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Environmental credentials of the Australian trucking industry

Prepared for

Australian Trucking Association

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Executive Summary

Life cycle assessments of the environmental impact of a truck indicate that the greatest environmental impacts are caused by firstly, fuel production (through fuel sourcing and production) and secondly, truck exhausts (Volvo Group, 2010). In order of scale, life cycle assessments have allocated environmental impacts to:

- 12 per cent materials and production;
- 58 per cent fuel (resource and production);
- 30 per cent exhausting emissions including CO_2;
- 5 per cent maintenance; and
- -5 per cent end of life (such as recycling through disposal).

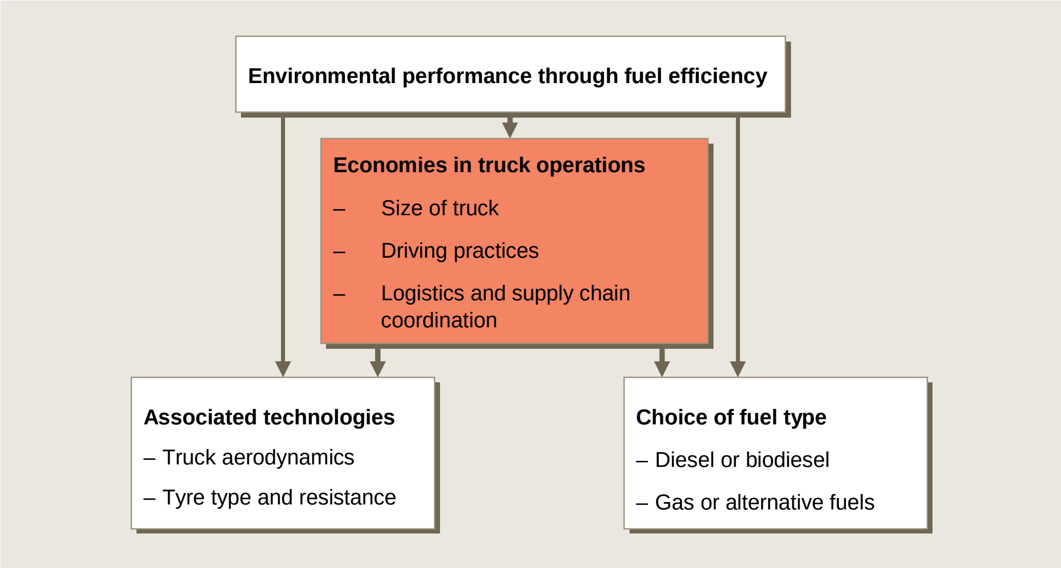
Ultimately, it is fuel use that generates the greatest environmental impacts through firstly, resource development and production and then, exhaust emissions from the burning of fuel. Therefore, when considering the environmental credentials of the trucking industry, improvements in fuel efficiency and changes in fuel mix are likely to be at the forefront of the analysis. Chart 1 identifies the main methods through which the environmental credentials of the trucking industry may be affected:

1. economies in operations —using economies of scale to move the freight task with improved fuel efficiency, less empty running and improved driving practices;
2. associated technologies — improving the performance of the existing fleet through aerodynamics and tyre technologies for example;
3. using the fuel choice — directly affecting environmental emissions through altered fuel type.

Through observing the progress of the trucking industry, both in Australia and internationally over the past 20 years, some of the largest gains to environmental performance have been achieved through the use of larger and more fuel efficient truck combinations. These economies in operation have had a significant effect on both the environmental performance of the industry as well as overall productivity.

This link between improved productivity and environmental performance is an important one in considering the future performance of the trucking industry. That is, the strong commercial incentive to improve productivity will be focussed on the major cost centres of fuel, tyres and labour. Where there are commercial incentives driving continual improvements in these cost centres, environmental efficiency is also targeted. With fuel use one of the major environmental issues associated with

1 **Trucks and the environment**



Data source: TheCIE.

road freight, as well as one of the largest cost factors, the industry has a commercial incentive, as well as a social responsibility incentive, to improve environmental performance.

Over the past 20 years, there has been a significant improvement in the rate of emissions in the road freight task. From 1990-2011, emissions of carbon dioxide equivalent (CO_2-e) across the entire fuel cycle have reduced by 35 per cent per billion tonne kilometre for rigid and articulated combinations. A further reduction of 10 per cent is projected by the Bureau of Infrastructure, Transport and Regional Economics (BITRE) to 2030 (BITRE, 2009a) from 2011 to 2020.

This striking improvement in emission performance has been achieved through a period of significant productivity growth. This growth, in turn, has been predominantly driven by the introduction and increased use of larger truck combinations such as B-doubles. Given the same engine technology (that is, no new or significantly more advanced engine designs across the trucks) a 19m B-double configuration will emit 23 per cent less greenhouse gases than a three-axle rigid truck and 11 per cent less than a six axle semitrailer configuration with road friendly suspension (ATA and Barkwood Consulting, 2010).

Following this period of strong improvement in environmental performance and productivity, the commercial incentives to promote environmental performance through fuel efficiency still remain. Therefore, the ability of the trucking industry to continue this improvement is likely to be either facilitated or impeded by two main factors — regulation and technology.

Where access regulations are the dominant pressure constraining the movement to larger truck combinations, there is a trade-off being made in terms of environmental performance and productivity growth of the trucking industry against other social and economic factors such as reported concerns around safety and road maintenance.

The benefits of expanded access to larger vehicles have been considered carefully in recent years. When analysing the potential contribution of larger truck combinations to environmental performance, the National Transport Commission (NTC, 2007) has estimated that B-triples could replace a fleet of 60 B-doubles and semitrailers and result in reductions in:

- the number of trips required by 25 per cent; and
- the number of truck kilometres travelled by 3.7million kilometres.

Such a move could save up to 2 million litres of fuel and 5 900 tonnes of CO_2-e (ATA, 2010).

Where the majority of road wear is generated through trip numbers (with a smaller proportion of road wear based on tonnage) such a move to larger configurations also has the potential to reduce, or redistribute, road maintenance costs.

Regulatory progress is being made, albeit slowly, to further expand road access for larger configurations. The performance based standards (PBS) system was introduced in 2007 with the goal of removing prescriptive regulations on mass and dimension limits for trucks and allow for innovative engineering solutions to balance issues of economies of scale, road wear, safety and congestion. As it is currently envisaged, the PBS could potentially affect up to 20 per cent of the Australian freight task (BITRE, 2011) increasing the use of higher productivity vehicles.

However, the development of the PBS has not been immediate with both the trucking industry and governments having to track along a steep learning curve with respect to decision making regimes, infrastructure capability and technical developments. In the meantime, performance based technologies are being developed at a truck level to improve the efficiency and environmental performance of the existing allowable fleet (for example, semitrailers and B-doubles). Improving the operational efficiency of the fleet is predominantly a technical issue but it does also include some regulatory elements — for example, where technical advances breach regulatory guidelines in terms of dimension limits.

The development of truck technologies has been driven from two angles, firstly from government regulations and secondly from drives to improve fleet productivity. Australia has experienced a rapid increase in direct emissions regulations for diesel engines in recent years. Newly manufactured heavy diesel engines now meet some of the strictest environmental standards in the world. While this push has been partially initiated by governments, it should be noted that it is also a factor of the source of most diesel engines in Australia. Where trucks are manufactured in Australia, all engines are imported and as such, the manufacturers are already meeting strict European, American and Japanese standards.

The second angle driving technology improvements is a move for both improved productivity and environmental performance. Technologies that are targeting fuel efficiency and tyre life span, as well as considerations of fleet configuration and logistics organisation are taking a leading position in industry development.

Through taking advantage of economies of scale, development of new technologies and trialling of alternative fuel types, the trucking industry has shown its ability to respond to incentives to improve fuel efficiency over the past 20 years. The majority of improvement in the environmental performance of the trucking industry since 1990 has been achieved through industry initiatives targeting fuel efficiency. Therefore, when considering future government policy initiatives to further promote fuel efficiency and environmental performance, such as a carbon price, there is already a strong industry base for innovation and implementation.

In terms of current climate change policy, should a decision be made to limit the amount of carbon produced in the economy, the introduction of a broad based carbon price is considered to be the most effective and efficient method of promoting both fuel efficiency and environmental performance in the transport industry. Should fuel be excluded from a carbon pricing scheme, there is a risk that governments may directly regulate transport emissions through standards and efficiency requirements. Direct regulation of transport sector emissions through standards and efficiency requirements run the risk of the transport sector paying a higher effective carbon tax than other sectors — an outcome which is economically inefficient.

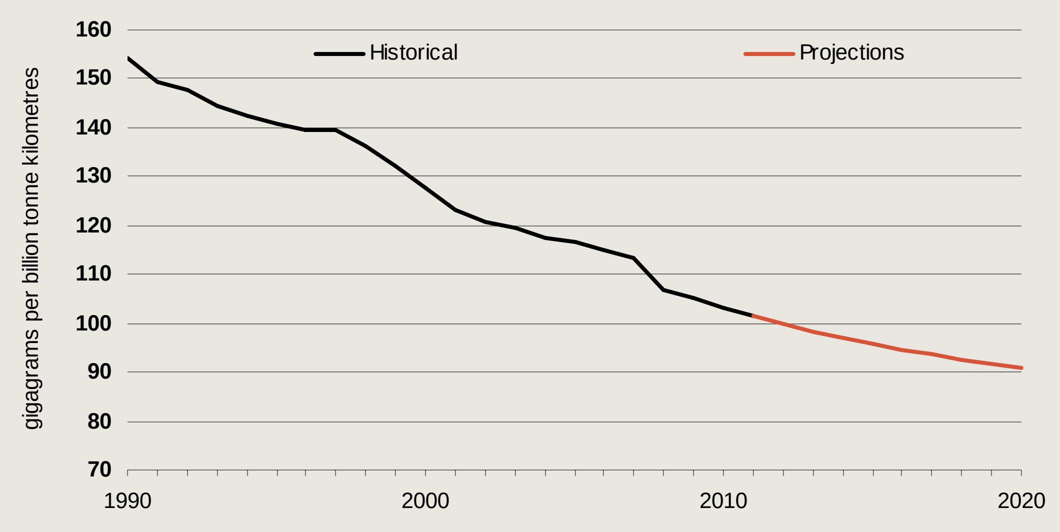
1 Contemporary trucking in Australia

Australia's vast distances and sparsely populated landscape ensures that the freight sector is important to overall economic growth. Since 1990, the Australian road freight task has increased from 91 billion tonne kilometres to almost 210 billion tonne kilometres in 2010, an average of 4.5 per cent growth annually. This trend is only set to continue, with projections from the Bureau of Infrastructure, Transport and Regional Economics (BITRE) estimating that the Australian road freight task could grow at approximately 3.5 per cent annually, reaching almost 300 billion tonne kilometres by 2020 (BITRE, 2011).

Environmental performance of the fleet

Over the 20 years to 2011, the Australian trucking industry has achieved a 35 per cent reduction in emissions per billion tonne kilometres for the combined rigid and articulated fleet. This reduction, illustrated in chart 1.1, has been achieved across the full fuel cycle which includes upstream emissions from extraction and processing of fuel through to engine emissions (BITRE, 2009a). Looking forward, the BITRE projects that a further 10 per cent reduction in emissions over the period 2011–10.

