NSW Green Truck Partnership

Technology assessment protocol

Prepared for

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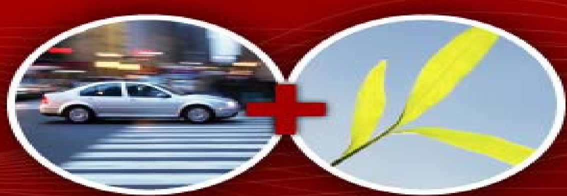

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1 Introduction

In September 2009, the NSW Roads and Maritime Services (RMS) (formerly the Roads and Traffic Authority) established the Green Truck Partnership (GTP) – a collaborative initiative between the RMS and the road freight industry.The partnership will provide the national road freight industry with real-world information on the economic, operational and environmental performance of alternative transport fuels and technologies.

The central premise of the GTP is that current uncertainty surrounding the genuine benefits of alternative technologies and fuels is making it difficult for the road freight industry to assess the merits of investment in cleaner vehicle alternatives. By first assessing the real-world performance of alternative fuels and technologies and then making the results freely available to industry, the GTP could assist the industry in identifying the options most suited to cleaner commercial vehicle operation in Australia.

A key requirement for the conduct of a programme of this nature is the development and application of a robust framework for the assessment of alternative vehicle technologies and fuels.Such a framework should not only assess the emissions and fuel efficiency benefits, but should provide the industry with information relating to its durability and operational performance relative to conventional technologies and fuels.

This paper presents thetechnology assessment protocol as developed for the GTP, with the assistance of the GTP Steering Group.

2 Background

Uncertainty about the real-world performance of alternative fuels has been (and continues to be) a major barrier to the adoption of alternative technologies in the Australian road freight sector. Addressing this uncertainty via the development of a comprehensive assessment framework will give industry greater certainty and, in turn, facilitate the industry adoption of more sustainable alternatives to conventional vehicle and fuel technologies.

One of the most significant (if not *the* most significant) barriers to the increased adoption of alternative fuels in the road freight industry involves the current level of uncertainty surrounding the real-world performance of alternative technologies.Relative to corporate passenger car fleets, the level of commercial risk involved in the adoption of a new technology that fails to deliver good economic and operational outcomes can potentially threaten the ongoing viability of a road freight enterprise.

Given that the Australian road freight industry is generally not equipped to assess the environmental credentials of alternative fuels, the industry has historically been required to rely on the testimony of alternative technology suppliersin respect of the 'green credentials' of a given technology.Such an approach carries a level of risk given the sometimes over-optimistic claims of new technology suppliers in their quest to promote increased market take-up of their products.

Alternatively, the industry has had to rely on the findings of government-sponsored demonstration projects.While these projects have traditionallyprovided good information in respect of the environmental performance of individual technologies, they often do not adequately assess the financial and operational performance of the new technologies.

Given the GTP's goal of providing the industry with case study information that is sufficiently robust to inform commercial investment decisions in the future, there is a need to develop and document a test protocol that can be used to assess the real-world performance of alternative vehicle and fuel technologies. Such a protocol must provide the road freight industry with an assessment of the performance of the new technology relative to conventional technology in terms of:

- air quality performance
- GHG performance
- operational performance
- financial performance.

3 Air quality performance

This section provides a discussion of the draft assessment methodology that will be adopted by the Green Truck Partnership to assess the air quality performance of new vehicle and fuel technologies.

3.1 Core considerations

Tail-pipe emissions of criteria air pollutants are regulated under Australian Design Rules (ADRs) that govern the design of new vehicles sold in Australia.These ADRs specify maximum limits for pollutants such as oxides of nitrogen, non-methane hydrocarbons, particulates and some air toxics.Tail-pipe limits are assessed on an engine dynamometer (i.e. engine out of vehicle) using regulated test regimes.

Until recently, Australia has not had a dynamometer capable of supporting the testing procedures for adherence to tail-pipe limits for large vehicles.Orbital Engine Corporation in Perth has since, with funding assistance from the Australian Government, developed a facility capable of conducting the necessary engine dynamometer tests – but this facility is located on the other side of the country and is likely to be expensive.

