweighting as an option for reducing emissions and may even create perverse incentives for automotive manufacturers to increase the mass of their vehicles in order to improve compliance. On the other hand, footprint encourages the use of lightweighting, it is less easy to manipulate than mass, and has safety benefits. Holden strongly supports the use of footprint for an attribute-based standard and strongly opposes the use of mass.

There are clear benefits from fleet averaging and pooling in that it allows automotive manufacturers to choose for themselves as to how best to comply with emissions reduction targets. Holden strongly supports fleet averaging and pooling for emissions reduction targets and would be extremely concerned if such flexibility mechanisms were denied to automotive manufacturers in an attribute-based standard as it offers the opportunity for the lowest cost reduction of CO\textsubscript{2} emissions.

Additional flexibility mechanisms, such as banking and borrowing will assist automotive manufacturers in minimising the compliance cost of a CO\textsubscript{2} emissions standard. Holden strongly supports the adoption of additional flexibility mechanisms and is extremely disappointed that the Discussion Paper has sort to downplay the possibility of providing additional flexibility mechanisms on the basis of administrative complexity.

Holden strongly supports the adoption of credit mechanisms to encourage the uptake of CO\textsubscript{2} emissions reduction technology. To withhold encouragement for the domestic production of
ethanol by not providing a CO₂ emissions credit for vehicles that can operate on E85 would be incompatible with other government policies that seek to encourage the uptake of biofuels and international best practice. The provision of credits for the uptake of emissions reducing technology such as EVs and PHEVs is consistent with best international practice as well as the policy advice of the IEA.

Finally, Holden believes the Australian Government should facilitate the transition to lower greenhouse gas emitting refrigerants in vehicle air conditioners through the provision of credits. Holden also strongly endorses the recommendation made by the FCAI on the provision of credit mechanisms.

Holden wishes to thank the Department of Infrastructure and Transport for the opportunity to provide a submission in response to its Discussion Paper and would welcome the opportunity to meet and discuss these matters in more detail.

Yours sincerely

Richard Marshall  
Director – Energy, Environment & Technology

Samantha Read  
Executive Director – Corporate Affairs
Bibliography