1.1 **Gigagrams of CO_2 equivalent per billion tonne kilometre**



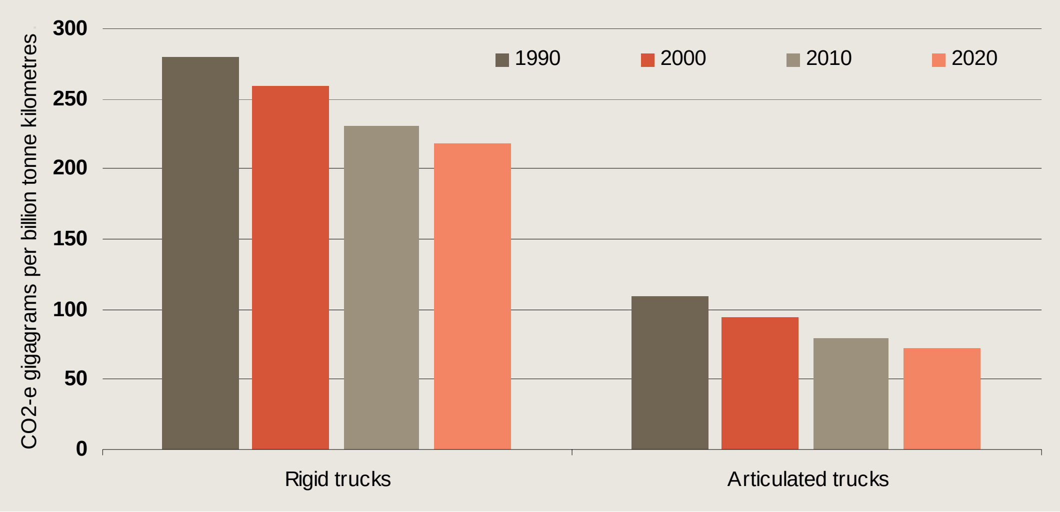
[a] Includes rigid and articulated trucks only.

Data source: BITRE estimates and CIE calculations, estimates based on full fuel cycle emissions.

This continuing progress in reduced emissions per tonne kilometre will become increasingly important as the Australian freight task grows over the coming years. As demand for road freight continues to grow, the effect on total emissions from the industry will be heavily reliant on improved efficiency to manage environmental impacts. Indeed, over the period 1990–2011 the freight task for rigid and articulated trucks increased by 140 per cent, but the total fuel cycle emissions from rigid and articulated combinations increased by only 65 per cent (BITRE, 2009a). This difference in the growth rate of emissions compared to the freight task was achieved through improvements in the environmental performance of the road freight fleet — that is, a 35 per cent reduction in emissions per tonne kilometre.

According to BITRE estimates, across the full fuel cycle, articulated trucks in Australia currently emit approximately 74 gigagrams of carbon dioxide equivalent per billion tonne kilometres. As can be seen in chart 1.2, this is a third of the emissions that smaller rigid trucks emit, at 218 gigagrams per billion tonne kilometres (BITRE, 2011). The striking difference is driven by the greater number of trips required by a small rigid truck to move the same amount of freight as a larger articulated truck.

1.2 **Comparison of rigid and articulated combinations over time**



Data source: BITRE estimates and CiE calculations.

The progress of articulated trucks in terms of carbon dioxide (CO_2) emissions can be tracked over the past 20 years, where in 1990 it was estimated that articulated trucks emitted approximately 108 gigagrams of carbon dioxide equivalent per billion tonne kilometres. On average, an articulated truck in 2011 performs 33 per cent better than 20 years ago.

Where the move from rigid to articulated vehicles provides significant progress in terms of emissions, this progress is achieved through economies of scale and fuel efficiency, derived from using large sized trucks. Apart from engine size and capacity, there is no fundamental change in technology required in moving from a diesel engine in a rigid truck to a diesel engine in an articulated truck.

The same economies of scale also hide important differences across the articulated truck fleet in Australia. Significant improvements in emissions profiles of articulated trucks are being achieved through technological advances as well as a change in the make up of the fleet, increasing reliance on larger sized articulated trucks, which have lower emission profiles than articulated semitrailers.

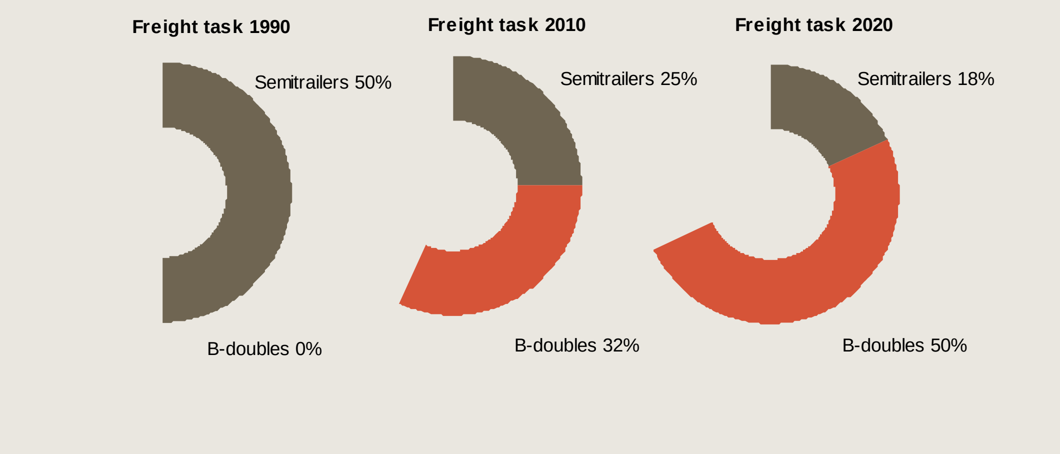
Road freight fleet characteristics

Over the past 20 years, there has been a significant change in the composition of the articulated fleet. Articulated trucks have steadily taken a greater proportion of the freight task (at the expense of smaller rigid trucks) and in turn larger articulated trucks have taken a greater responsibility at the expense of smaller semitrailer (six axle combinations). Chart 1.3 illustrates the change in shares of road freight across semitrailers and B-doubles from 1990 through to expectations for 2020.

In 1990, semitrailers accounted for 50 per cent of the national road freight task, with no B-double configurations in use. At this time, the remaining freight task was taken up by rigid trucks and smaller (less than six axles) articulated trucks. Since access for B-double combinations started in the early 1990s their share of the freight task has steadily increased. By 2010 they accounted for approximately 33 per cent of the freight task, with semitrailers only accounting for 25 per cent.

The dominance of B-double combinations is expected to grow, with B-doubles expected to account for 50 per cent of the road freight task by 2020. This trend indicates a continuing move of improved environmental performance and productivity in the trucking industry, with a move towards more efficient, larger truck combinations.

1.3 **Allocation of freight task to semitrailers and B-doubles over time**



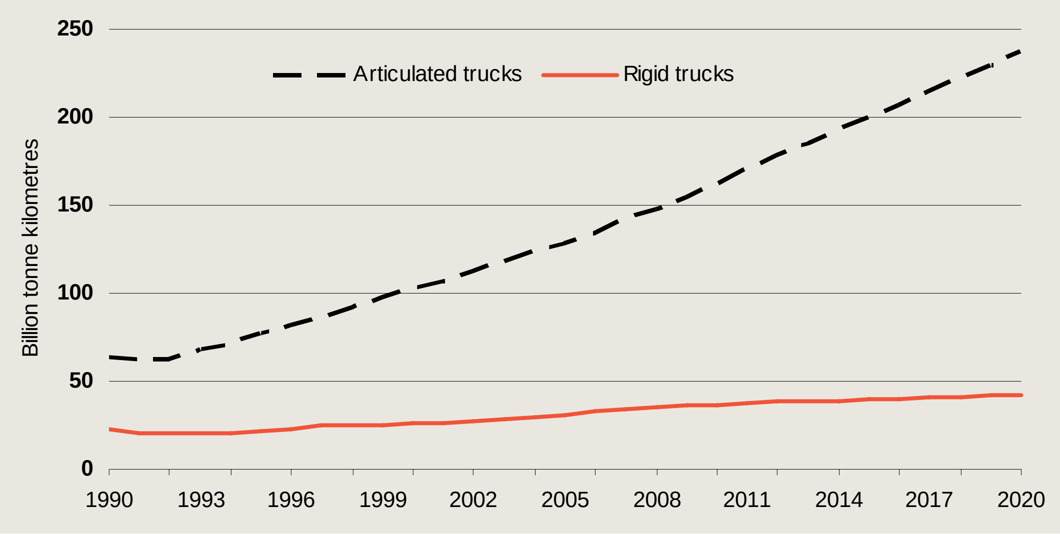
Data source: BITRE (2011) Truck productivity: sources, trends and future prospects.

In 2006, Australia had a total of 69 600 articulated trucks, of which 11 400 were B-doubles — with 58 200 semitrailers or smaller five axle articulated trucks (OECD, 2011). These B-doubles were one of the key factors involved in improving the productivity of the Australian road freight industry since their introduction to Australian roads. Based on these 2006 figures, had the 11 400 B-doubles not have been allowed on the roads, an additional 18 100 articulated trucks would have been required to meet the road freight task — a 26 per cent increase in the number of articulated trucks on Australian roads.

These figures have been confirmed by the Victorian Department of Transport in a 2008 report that estimated the movement towards B-doubles had reduced the total fuel consumption of the articulated truck fleet by approximately 11 per cent (Victorian Department of Transport, 2008).

The industry will continue to take advantage of both the environmental benefits and productivity gains associated with larger, articulated trucks. As illustrated in chart 1.4, the majority of growth in the road freight task in the coming year is expected to be taken up by articulated trucks. Based on BITRE status quo modelling assumptions there is expected to be a shift away from rigid trucks which currently account for 18 per cent of the freight task to articulated truck which will increase their share of the freight task from 78 per cent to 81 per cent.

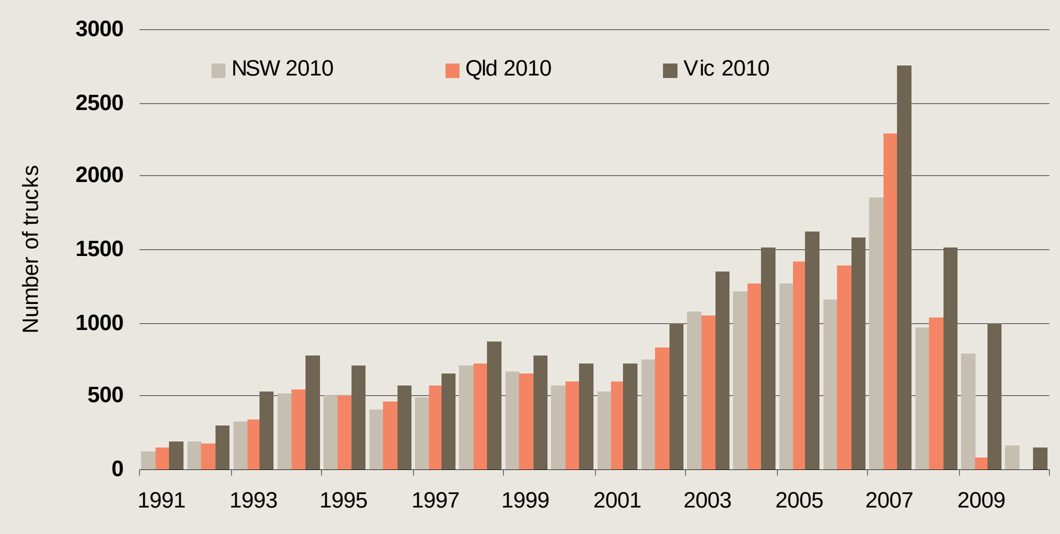
1.4 **Projected freight task**



Data source: BITRE.