An alternative to engine dynamometer tests is the use of chassis (i.e. engine in vehicle) dynamometer testing.While this testing cannot be used to determine compliance with the absolute limits stipulated in emission ADRs, this form of testing can be used to compare the performance of a vehicle equipped with alternative technology and a conventional vehicle that is known to be compliant with tail-pipe emission limits.

A chassis dynamometer test is not as involved as an engine dynamometer test and can be conducted at a number of facilities around the country, including in NSW. In addition to providing greater accessibility to testing centres, chassis dynamometer testing is less labour intensive and less expensive than engine dynamometer testing.

A further consideration is the nature of the test regime to be adopted.Three test regimes are available including the 13 Mode test, the DT80 test and the Composite Urban Emission Drive Cycle (CUEDC) test.Of these, the CUEDC test is considered to be the most appropriate for comparison of heavy vehicle air quality performance given that it more closely mirrors real-world driving conditions.

3.2 Assessment methodology

The air quality performance of the *test vehicle* (fitted with the trial vehicle or fuel technology) will be assessed by comparing the tail-pipe emissions of the new technology vehicle against a *baseline vehicle* (i.e. an equivalent conventional vehicle).

3.3 Test regime

The tail pipe emissions of both the test vehicle and the baseline vehicle will be measured via a series of CUEDC tests using a heavy vehicle chassis dynamometer equipped with a five-gas analyser.

Given the potential influence of vehicle operating temperature on emission test results, successive CUEDC tests will be conducted on each vehicle until such time as the NOx and PM results of two successive tests vary by less than 5%.

3.4 Baseline vehicle specifications

The baseline vehicle will ideally be identical to thetest vehicle.This may be achieved by conducting an assessment of the test vehicle prior to the installation of new technology and then measuring the performance of the vehicle after the new technology (or fuel) has been fitted.

Alternatively, an identical vehicle (i.e. same engine family, engine rating, and transmission settings) could be used as the baseline vehicle.

The baseline vehicle must be a current model vehicle (i.e. compliant with prevailing ADRs).

Both the baseline vehicle and the test vehicle should be serviced immediately prior to the testing and tuned in accordance with manufacturer specifications (or they should be known to be well maintained at the time of testing).

3.5 Results

Test results will be collated for each of the criteria pollutants covered under the emission design rules. The emission results of the test vehicle will then be reported as a percentage of the emission results of the baseline vehicle and summarised in graphical format.

4 GHG performance

The GHG emissions of a vehicle are directly related to the total volume of fuel that is burned by the vehicle during normal operation. As a consequence, measurement of changes in the fuel consumption (or energy consumption in the case of alternative fuels) can be used to compare the GHG performance of new technologies with that of conventional technologies.

This section provides a discussion of the draft assessment methodology that will be adopted by the Green Truck Partnership to assess the GHG performance of new vehicle and fuel technologies.

4.1 Core considerations

As with assessment of air quality performance, the GHG performance of a test vehicle can be assessed by comparing the performance of the test vehicle against that of a baseline vehicle (i.e. identical or equivalent vehicle).

While the GHG performance of a test vehicle (fitted with new technology) can be measured in a laboratory using a chassis dynamometer, and potentially compared with that of a baseline vehicle, such an approach has several limitations:

- The test cycle is unlikely to reflect real-world fuel consumption and will provide only a comparison for those modes of operation that are assessed under the test.As a consequence, the test result for both the baseline vehicle and the test vehicle may be artificial.

- A chassis dynamometer test cannot take due account of the performance of the vehicle when loaded and generally measures only the performance of the prime mover.As a consequence, technologies that are load sensitive may provide false results relative to the baseline vehicle.

- A chassis dynamometer test cannot take due account of environmental conditions such as prevailing wind and associated wind resistance (unless combined with a wind tunnel).Nor can it measure the performance of technologies that reduce rolling resistance such as low rolling resistance tyres.

An alternative to the chassis test is a 'closed-circuit' or 'test track' evaluation.While this approach minimises the project burden on the transport operator, these tests generally do not reflect real-world conditions as they fail to take account of terrain.

In-field measurement of fuel performance provides the best measure of GHG emissions of a given vehicle.An increasing range of affordable vehicle measurement hardware and telemetry systems mean that the data burden associated with this form of measurementhas greatly decreased in recent years.