Chart 1.5 outlines the distribution of articulated trucks, by year of manufacture for New South Wales, Queensland and Victoria. The distribution has a long tail, with the largest proportion of trucks having been manufactured in 2007. It is this long tail that increases the average age of the fleet, with a quarter of the fleet being less than four years old.

1.5 **Articulated truck numbers, by year of manufacture, NSW, Qld and Vic**



Note: Due to data availability, Queensland figures are drawn form the 2009 motor vehicle census.
Data source: ABS motor vehicle census.

Comparisons of truck types

The movement away from semitrailers towards larger B-double configurations and beyond has been driven by a number of factors. These include increased running efficiency, lower fuel and driver expenses, as well as increased safety and environmental outcomes. While these scenarios are sometimes considered to be counter-intuitive on an initial assessment, increased stability control, improved on-board technologies and increased fuel efficiency all work towards a combined outcome of improved environmental, safety and financial outcomes from larger trucks.

General mass limits[1] (GML) have increased by between 15 and 28 per cent and when moving into higher mass limits[2] (HML) of articulated trucks, this increase is up to 33 per cent above previous limits. These increased mass limits mean that a reduced number of trucks are required to transport a given amount of freight across the country.[3]

Chart 1.6 provides a measure of the number of trips that are required by truck type to move 1000 tonnes of freight 1000 kilometres. Moving from a 6 axle semitrailer

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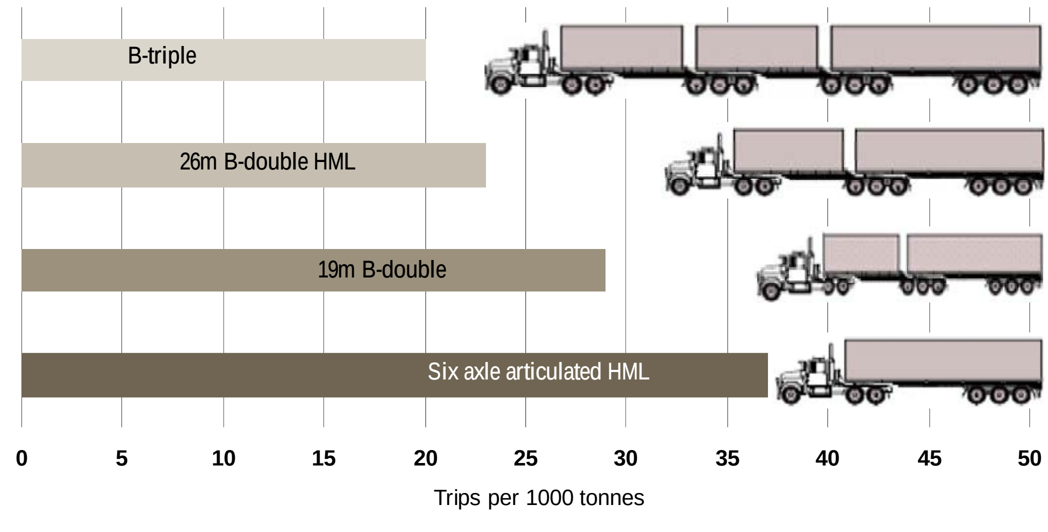
[1] General mass limits refer to the maximum mass limit allowed with unrestricted access to the road network.

[2] Higher mass limits refer to a higher level of vehicle mass allowed on a given road network for specially registered vehicles.

[3] Note that higher mass limits were introduced in 1999 but have but still not yet fully been implemented in NSW/QLD. Restricted routes and additional IAP conditions are costly and have negatively affected industry take-up.

requiring 37 trips, a higher mass limit B-double would require only 23 trips, a 38 per cent reduction. B-triples would achieve a further reduction to only 20 trips, almost halving the number of truck trips compared to semitrailers. Improvements in labour and capital productivity are proportional to the reduction of the number of trips required to move the freight task. Fuel efficiency improves markedly, but not in direct proportion to the number of trips due to the greater weight transported per load.

1.6 **Estimated trips per 1000 tonnes, by articulated truck category**



Data source: Truck impact chart, Barkwood Consulting.

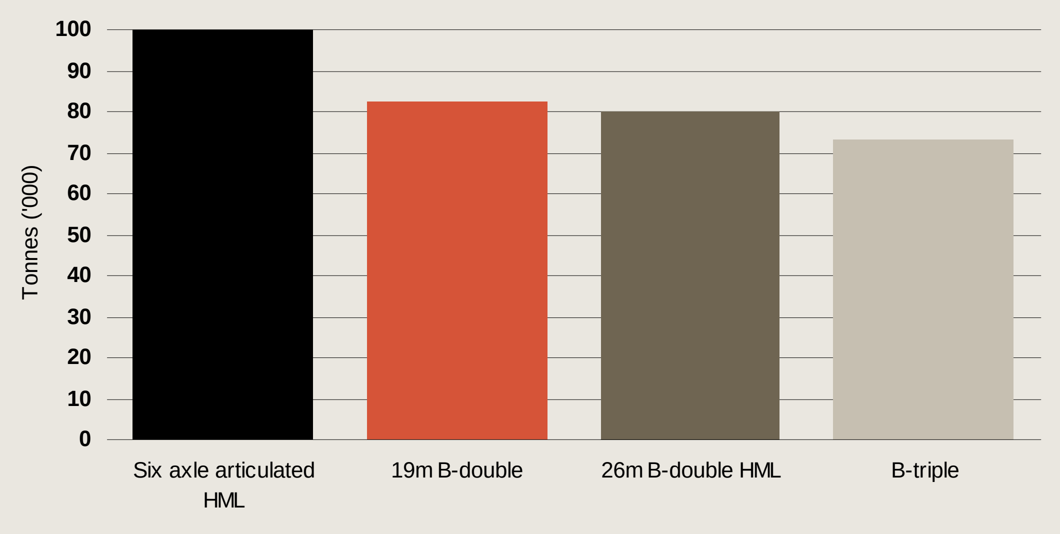
Nonetheless, combined with improved engine technologies, this reduction in required trips per 1000 tonnes of freight is a key factor in reducing overall greenhouse gas emissions across the industry. Chart 1.7 illustrates the CO_2 equivalent emissions for 19m B-doubles, 26m B-doubles (HML) and B-triples compared with a standard six axle semitrailer combination. Based on the movement of 1000 tonnes of freight, a 19m B-double produces only 83 per cent of the emissions that a semitrailer would, a 26m B-double (HML) only 80 per cent and a B-triple with GML would only emit 63 per cent.

Emission regulations

The Australian Design Rules (ADR) among other things, outline performance requirements for heavy vehicle engines in Australia. These rules have been progressively strengthened over recent years, in line with European, American and Japanese environmental requirements. These performance requirements have specifically targeted particulate matter emissions and nitrogen oxide emissions. This progression is illustrated in chart 1.8.

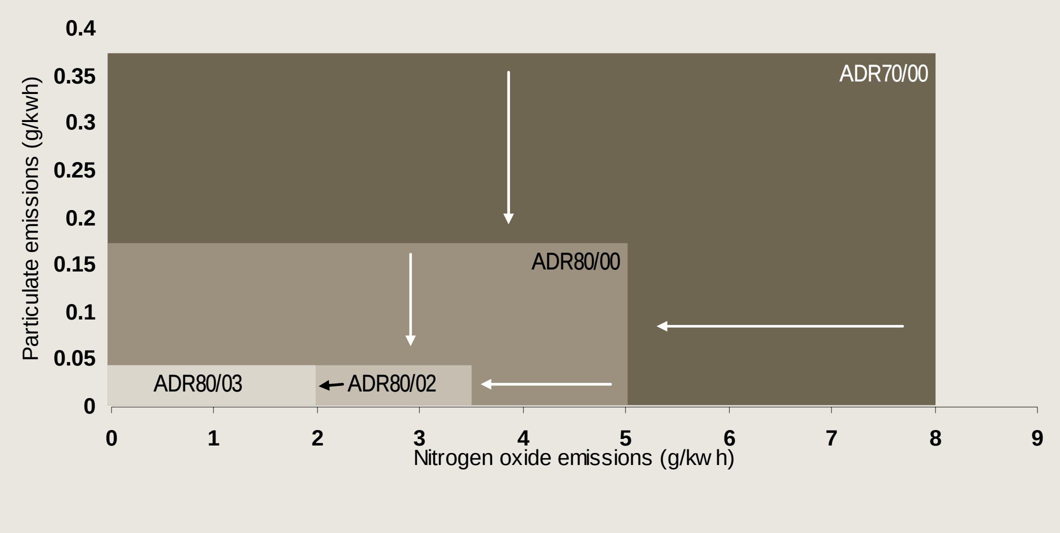
Particulate Matter emissions (PM) and nitrogen oxide (NOx) emissions are important factors in terms of environmental outcomes for the trucking industry as they are both significant contributors to smog as well as NOx being an indirect greenhouse gas.

1.7 **Relative CO_2-e emissions by truck type, per 1000 tonnes**



Data source: Truck impact chart, Barkwood Consulting.

1.8 **Comparison of emission regulations over time**



Data source: Australian Design Rules

However, requirements to reduce both emissions is a somewhat complex task, as general characteristics of diesel engines mean that design factors that directly reduce NOx emissions generally result in an increase in PM emissions, and vice versa. Following progressively more stringent regulations on both NOx and PM emissions, engine manufactures have progressed from pure design based technologies to also include exhaust treatment technologies to overcome these emission trade-offs.

As can be seen, ADR70/00 which was in effect in 1995/96 (and equivalent to the Euro 1 standards) allowed for 8 grams of NOx emissions per kilowatt hour, and 0.36 grams of particulate emissions per kilowatt hour. This is compared to 5g/kwh of NOx and 0.16g/kwh of PM emissions introduced under ADR80/00 in 2002–03.

The most recent design rules for diesel engines, ADR80/03 which was introduced in 2010, require 2g/kwh of NOx emissions and 0.05g/kwh of PM emissions. This is a 75 per cent reduction in terms of NOx emissions, and a 92 per cent reduction in terms of PM compared to trucks manufactured in 1996.

Emissions regulations and fuel types

These increasingly stringent design regulations are having a significant effect. A recent report commissioned by the Australian Department of Environment, Water, Heritage and the Arts (DEWHA), noted that once engines had progressed to the ADR80/03 standard, alterations in fuel type had a relatively insignificant effect on emission profiles (Orbital Australia). That is, in the newer, more advanced engines, it is the design features that are able to have a greater impact on environmental performance rather than the fuel type. For example, the report concludes that the current ADR80/03 requirements reduce PM emissions so low that any difference across the tested fuel types could not be discerned. The same result was found for NOx emissions.

The fuels that were tested were low and high cetane diesel, biodiesel — B5 and B20 and R50, a synthetic low density diesel with 50 per cent renewable component.

2 Best practice and emerging technologies

There have been significant improvements in the use of leading edge technologies in the Australian and international trucking industry in recent years. With the freight task set to double over the 20 years 2010 to 2030 in Australia, emphasis is being placed on finding ways to ensure that this task is met both economically and with a focus on environmental outcomes.