The key challenge with this approach relates to the need to ensure that the drive cycles of both the test vehicle and the baseline vehicle are similar. This can be achieved by recording the drive cycle of both vehicles (e.g. average speed over time, stopping frequency over time) and then comparing the vehicle 'trace' of each vehicle to ensure that the comparison is valid (Figure 1).

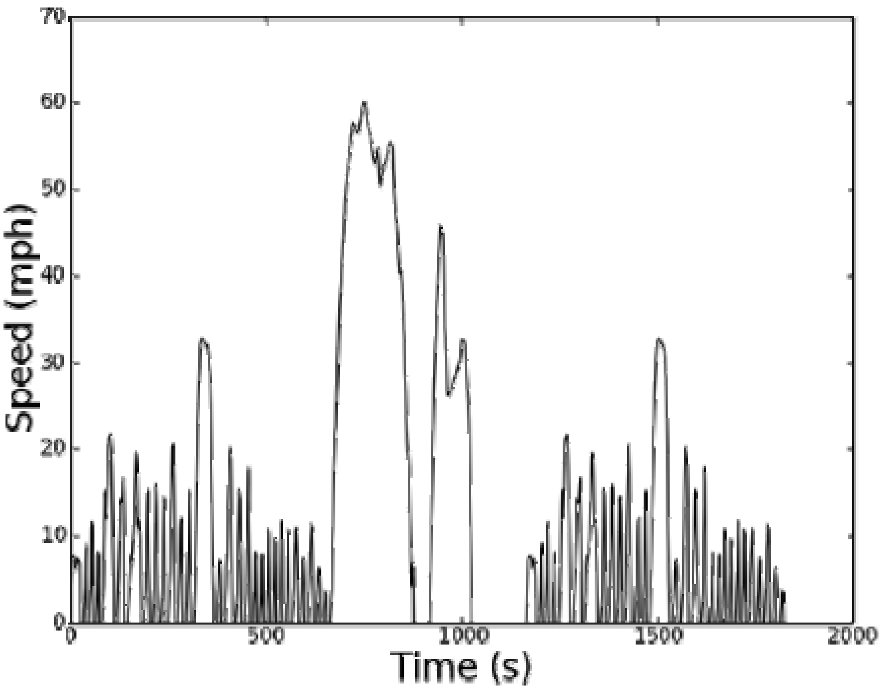

Figure 1 Example of drive cycle trace (as defined by speed versus time relationship)

4.2 Assessment methodology

The GHG performance of a test vehicle (fitted with the trial vehicle or fuel technology) will be assessed by comparing the fuel consumption (or energy consumption in the case of alternative fuels) of the test vehicle against a baseline vehicle (i.e. an equivalent conventional vehicle).

4.3 Test regime

Fuel consumption data will be collected on a daily basis via the installation of a CANgate bus (or similar device) to the baseline vehicle. Ideally the test vehicle and the baseline vehicle will be the same vehicle, with measurement occurring on a before technology application and after technology application basis.

Aggregate fuel consumption data will then be recorded for the baseline vehicle, together with a speed versus time trace, on a daily basis for a period of not less than one month.

Following completion of this work, the measurement hardware will be fitted to the test vehicle (or the baseline vehicle converted to new technology operation). Following a suitable running-in period, fuel consumption and drive cycle data will again be collected for the test vehicle. Data will be collected for a minimum of three months of operation.

4.4 Baseline vehicle specifications

Ideally,the baseline vehicle will be identical to the test vehicle.This may be achieved by conducting an assessment of the vehicle prior to the installation of new technology and then measuring the performance of the vehicle after the new technology (or fuel) has been fitted.

Alternatively, an identical vehicle (i.e. same engine family, engine rating and transmission settings) could be used as the baseline vehicle.

The baseline vehicle must be a current model vehicle to provide a contemporary baseline of vehicle fuel consumption.

Both the baseline vehicle and the test vehicle should be serviced immediately prior to the testing, and maintained in accordance with manufacturer specifications for the duration of the testing process.

4.5 Results

Upon completion of data collection for the test vehicle, the daily fuel consumption of the test vehicle will be compared with that of the baseline vehicle to derive average daily fuel consumption for each vehicle.

Where a daily drive cycle varies significantly from the typical drive cycle of the vehicle (for the baseline vehicle and/or the test vehicle) the fuel consumption recorded on that particular day will be excluded from the analysis.