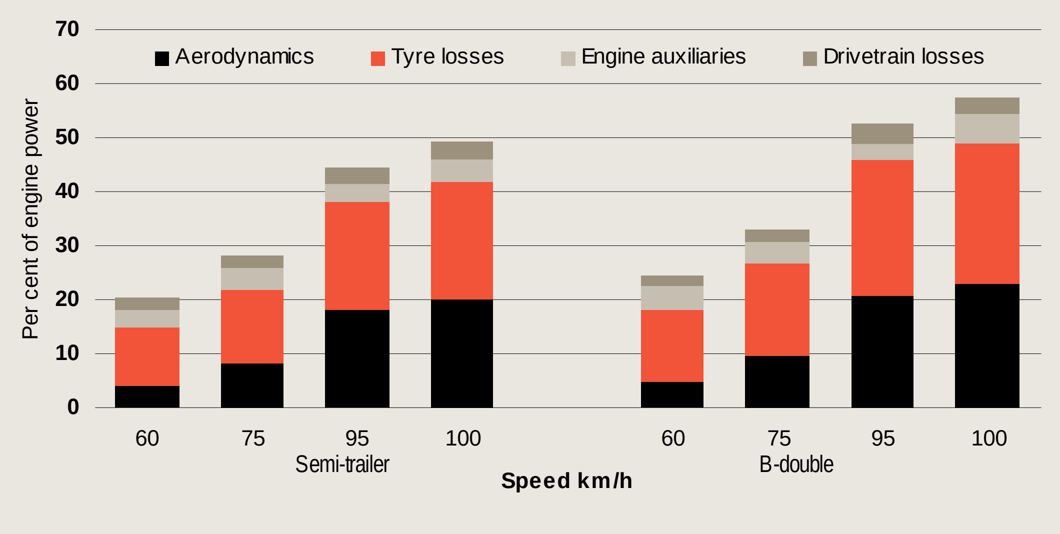
While the 20 years to 2011 have seen significant growth in terms of industry productivity, this has been achieved predominantly through the use of larger and more efficient vehicles. Looking forward, there is still significant potential for further movement towards larger trucks, both within existing categories, such as semitrailers to B-doubles, but also through B-doubles into B-triples. However, the main impediments to such gains are generally regulatory.

Where there are regulatory impediments to improving the productivity of the industry, technology can work on the other side of the equation to improve the operational efficiency of the existing fleet. It should also be noted that technology is also currently working to meet regulatory conditions and expand access to larger combinations through improved operational features of the existing fleet, for example swept path.

One of the main challenges for the environmental performance of the trucking industry (and transport in general) is that one of the only means of managing carbon dioxide emissions is to limit the amount of fuel used, or the type of fuel used. Where other engine emissions may be chemically altered and transformed into innocuous compounds such as nitrogen and water, nearly all of the carbon burnt during combustion will be transformed into CO_2 (AECC, n.d.). Therefore, to target technological improvements for fuel efficiency and provide some of the greatest advances in productivity and environmental performance the main draws on engine power should be considered. This information is presented in chart 2.1 where it is seen that across semitrailers and B-doubles aerodynamic drag and tyre resistance account for between 75 and 85 per cent of total engine power use.

It therefore follows that research directed towards the aerodynamic performance of trucks and tyre resistance could provide some of the greatest improvements in fuel efficiency across the truck fleet. This progress in fuel efficiency would drive improvements in fleet productivity and therefore environmental performance, with reductions in fuel use, fuel costs and emissions for a given freight task.

2.1 **Engine power losses**



Data source: Hart, P. (2007) Where the fuel goes: Truck factors that use power. Presentation to the 2007 Technical and Maintenance Conference, fuel efficiency session, for the Australian Road Transport Suppliers Inc.

Aerodynamic cabin and trailers

Trucks moving at speeds above 80km/hr will be subject to a drag effect that creates a discernable reduction in fuel efficiency. This can be seen in chart 2.1, where aerodynamic losses increase significantly at higher speeds. When considering long haul freight routes, this drag can be a significant cause of both increased fuel costs and environmental emissions. A recent joint study by Linfox, MaxiTrans and Monash University has indicated that improved aerodynamic design of trucks and trailers could provide a 15 per cent reduction in fuel consumption (specifically on routes that allow for a large proportion of higher speed travel) which could reduce carbon emissions by up to 8.4 per cent per year.

While it is possible for such aerodynamic improvements to be retrofitted to existing trucks, one of the main findings of the study was that the aerodynamic solutions, and therefore the benefits, are specific to given truck and trailer combinations. That is, they will be effective for example, for a semitrailer combination but could not easily allow for the trailer to be transferred to a B-double combination for example.

Further research is also being carried out into the weak spot located at the back of the trailer that is the major source of so-called pressure drag on the vehicle (White, 2007). Rear of trailer additions could be attached to the end of the trailer and more effectively direct air flow around the trailer. Preliminary studies indicate the possibility of up to 6 to 9 per cent improvements in fuel consumption. One of the key limitations to the growth in these options is the potential for them to breach either rear overhang limits or overall length limits. Therefore, without policy modifications they cannot be rolled out in Australia.

Tyre technologies

As shown in chart 2.1, tyre resistance on the road can account for up to 20 per cent loss in engine power performance for both semitrailers and B-double configurations. In addition, where tyres account for as much as a third of the operational costs of a truck, there is a strong incentive for the industry to improve tyre technologies for both economic and environmental considerations.

Reduced rolling resistance

Friction between the road and tyres firstly allows for grip, but also increases the drag on a truck and the fuel requirements for the freight. Studies have indicated that a reduction in rolling resistance of approximately 25 per cent could improve fuel efficiency by up to 5 per cent without any reduction in tyre or truck safety. However, this improved fuel efficiency does come at the cost of a reduction in expected tyre life and needs to be taken into account. A recent study in the United Kingdom observed the effects of using reduced rolling resistance tyres over a study period of 140 000 kilometres. The results indicated that up to 13 per cent fuel savings were possible, but at the expense of a reduced tyre life of one third. Not taking into account the end of life disposal costs of the tyres, there was a net improvement of $4000 per year per truck (UK Dept for Transport, 2010).

Ultra wide tyres

Ultra wide tyres have the combined benefits of reducing the rolling resistance of the tyre, reducing the tare weight of the truck and improving the overall safety of the truck by lowering the centre of balance for the trailer. These single tyre configurations have been noted to allow 4 to 8 per cent increase in fuel efficiency according to the US EPA SmartWay program, driven mainly by a reduction in rolling resistance. These benefits have been shown to be achieved with little to no change in road impact (Pearson, 2010).

Further environmental benefits associated with wide and ultra wide tyres is the reduced demand for oil products in their manufacture, and further reduced environmental impact when they are disposed of. Analysis undertaken by Barkwood Consulting Pty Ltd has indicated that wide single trailer configurations could require up to 32 per cent less oil than a standard dual tyre configuration, and an ultra wide drive single configuration could require up to 28 per cent less oil (see table 2.2).

Pressure monitoring and automatic inflation technology

Operationally, correct tyre inflation allows the optimal level of tread contact to be made with the road, without excess damage to the tyre from rolling movement (that is, the squashing of under inflated tyres as they make contact with the road). Further, the maintenance of correct tyre pressure has a two fold advantage to the

2.2 **Oil consumption in manufacture of tyres**

Tyre size	*Typical weight*	*Required number in configuration*	*Relative oil use in configuration*	*Typical use*
11R22.5	60	2	100	Trailer/drive tyres
445/50R22.5	82	1	68	Wide single trailer
495/45R22.5	88	1	73	Ultra wide drive

Source: Barkwood Consulting Pty Ltd.

environmental credentials of the trucking industry. Firstly, there is reduced tyre wear and extended life span of the tyres, in some cases increasing tyre life by up to 10 per cent. Where B-double tyres used on overnight runs can achieve useful lives of up to 160 000km (steer) and 350 000km (drive) this saving is potentially significant. Secondly, fuel consumption could be reduced by up to 2 per cent through reduced rolling resistance, allowing for a commensurate reduction in environmental emissions.

While the results are likely to be case specific, studies indicate that in general:

- continuous over inflation by 10 per cent could reduce tyre wear by approximately 10 per cent;
- constant under inflation of 20 per cent could reduce tyre life time by up to 30 per cent; and
- for every 10 psi (pounds per square inch) of under inflation fuel consumption is increased by between 0.5 to 1 per cent.

While pressure monitoring technologies are currently available, some fleet operators have noted difficulties in getting qualified, on the road maintenance support for the monitors. As the pressure monitoring technology is sensitive, it is required to be installed correctly each time the tyre is changed or rotated. Where this does not occur, the effectiveness of the technology is diminished.

ADR 80/03 and Euro 5-6 diesel emissions standards

As emissions standards have progressively increased, truck engines have had to move beyond design solutions to meet NOx and PM emissions requirements to after treatment technologies. Where design characteristics of an engine are able to reduce either NOx or PM, after treatment technologies are then introduced to address the remaining engine emissions.

Managing nitrogen oxide emissions

The current ADR 80/03 standards have extremely low allowable NOx emissions levels, 0.03 grams per kilowatt hour. The key technologies employed to meet these standards are exhaust gas recirculation (EGR) and selective catalytic conversion

(SCC). Both technologies work to reduce the emissions of NOx, either through altered combustion cycles or fuel additives.

EGR works to reduce the overall NOx emissions produced through displacing excess oxygen in the engine pre-combustion, this also works to reduce the combustion temperature within the engine. By displacing the excess oxygen with recirculated exhaust gas, and reducing combustion temperature, reduced levels of NOx are produced and emitted.

However, the use of EGR technologies is not without downfalls, the first trade-off being that EGR can reduce the power of an engine, therefore increasing overall fuel requirements. The recirculation may also introduce abrasive contaminants and increase engine oil acidity, both of which work to reduce engine life.

SCC alternatively utilises a urea additive to the engine which converts NOx produced in combustion to nitrogen and oxygen, both of which have negligible environmental effects. The downsides associated with SCR technology currently include issues with maintenance and monitoring, performance after cold engine starts and wear through the system due to the chemical makeup of the urea (Kinnear, 2010).

Managing particulate matter emissions

Diesel particulate filters (DPF) physically filter exhaust gases to remove soot particles. In isolation, DPF can remove up to 85 per cent of particulate emissions, and can potentially remove up to 100 per cent depending on the type of filter and other equipment in use. Accumulated particulates are then burned off through either using existing exhaust gas temperatures, or when this isn’t possible, auxiliary burners, fuel additives, catalytic coatings or oxidation (Kinnear, 2010).

Alternative fuels

The vast majority of Australian trucks are powered by diesel fuel with the ABS reporting that in 2010, 98 per cent of articulated trucks and 93 per cent of rigid trucks were diesel powered.

Diesel is a high energy density fuel, allowing for increased energy capacity in a reduced volume compared to other fuels. In contrast, LPG has an energy density rating about a third below diesel (that is a one third increase in volume is required to supply the same energy content), LNG is just over 40 per cent lower, and CNG has an energy density rating around 78 per cent below diesel.

Where tare weight and truck dimensions are important indicators of freight industry performance, reduced energy density is a strong impediment to using alternative fuels across the industry, further strengthening diesel’s dominance of the market.

This is one of the reasons why the ADR requirements on diesel engines have been introduced with progressively stronger restrictions on emissions, working to improve the environmental outcomes of the industry.

Biodiesel

The impetus for the development of biodiesel is to develop a more carbon neutral fuel option for the transport sector. While biodiesel is not yet considered to be completely carbon neutral, when considering the market penetration of alternative fuels, biodiesel is currently gaining the greatest head way in terms of larger articulated vehicles. This is due to a number of key current advantages, such as the ability to use biodiesel in unmodified mineral diesel engines.

However, despite this advantage, there are a number of impediments within the market that need to be overcome to grow the current fleet of a couple of thousand articulated trucks estimated to be currently running on biodiesel. Where there is growing evidence from both laboratory and practical experience that biodiesel can be used without significant reduction in engine performance, manufacturers continue to be cautious, limiting the level of biodiesel allowed before engine warranties are voided. Further issues associated with a wider uptake of biodiesel include sourcing of suitable feedstock, such as concerns around competition for feed stocks for first generation fuels (those utilising food crops) and second generation fuels (those utilising non-food crops), which are not yet produced in large enough quantities.

In terms of reduced CO_2 emissions, biodiesel performance depends primarily on the feedstock used. Table 2.3 presents the results of a CSIRO study into the CO_2 emissions reductions from various feedstocks. As can be seen, biodiesel is not quite carbon neutral, with some conversion losses through processing. A B5 blend with a canola feedstock could reduce CO_2 emissions by 0.89 per cent compared to mineral diesel, and a B20 blend with recycled or reclaimed cooking oil feedstock could reduce CO_2 emissions by up to 17 per cent.

2.3 **Per cent reduction in CO_2 emissions, by biodiesel blend**

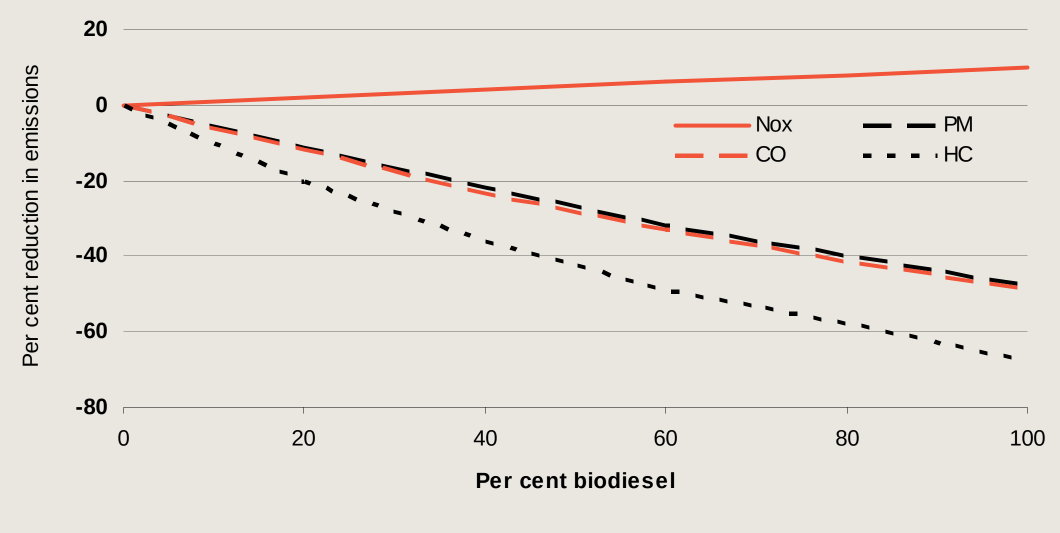
Feedstock	***B5***	***B10***	***B20***
Canola	-0.89	-4.5	-9
Tallow	-1.46	-7.3	-14.7
Used cooking oil	-1.69	-8.5	-17

Note: The measures are taken for ultra low sulphur diesel

Source: CSIRO (2006) Greenhouse and air quality emissions of biodiesel blends in Australia, Canberra.

Considering other engine emissions in general, engine standards such as the Australian Design Rules (ADRs) will be the binding constraints on overall emissions. However, as an illustration, biodiesel can still deliver noticeable improvements in emissions. Results of a US study presented in chart 2.4 support reports that biodiesel can reduce emissions of particulate matter, carbon monoxide and hydrocarbons, as

2.4 Biodiesel emission performance



Data source: http://www.epa.gov/oms/models/analysis/biodsl/p02001.pdf.

well as sulphur dioxide. The trade-off is that higher NOx emissions are reported. So research continues into reducing NOx emissions potentially through the use of inhibitors (similar to petroleum diesel).[4]

LNG and CNG

Generally requiring different engine technologies to mineral diesel based fuels, natural gas powered articulated trucks have only been introduced into Australia since 2009. Trial vehicles of CNG were introduced as early as 2002 — but are more suited to smaller sized trucks.

Table 2.5 brings together disparate sources of information on both LNG and CNG in terms of emissions profiles. Firstly, due to the chemical makeup, natural gas fuels are virtually free of particulate emissions, with noticeable savings in carbon dioxide emissions, being up to 30 per cent in both fuels.

2.5 Reduction in emissions compared with mineral diesel

Emission type	*CNG*	*LNG*[a]
Nitrogen oxides	Reduced to 0.2g/kwh	>10 per cent
Particulate matter	Virtually eliminated	>90 per cent (virtually eliminated)
Carbon dioxide	Up to-30 per cent	30 per cent

[a] *Australian government sponsored testing of Australia's first ADR80/02 compliant >450hp LNG engine.*

Source: www.evollng.com.au/images/engineering-innovation.pdf and EvolLNG (2010) Engineering Innovation, WA transport industry awards.
primemovermag.com.au/testdrive/article/isuzu-CNG-powered-trucks.

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[4] Magazinovic, R. (n.d.) Biodiesel ahead in fuel race, UniSA, accessed on 2 May http://www.unisa.edu.au/unisanews/2005/November/main3.asp

While natural gas does have some significant advantages over diesel based fuels in terms of emissions, there is currently only a small proportion of the Australian heavy road freight fleet being powered by LNG. The moves towards an LNG powered fleet in particular are focussing on the market areas of smaller trucks and shorter freight trips for heavy vehicles, especially in inner city areas and back to base operations of up to 800km.

The characteristics driving this comparison include the lower energy density of gas based fuels compared to diesel meaning that a greater volume of fuel is required to be held on board to make the same distances, or more refuelling stops are required. A further complication with a lower energy density is that where a larger fuel tank is required, mass and dimension limits for some trucks are also currently constraining the roll out of LNG based fuels.

There are additional concerns around natural gas based fuels for heavy trucks compared to diesel. Firstly, natural gas is generally more flammable, and secondly, the fuel is stored under pressure These factors could be considered to increase the risk of damage in the event of an incident.

However, given the evident reduction in emissions and environmental footprint of gaseous based fuels compared to diesel, LNG in particular is likely to continue to increase market share as supply infrastructure expands, and improved technology is introduced to the fleet through turnover and expansion. It is expected that LNG could play a noteworthy role in the longer term progression to reduced carbon emissions in the trucking industry.

Driving and driver training

Driver actions are another key factor affecting fuel efficiency and environmental performance of the trucking industry. As such, there has been a strong industry emphasis on driver training, education and performance review in recent times. Studies across entire fleets have indicated that between 6 to 10 per cent improvements in fuel efficiency, and therefore environmental impact, could be achieved by improved driver performance (Linfox, 2010 and Agnew, 2007). Accounting for driving practices, such as skip shifting, controlled acceleration and braking, lane choice and controlled use of the air-conditioner, eco-driving is a low cost measure currently being implemented by the industry to improve fuel efficiency, engine longevity and environmental performance.

Automated manual engines

Beyond the use of driver training and controlled acceleration and braking, newer engines are being fitted with automated manual transmissions where computerised gear changes allow for more efficient use of torque and exact gear changes. While there is limited quantitative analysis of the level of fuel efficiency improvements offered by automatic manual transmissions, compared to standard manual transmissions, their use does reduce the variance in fuel efficiency across drivers raising them to above average performances.

An additional feature of some automated manual transmissions is the ability to cruise at highway speeds drawing on the momentum of the truck to move it. This is able to further reduce fuel use, and in turn emissions.

Speed limits

There has been significant interest recently in the application of voluntary speed limits on trucks and the implications for fuel use and environmental impacts. Published in the Prime Mover Magazine on 5 April 2011 are the results of a comparative speed test along the Sydney-Melbourne route. Two B-double combinations were sent on the return trip one with a maximum speed limit of 100km/h, the other limited to 90km/h. A summary of the results is included in table 2.6. While there are clear differences in savings based on the road conditions, such as gradient, across both tests, the truck travelling at 90km/h reduced fuel consumption and CO_2 emissions compared with the truck travelling at 10km/h faster.

2.6 **Speed comparison test**

	Sydney to Melbourne			***Melbourne to Sydney***		
	100km/h	*90km/h*	*Difference*	*100km/h*	*90km/h*	*Difference*
Fuel use (litres)	486	475	11	494	449	45
CO_2 emissions (kg)	1290	1260	30	1308	1190	118
Average speed (km/h)	88	80	8	85	77	7
Travel time (min)			53			40

Source: Prime Mover Magazine (2011) Scania Fuel Duel.

Rough extrapolations to fleet wide results indicate that an operator travelling the route five times per week could save in the order of $10 000 per vehicle over the course of a year. These fuel savings would translate into approximately 38 500 kg of CO_2 emissions abated per year per truck (along the return Sydney-Melbourne route, five times a week, 260 times per year).

However, it should be noted that these results do not consider issues such as increased labour requirements or the effects of increased truck time on the road.

Route optimisation and supply chain logistics

When considering the national freight task, there are a large number of components working together to ensure that empty truck and trailer movements are limited. The ABS survey of motor vehicle use estimated that in 2007 articulated trucks travelled on average 26 per cent of their total kilometres empty. This was compared to 2004 where 24 per cent of kilometres were travelled empty.

In recent years, subsequent to the latest ABS survey, there have been reports of communication technology companies working to improve the performance of the road freight fleet by reducing the amount of empty running occurring. Niche business operations have also been established to connect freight with trucks and trucks with freight across the country, to further minimise empty running.

Supply chain evaluation software programs are also evolving to consider not only time and cost implications, but also greenhouse gas emission profiles of different options. In general, the parameters that might be able to affect overall supply chain performance include:

- source of the freight task — is there a better location to source goods from or to aggregate pick ups from distribution centres?;
- mode of transport — should a combination of transport modes such as road and sea or road and rail be considered?; and
- route — avoiding high congestion points or allowing larger vehicles to carry the load.

Such changes in supply chains are going to be more accessible to larger operators working across a large number of clients, where there is more flexibility to alter routes and configurations.

Comparison with rail and intermodal transport options

Shifts across transport modes are often presented as a means of optimising emissions across the national freight task. Where inter-modal discussions of road and rail are considered, it is important to consider the characteristics of the current split across modes and the reasons for it. Table 2.7 presents the Australian freight task broken down by transport mode and freight type for 2006–07 (the most recent year for which comparable figures are available).

2.7 **Distribution across bulk and non-bulk freight, 2006–07**

	Bulk freight	*Non-bulk freight*	*Total*
Road	57.2	133.5	190.7
Rail	171.7	25.9	197.6
Other	115.1	9.6	124.7
Total	344	169	513

Source: BITRE infrastructure yearbook, 2011.

The figures show that road accounts for 78 per cent of the non-bulk freight task in Australia, compared to rail which carried only 15 per cent. Therefore, while road and rail carry roughly the same freight task — road with 190 btk and rail with 197 btk, rail is a much more specialised freight mode, concentrating on bulk goods. Over 90 per cent of the rail freight task in 2006–07 was allocated to bulk goods such as mining and agricultural products.

This specialisation across the freight modes is not surprising given the relative strengths of the modes. Where road transport is highly flexible, with access to the majority of the country, rail is highly location specific with the benefits of being able to move large volumes across large distances, generally from one point of production (a mine) to one point of sale (a port).

Further investigation into the road and rail modes indicates that contestability only occurs on a small proportion of the freight task. But even then, pricing analyses have shown a relatively weak level of substitutability. Table 2.8 presents the results of price elasticity studies where it can be seen that rail freight is relatively unresponsive (elasticity of less than 1 in absolute terms) to changes in freight prices, apart from over medium distances. Over medium distance corridors it was estimated that a 1 per cent increase in road freight rates could increase rail freight values by 1.08 per cent, and a 1 per cent increase in rail freight rates could reduce rail freight values by 1.15 per cent (BITRE, 2009b).

2.8 **Inter-capital road and rail long-run price elasticities, by corridor**

	Short distance corridors		***Medium distance corridors***		***Long distance corridors***		***All corridors***	
		Freight rate		Freight rate		Freight rate		Freight rate
Mode	Road	Rail	Road	Rail	Road	Rail	Road	Rail
Road	-0.36	0.35	-0.43	0.33	-1.08	0.66	-0.46	0.58
Rail	0.88	-0.93	1.08	-1.15	0.42	-0.78	1.04	-1.66

Source: BITRE (2009).

These results support the assertion that there is currently limited substitutability across road and rail transport in response to prices, but that this comparison does weaken when considering longer distance freight routes, where there is increased competition between the modes. In general however, the road freight task is considered to be unaltered by changes in road freight prices and vice versa (BITRE, 2009b).

In terms of an environmental comparison, care must also be taken to compare like with like. Along the routes where there is contestability with rail, road freight is carried by the most efficient, larger truck combinations — that is B-doubles and B-triples. Therefore, considerations of inter-modal freight movements are likely to:

- only consider movement across a small proportion of the national freight task;
- only be able to affect movements by the most efficient truck combinations; and
- potentially affect congestion and increase smaller truck movements in and around loading and unloading points along the rail corridors.

It is also likely that such inter-modal shifts, when considered to be cost effective, will already have taken place by freight users.

Emissions regulations for locomotives

When considering the broader environmental effects of this inter-modal comparison (that may not be directly considered in the private decision), it is important to consider the environmental credentials of rail freight as well. In Australia, there are no emissions regulations or restrictions imposed on locomotive engines, and there is limited information on the emissions performance of specific industry components.

A symptom of no emissions regulations for locomotives is that the average age of Australia's freight locomotives is over 36 years (ARA, 2010). The same report from the Australian Railway Association (ARA) notes that some of these locomotives are utilising diesel engines that are up to 40 years old. Compared to leading edge locomotive technology utilised in the United States, these 40 year old engines have been estimated to emit:

- more than six times the level of carbon monoxide;
- approximately four times the level of particulate matter;
- double the level of nitrogen oxides; and
- 20 to 30 per cent more carbon dioxide per tonne kilometre.

This is compared to the situation in the United States for example, where progressively more stringent emissions regulations have been introduced for locomotive engines since 1997. Divided in to Tiers, the emissions regulations consider the age of the locomotive engine and generally apply both to newly manufactured locomotives, as well as when they are remanufactured (that is, rebuilt with new parts to extend its useful life).

3 *Policy discussions*

The considerable productivity achievements of the trucking industry over the past two decades demonstrate its responsiveness to market incentives to achieve efficient outcomes. With the correct institutions and policy settings covering both economic and social concerns, market incentives can provide strong impetus for industry change toward efficient outcomes.

As technology and information transfer become more sophisticated over time, the industry has greater resources to manage its operations and to do so more efficiently. This includes optimisation of transport routes to minimise time and fuel use, coordination of freight tasks to minimise empty movement of trucks, and increased design sophistication of trucks to minimise variable costs through increased fuel efficiency and aerodynamics. All of which will ultimately reduce the environmental footprint of the industry as well.

However, there will inevitably be trade-offs involved with other social and economic priorities across different regions and at different levels of government. For the trucking industry, these trade-offs and discrepancies in priorities usually involve access for larger trucks and for example, the removal or imposition of curfews. When considering these trade-offs, it is important to identify and resolve ongoing regulatory impediments to progress first, for example road funding responsibilities. Then, efforts can be made to address broader economic and environmental trade-offs to ensure that all policy development and implementation is made for the greatest return to Australia overall. Such access considerations will be particularly important in Australia during discussions of the proposed carbon pricing policies. The ability of the transport industry to respond effectively to these carbon policies will be affected by the uptake of combined measures of economies of scale, technology advances and logistics.

Potential carbon price

The carbon policy discussions that are currently on the national policy agenda provide the potential for gains in both environmental outcomes and fuel efficiency incentives across the Australian trucking industry.

Given the policy decision to limit carbon emissions in the Australian economy, it is the choice of policy instrument that becomes very important. The most efficient design from the transport industry’s perspective would be the upstream imposition of a carbon price, for example at the refinery level, which is then passed down in terms of a carbon premium at the bowser. Such a design would allow for incentives to improve fuel efficiency at the individual truck level, as well as at the fleet level, with fewer chances of inadvertent regulatory effects.

The preference for a broad based carbon price stems from the risks associated with alternative policies. That is, where numerous restrictions and regulations are imposed on any industry to indirectly reduce social or environmental impacts, there is generally a tendency towards unintended consequences, and higher implicit prices, that can turn out to be more damaging than the initial problem.

Options for managing carbon emissions

The ultimate aim of mitigation policies is to constrain the amount of carbon emitted by a range of economic activities. There are a variety of policy instruments available to impose this constraint, each with its own costs and benefits.

As outlined in table 3.1, different policies impose costs and create incentives in different ways.

- **An explicit carbon price**. Policies such as a carbon tax or emissions trading scheme explicitly establish a carbon price which applies at the margin to activities that are covered. These policies provide a direct and transparent signal to industry about the cost of each unit of carbon (or carbon equivalent).
- **A compliance carbon cost**. Policies such as regulations of various kinds (perhaps technological standards, or energy efficiency regulations) generate a carbon cost through their compliance requirements. They do not necessarily generate an explicit carbon price that applies at the margin, and this price is often difficult to observe or manage.
- **A subsidy cost**. Policies that work through direct subsidies do not create an explicit carbon price, but do involve a budgetary cost. It is likely that these costs will be transmitted to taxpayers rather than to particular industries, although there will be an indirect effect on industries as taxpayers respond to changes in taxes.
  - The choice of product to subsidise also creates additional issues around governments ‘picking winners’ and deciding which products and processes should be promoted at the expense of others. There is no market mechanism involved in the choice.
  - Where winners must be chosen, there is additional risk that the decision to subsidise may be based on the possible political gains rather than economic or environmental imperatives.
- **A ‘proxy’ carbon price**. Some policies act by effectively changing the price of different forms of energy generation (coal fired versus renewables, for example).

In this case the policy is associated with a cost in terms of generation units (MWh, for example), which is indirectly related to a carbon price.

3.1 **Broad classification of carbon policies and economic effects**

		Core example	*Types of economic effects*
Carbon constraint implemented through explicit price mechanisms	***Price target***	Carbon tax or levy applying to production of emissions or to emissions embodied in consumer items	Price is explicit and applies at the margin to all covered activities
	Quantity target	Emissions trading scheme. Producers of emissions need to acquit permits	Price is explicit, emerges from trades and applies at the margin to all covered activities
Carbon constraint implemented by other means	***Regulatory measures or mandatory requirements***	Mandatory emissions limits (or emission intensity requirements)	No explicit price, but clearly an implicit cost to producers. This can be converted to a unit price, but does not necessarily apply at the margin.
	Budgetary measures	Subsidies for abatement	No explicit price. Costs of producers do not necessarily increase, although costs to taxpayers do
	Proxy measures	Renewable energy targets	May be an explicit unit price (if targets are tradeable, for example) but the units are not necessarily carbon emissions. Cost needs to be converted to carbon units
Demand side measures	***Subsidies for 'green goods'*** ***Taxes on consumption*** ***Regulations***	Congestion taxes, fuel charges	Impact on industry is through indirect demand effects. For given total production, changes in demand may influence surplus or deficit for import or export

The advantage of policies involving an explicit price of carbon is that they provide the most transparent and cost effective means of implementing a carbon constraint within the economy. A crucial component of establishing a price on carbon is ensuring that the industry sees a transparent long term price — this allows industries to plan the response.

The major impact of an explicit carbon price on the transport sector is through the price of fuel. There is, in effect, a direct relationship between the dollar carbon price and the associated increase in the price of fuel.

Table 3.2 presents some indicative calculations of the cents per litre increase in the price of both diesel and petrol based on different carbon prices. Given a $25 per tonne price of carbon for example, based on direct calculations from carbon intensity of the fuels, an additional 7 cents per litre could be expected on the price of diesel or 6 cents per litre on petrol.

3.2 **Change in fuel prices**

Carbon price	***Change in fuel price***	
	Petrol	***Diesel***
$/t CO_2-e	c/L	c/L
20	5	5
25	6	7
30	7	8
35	8	9
40	9	11
50	11	13
60	14	16

Source: CIE calculations based on carbon intensity factors and fuel combustion emission factors taken from Department of Climate Change and Energy Efficiency National Greenhouse Accounts Factors July 2010.

Using an average current price of around $1.50 per litre for diesel fuel, a carbon price of $25 per tonne would equate to approximately a 4.6 per cent increase in the final price of diesel. To put this in context, diesel prices fluctuate annually, and even quarterly and monthly, to a similar degree. The terminal gate price (wholesale price) of diesel in January 2011 was on average 8.8 cents per litre below the average price in May 2011. At the more extreme end, the spike in diesel prices observed in mid 2008 saw a 60 cent per litre increase in prices from October 2007 to July 2008.

Therefore, while the imposition of a carbon price on diesel fuels will be an additional cost to the industry, it should not be outside of the scale of price increases that are observed through the market. Further by imposing an explicit price on carbon the additional cost would be clearly observable to both industry participants and freight users and not hidden in increased costs of technology for example.

Risks of excluding fuel

There are two levels of uncertainty in carbon policy in Australia affecting the transport industry at the moment. Firstly, there is considerable uncertainty about the likely magnitude of a carbon price that is consistent with the long term carbon emissions targets and reductions that Australia has proposed. Secondly, there is policy uncertainty as to whether any fuel price effects of the carbon price will be offset through changes in the excise on fuel, or whether the transport sector will in fact be included in any broad based carbon constraint policy.

The danger for the trucking industry is that if fuels are ultimately excluded from a broad based policy such as emissions trading, then there is likely to be a strong temptation for governments to directly regulate transport emissions through standards and efficiency requirements. While such measures are no doubt familiar to many transport operators (who are subject to many similar forms of regulation at the moment), the disadvantage with these approaches is that their implicit carbon cost is not transparent. This lack of transparency may also lead to unintended effects of reduced fuel efficiency across the entire fleet through changes in engine power for example.

Direct regulation of transport sector emissions through standards and efficiency requirements run the risk of the transport sector paying a higher effective carbon tax than other sectors — an outcome which is economically inefficient.

Carbon policy and the trucking industry in transition

A carbon price is unlikely to bring about substantive adjustment in the short term. The objective, however, is to provide explicit incentives for continued improvements over the long term. It is this transition period that may create some uncertainty for both the road freight industry and its customers.

Increases in fuel prices will clearly pose a major challenge for transport operators. The main adjustment mechanisms that the industry would have available to mitigate the costs of a carbon price are essentially the adoption of the range of techniques canvassed in this report. The three main options would be:

1. Transition to larger truck combinations with better logistics coordination that reduce the carbon intensity of the freight task using standard fuel types.
2. Transition to lower carbon intensive fuel options that allow for standard truck combinations to operate with a lower carbon balance.
3. From the perspective of the national economy, a transition and reallocation across transport modes to reduce the carbon intensity of the national freight task.

Given these three alternatives, there should be careful consideration of the transition path the transport industry takes, or is led down, towards a lower carbon footprint. That is, there is a risk that if left to market forces, and competing with other policy constraints such as access for heavy vehicles, the transition costs will be high enough to have a negative effect on industry structure. Where efficient operators leave the industry because of unnecessarily high transition costs, there is a cost to the Australian economy.

Therefore, during this transition period, there is a strong argument for revenue from the carbon price (or alternative government funding initiatives) to be directed into research and development initiatives to accelerate technological progress or improved policy initiatives to minimise inefficient transition costs.

A key example of this is the use of larger truck combinations. As outlined above, possibly the main avenue for transitioning to a lower carbon footprint in the road freight industry is the use of larger combinations that reduce the carbon intensity of the freight task. Should the use of these vehicles be inefficiently constrained by policy decisions, this will also constrain the industry's ability to adjust to a lower carbon path at least cost. The ultimate result will be an increase in the overall transition costs paid by the industry.

Performance based vehicles standards

Currently, the most efficient way to manage the environmental footprint of the trucking industry is to allow economies of scale to be achieved. As technology progresses, the safety performance of larger high performance vehicles continues to improve and so does the fuel efficiency performance. This progress has been keenly observed in recent years across Australia, as firstly semitrailers were introduced and then B-doubles and larger road train configurations.

Australian governments have made moves recently to allow the industry to gain access to a wider road network for larger vehicles such as B-triples, and HML B-doubles (26m), as well as improving access arrangements and physical impediments to GML B-doubles. These movements by government are aimed at removing impediments to productivity and environmental improvements across the industry.

The Performance Based Standards (PBS) scheme was introduced in 2007 with a view to better aligning the national road freight task with vehicles that could achieve greater productivity outcomes. The PBS was to focus on how well the vehicle behaves on the road, rather than prescriptive dimension and mass limits (NTC, 2010).

Australian studies by the NTC have provided an indication of the environmental improvements possible from greater access to larger trucks. In 2007, a report noted that substitution of 60 B-doubles and semitrailers to B-triples on inter-capital routes could reduce the number of required trips by up to 25 per cent, and reduce total operating costs by around 22 per cent, saving almost 3.7 million kilometres of truck travel annually. These gains convert into approximately 2 million litres of saved diesel and 5900 tonnes of CO_2 equivalent annually (COAG factsheet, 2007).

Greater access to larger vehicles has been reported to have multiple benefits to both the industry and economy. Firstly, with larger freight loads, fewer prime movers are required to be on the road at any one time. Beyond the environmental improvements, this reduction in prime movers has the effect of improving road safety through a reduction in truck numbers as well as improving economic performance of the industry. In many cases, larger trucks may also be able to reduce overall road wear — where the greatest amount of road wear is imposed by the front turning axle on the prime mover. Equivalent standard axles (ESA) is a measure of road wear and table 3.3 summarises the ESA's required to move 1000 tonnes of freight by different truck combinations. A B-double combination with road friendly suspension provides the lowest level of ESA per 1000 tonnes of freight.

3.3 Equivalent standard axle measures

Truck combination	*ESA's per 1000t*
19m Semitrailer, 6 axle	226
19m truck and dog, 6 axle	233
19m B-double	256
26m B-double, HML, RFS	173

Source: Barkwood consulting truck comparison chart.

Access issues are likely to affect the entire supply chain of road freight, with often the last few kilometres, and in some case metres, dictating the configuration that is used for an intra or inter-state trip. For example, access to loading yards or driveway positions along a route could preclude the use of B-double configurations and instead force the use of multiple semitrailers for an entire journey.

While there is a general understanding of the benefits of the scheme, following a review of the initiative, it was conceded there had been limited success. This delay in achieving benefits is thought to be due to inconsistencies across State and Territory government implementation, the high costs and uncertainties imposed on operators to participate, and the limited flexibility observed in practice in responding the vehicle configurations (NTC, 2010).

Currently, the issues around the PBS surround road access uncertainty, with the national network not yet having been decisively mapped into categories as was originally envisaged by the initiative. Currently, the mapping across roads and truck categories is considered to be indicative, with operators needing to provide detailed specifications of configurations, often requiring construction and delivery of the vehicle, before final confirmation of access is agreed. Further industry concerns surround an apparent lack of accountability for decision making. Such uneven risk sharing is unlikely to deliver benefits.

From the state and territory government perspective, there are additional risks associated with a full and decisive mapping of local and regional roads. Current legislative policies ensure that road maintenance and upgrade is handled at the State government level, with many local councils also holding some responsibility. Where there are unclear links between granting access to larger vehicles, changes in road costs, and access to funding for road maintenance and repair, conservative approaches from State and local governments can reasonably be expected.

Registration charges

Moves towards larger combinations are also affected by factors such as relative registration charges. In Australia, registration charges for heavy vehicles are calculated based on an initial component of allocating national road expenditure costs, and a secondary component based on expected road usage (Australian Transport Council policy). While such calculations may be considered efficient for recouping heavy vehicle related road expenditure costs, provided there is sufficient and accurate monitoring of both components and their application to different truck combinations, there is still the potential for unintended effects. In fact, the current registration charging ratios provide a disincentive towards registering larger B-double combinations compared to less efficient semitrailer and truck and dog combinations.

Table 3.4 provides a comparison of the logistic nature of different truck configurations with the estimated registration charges.

3.4 National transport commission registration fees and environmental effects

	Trips per 1000t	*ESA's per 1000t*	*Emissions per 1000t (index)*	*Registration charges*[a]
19m Semitrailer, 6 axle	37	226	100	5612
19m truck and dog, 6 axle	34	233	89	7491
26m B-double, HML, RFS	23	173	80	15340

[a] *Based on 2010-11 rates, changes proposed from July 2011 do not alter results.*

Note: HML — higher mass limits, RFS — road friendly suspension.

Source: http://www.ntc.gov.au and Barkwood Consulting Pty Ltd truck comparison chart.

Based on the ATA and Barkwood Consulting Pty Ltd truck comparison chart, of the three configurations considered, the HML with RFS B-double allows for the least number of trips per 1000 tonne load. This also allows for a lower number of ESAs (as a measure of road wear) and generates 20 per cent less greenhouse gas emissions than a standard 6 axle semitrailer. However, for a 60 per cent increase in load carrying capacity, the HML RFS B-double combination pays a 170 per cent registration premium over a 19m semitrailer. Compared to the 19m truck and dog combination, the HML RFS B-double allows for a 48 per cent increase in load carrying capacity, but has a 100 per cent increase in registration charge.

Addressing road costs, safety consideration and environmental concern is a difficult balancing act to be achieved through the use of registration charges. In general, a single economic instrument should be utilised to achieve a single policy objective. However, it is possible to design a dual based charging mechanism that accounts for both the expected road wear and maintenance costs, as well as providing incentives for movement towards more environmentally friendly combinations. Where road use might be most easily represented in terms of fuel use, rebalancing the combination of a fixed registration charge and road use charge could present an efficient alternative to the current arrangements, see ATA proposal in box 3.5.

3.5 Australian Trucking Association registration and fuel charging option

The ATA considers that there is a more effective method of allocating and collecting road use and wear fees across the industry. This dual system suggests that a lower flat fee be introduced for vehicle registration, and combined with an increase in the rate of fuel based, road user charges. That is:

- flat truck and trailer registration fee of $400; and
- road user charge (fuel based and currently 21.7 cents per litre) split into two charging categories:
  - Class A would include two axle rigid trucks, and special purpose vehicles at 24.0 cents per litre;
  - Class B vehicles would pay 39.0 cents per litre [a].

The ATA concede that under current political arrangements there may be contention with respect to collection and allocation of these funds and therefore there must be a mechanism included to allow road asset managers to be able to apply for funding to upgrade their roads.

Further, these rates must also be set to allow for both providing the correct incentives to the road freight fleet in terms of vehicle use and environmental footprint but also in terms of sufficient collection of revenue to ensure the industry pays its fair share to upgrade and maintain infrastructure.

Source: ATA (2010) Truck Week factsheet.

[a] Based on 2009–10 cost base.

Emissions regulations

Emissions regulations, such as the ADRs, are quantitative regulations that provide an upper bound on emissions without consideration of other factors such as the cost of the technology or impacts on fuel efficiency. However, in considering the progression of emissions restrictions that have been introduced both in Australia and Europe, through the Euro I-V regulations, there has been a progressive slowing of the rate of restrictions. This is partly due to the extremely low levels of regulated emissions currently allowed for, but also provides an indication of the implied rate of technological progress that is expected to be achieved.

Further research into the nature of environmental impacts from these regulated emissions has also led to expected increases in emissions allowances for future regulations. For example, PM emissions allowances expected to be included in the Euro VI standards (and hence the ADR80/04), due in the coming years, are higher than currently under the Euro V (and ADR80/03) standards (see table 3.6).

3.6 Emissions allowances for transient cycle tests, g/kwh

Euro standard	*III*	*IV*	*V*	*VI*
Australian design rules	80/01	80/02	80/03	80/04
CO	5.45	4.00	4.0	4.00
Hydrocarbons	0.78	0.55	0.55	0.16
NOx	5.00	3.5	2.00	0.5
PM	0.16	0.03	0.03	0.4

Note: Euro VI and ADR 80/04 are only proposed, expected around 2013.

Source: Kinnear, S. et al. (2010).

This result has been attributed to research noting that the environmental effect of PM is more closely associated with the distribution of particle size, and chemical features of the emissions rather than the straight quantity (Kinnear, et al. 2010). Such changes highlight some of the risks associated with stringent regulations that may force technology development in inefficient directions and draw attention to the benefits of designing regulations, which are flexible and for example, allow updating of restrictions based on new scientific evidence.

There are reports that increasingly stringent emissions regulations are beginning to achieve diminishing marginal returns in terms of environmental outcomes, for example through reducing fuel efficiency. Where this is the case, there is likely to be an economic incentive to optimise the regulatory framework to better target the overall fuel efficiency of the fleet. As has already been discussed, there are many options for promoting increased fuel efficiency, both through pure commercial incentives that are likely to be adopted by operators, but also through market based instruments that also correct environmental externalities — through a carbon price.

Fleet age and turnover

Changes in effective life and depreciation schedules may allow for increased turn over of capital within a business, promoting a faster rate of uptake of leading technologies. In the case of the trucking industry, an accelerated rate of depreciation allows fleet operators to write down the value of their fleet and bring forward the replacement time. Given the rate of change in emissions standards in Australia currently, such a policy also promotes a greater uptake of more and more environmentally friendly trucks through the Australian fleet.

By number, the Australian road freight fleet is currently dominated by rigid trucks. According to the Australian Bureau of Statistics (ABS) motor vehicle census, there was a total of just over 431 000 rigid trucks in operation with an average age of 15.4 years (see table 3.7). However, these rigid trucks only accounted for 18 per cent of the road freight task in 2010 (ABS, 2010). This is compared to just over 82 400 articulated trucks, consisting of semitrailers, B-doubles and road trains, which had an average

age of approximately 10.9 years and accounted for 78 per cent of the road freight task.

3.7 Number of vehicles

	2003	***2004***	***2005***	***2006***	***2007***	***2009***	***2010***
Rigid trucks	346538	358704	366875	386626	392837	421702	431278
Articulated trucks	62982	66197	68509	69696	74343	81217	82436

Source: ABS Survey of Motor Vehicle Use.

The general distribution of these trucks to the Australia freight task is shown in table 3.8. In general, the newer and more sophisticated trucks will be rolled out across the higher distance tasks, noting their relatively high level of operational reliability and capacity to undertake long distance travel efficiently.

3.8 Average age of fleet, and general tasks assigned — environmental credentials

	Operational reliability				***Probable application***				
Average age (years)	Low	Medium	High	Emissions technology	Long haul interstate	Intrastate	Short Haul	Local	Noise emissions
1-3			▨	ADR 80/02, 03	▨	▨			ADR 83/00
4-6		▨	▨	ADR 80/01, 02	▨	▨	▨		ADR 83/00
7-10		▨		ADR 80/00 ADR 70/00	▨	▨	▨		ADR 28/01
10-15	▨	▨		ADR 70/00		▨	▨	▨	ADR 28/01
15+	▨			ADR 30/00, 01				▨	ADR 28/00, 01

Source: Australian Trucking Association.

As the trucks age they are progressively allocated to shorter distances across the intrastate and short haul networks, accounting for their somewhat reduced operational reliability, such as increased servicing requirements.

Progressing into the oldest cohorts, these trucks are allocated to the short haul and local transport tasks. As noted in the ABS motor vehicle census, these older trucks are also more likely to be rigid configurations, an outcome of transforming prime movers to rigid models only towards the end of their useful lives, once they have finished on long haul routes.

This allocation decision is two-fold, where firstly smaller trucks have greater ease of access across the local networks either being granted local council approval on roads that larger trucks are not, or else they are able to drive into depots and loading stations where larger trucks are physically unable to. The second reason for this allocation is that local and short haul freight tasks are generally characterised by low profitability runs with high wait times in local traffic. Therefore, older trucks with limited capital values are used instead of high value newer trucks.

In a closed system like Australia, with limited options to export older technologies (compared for example to Europe and the United States), there is a tendency for an older average age of the fleet. For example, heavy duty trucks in the United States have an average age of almost seven years. This is compared to 10.4 years in Australia. However, given the optimisation of the freight task across these age profiles, and the projected growth of the road freight task in the future, this average is continuing to lower.

Given the growing expectations of the road freight task in Australia in the coming years, it is expected that a greater proportion of new trucks are likely to be commissioned. This influx of trucks both to replace the older existing fleet, as well as meeting the growing freight task, will work to improve the overall environmental performance of the industry, lowering the average age of the fleet and drawing newer technologies into a greater proportion of the fleet.

4 *Conclusion*

The improvement in environmental performance of the Australian trucking industry over the past 20 years has been strong. Over the period 1990 to 2011, there was an annual reduction in CO_2-e emissions per billion tonne kilometres of 2 per cent per year. Across the full fuel cycle, this equates to CO_2-e emissions per tonne kilometre in 2011 being 35 per cent below what they were in 1990.

The improvement in environmental performance of the Australian trucking industry is expected to continue, with BITRE projecting a further 10 per cent reduction in CO_2-e emissions over the period 2011 to 2020.

Where the environmental performance of the trucking industry is determined predominantly through fuel use, the environmental footprint of the industry may be affected through three main avenues:

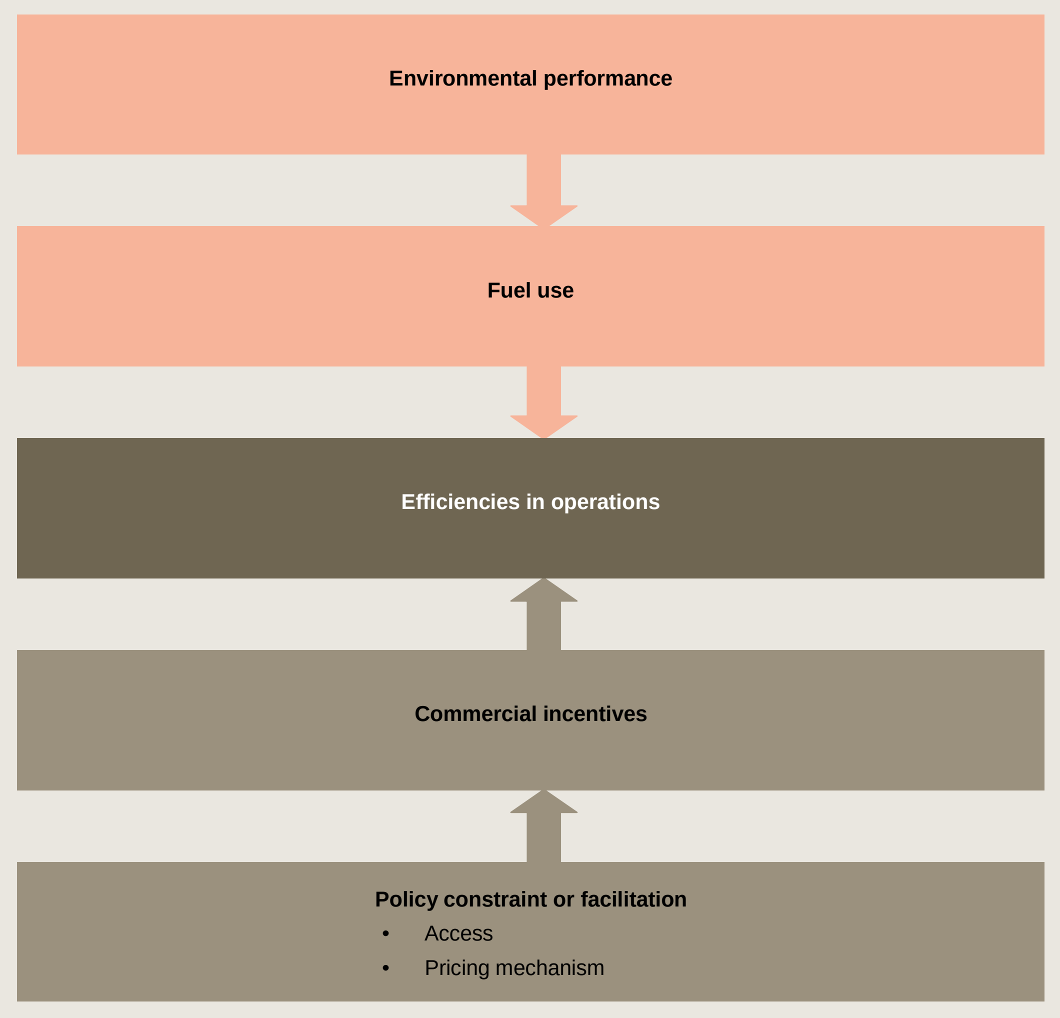
- efficiencies in operations;
- associated technologies; and
- fuel type.

While the elements may be used in conjunction with each other, it has been improved efficiencies in operation and movements towards larger and more efficient truck combinations that have been the biggest drivers of environmental performance of the entire fleet in the past. These movements towards larger and more efficient truck combinations have been undertaken voluntarily by the industry, recognising firstly the commercial incentives they hold to improve fuel efficiency, and more recently the recognition of the strong environmental benefits that are also associated with the move.

However, when considering the future potential of the industry to improve efficiency and environmental performance, it is likely to be government policies working most strongly to either facilitate or constrain this movement.

While there is currently substantial uncertainty around carbon policy in Australia, there is widespread acceptance that policies involving an explicit price of carbon provide the most transparent and cost effective means of implementing a carbon constraint within the economy. The major impact of an explicit carbon price on the transport sector is through the price of fuel. There is, in effect, a direct relationship between the dollar carbon price and the associated increase in the price of fuel.

4.1 **Continued improvement in environmental performance**



Data source: TheCIE.

The danger for the trucking industry is that should a broad based carbon price be established in the economy and fuel be excluded, there is likely to be a temptation for governments to directly regulate transport emissions through standards and efficiency requirements.

Direct regulation of transport sector emissions through standards and efficiency requirements run the risk of the transport sector paying a higher effective carbon tax than other sectors — an outcome which is economically inefficient.

An explicit carbon price, transferred through the price of fuel will provide further incentives for the trucking industry to increase fuel efficiency. The ability of the industry to make these improvements at least cost is likely to be affected heavily by access issues for larger truck combinations. It is important that the introduction of one policy mechanism to promote environmental performance (a carbon price) is not unduly constrained by associated policy mechanisms (access and logistics for larger, more efficient combinations).

The performance based standards were introduced in 2007 with the intention of removing highly prescriptive mass and dimension limits to more closely match the road freight task with high productivity vehicles and road conditions. Australian studies by the NTC have noted that substitution of 60 B-doubles and semitrailers to B-triples on inter-capital routes could reduce the number of required trips by up to 25 per cent and reduce total operating costs by around 22 per cent, saving almost 3.7 million kilometres of truck travel annually. These gains convert into approximately 2 million litres of saved diesel and 5900 tonnes of CO_2 equivalent annually (COAG factsheet, 2007).

However, progress towards the full implementation of the PBS has been slow, being hindered by inconsistencies across State and Territory government implementation, the high costs and uncertainties imposed on operators to participate and the limited flexibility observed in practice in responding the vehicle configurations (NTC, 2010).

Some of the hesitation on the part of authorities is consideration of the potential risks associated with expanded access for larger combinations. That is, where there are unclear links between granting access to larger vehicles, changes in road costs, and access to funding for road maintenance and repair, conservative approaches from State and local governments is being observed.

Beyond economies in operations, associated technologies such as aerodynamic design and reduced rolling resistance have also been researched and are beginning to be implemented both internationally and across Australia.

Restrictions on engine emissions have also provided a regulatory impetus for improved emissions technology in heavy duty diesel engines. The regulations in Australia, based on European, US and Japanese regulations, are some of the most stringent in the world. However, diminishing returns are now being observed with increasing stringency for particulate matter and nitrogen oxides most particularly beginning to adversely affect engine power and overall fuel efficiency.

This threshold effect provides additional support for a move towards broader based policy mechanisms targeting fuel efficiency (such as a carbon price) in preference to direct regulation to promote environmental improvements in the transport industry. Such a coordinated approach between governments and the Australian trucking industry will allow for the environmental performance of the industry to continue to improve in the most efficient manner.

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