The average daily fuel consumption of the test vehicle will then be calculated and reported as a percentage of the baseline vehicle.

5 Operational performance

The operational performance of a new technology relative to incumbent conventional technology is an important consideration in the market adoption of that technology in the road freight industry. Ideally, the new technology should not:

- impose increased maintenance costs
- result in increased vehicle downtime
- adversely affect the driveability of the vehicle.

This section provides a discussion of the draft assessment methodology that will be adopted by the Green Truck Partnership to assess the operational performance of new vehicle and fuel technologies.

5.1 Core considerations

The operational performance of a vehicle can be characterised by several dimensions – both qualitative and quantitative.These include (a) vehicle maintenance costs, (b) vehicle down time, (c) drive perceptions of vehicle performance, and (d) real-time assessment of vehicle performance.

Most fleet operators maintain good records in terms of costs associated with maintaining their fleet.This is generally broken down in terms of the cost of vehicle parts and the cost of mechanical labour.This baseline can be used to compare the maintenance costs of a new technology vehicle in terms of cost of parts and mechanical labour, provided the vehicle is operated for a reasonable test period.

Vehicle downtime is also something that is generally collected by fleet managers in individual vehicle log books, thus providing a baseline for future compare

ison.The performance of a new technology vehicle can then be compared by keeping a similar log over a representative period of time (i.e. 3–6 months).

Driver perceptions of the performance technology of a new technology vehicle can be obtained by ‘before’ and ‘after’ surveys. The qualitative information collected by this process can be correlated against the actual performance of the vehicle, possibly measured by comparing the trace of the drive cycle (i.e. speed versus time relationship) on a before and after basis.

5.2 Assessment methodology

It is suggested that the assessment of operational performance of a vehicle would be determined by a comparison of the test vehicle with a baseline vehicle over a minimum three-month period in terms of (a) vehicle maintenance costs, (b) vehicle down time, and (c) vehicle driveability.

5.2.1 Vehicle maintenance costs

A record of the costs of maintaining the test vehicle (separated by labour and parts) would be kept over the duration of the test period and then compared with those of the baseline vehicle.

5.2.2 Vehicle downtime

A record of the amount of time the test vehicle spends off-road (recorded by scheduled and unscheduled time – and excluding accidents) would be kept over the duration of the test period and then compared with that of the baseline vehicle.

5.2.3 Vehicle driveability

Vehicle driveability would be assessed by both a qualitative and quantitative technique.The qualitative technique would involve the conduct of driver interviews prior to and immediately following the test period.The 'before' interviews would gauge driver preconceptions while the 'after' interviews would assess opinion on actual performance of the vehicle.The results would be used to prepare a qualitative assessment of the operational performance of the new technology.

In addition, the drive cycle traces (i.e. speed versus time) would be compared on a 'before' and 'after' basis to determine whether the technology had any marked impact on the vehicle drive cycle (i.e. slower acceleration rates or lower top-end speed).The results of this quantitative analysis could be used to validate the qualitative driver feedback.

5.3 Baseline vehicle specifications

Ideally, the baseline vehicle will by identical to the test vehicle.Alternatively, an identical vehicle (i.e. same engine family, engine rating, and transmission settings) could be used as the baseline vehicle.The baseline vehicle must be a current model vehicle.

5.4 Results

A comparison of the operational performance of the test vehicle relative to the baseline vehicle will be conducted and reported in terms of any variation in:

- annualised maintenance costs (separated by parts and labour)
- vehicle downtime (scheduled and unscheduled)
- vehicle driveability.

6 Financial performance

The capital cost of new technology is typically higher than that of conventional technology. Suppliers argue that this additional cost is offset by savings in recurrent costs (i.e. fuel savings and vehicle maintenance costs). Quantification of the overall financial benefit to the operator is therefore a key consideration in any assessment of a new technology for the road freight industry.

This section provides a discussion of the draft assessment methodology that will be adopted by the Green Truck Partnership to assess the financial performance of new vehicle and fuel technologies.

6.1 Core considerations

The financial performance of any road freight vehicle is a factor of (a) the capital cost of the vehicle, (b) capital depreciation, (c) recurrent operating costs, (d) any payload considerations, and (e) the residual value of the vehicle at the end of its operating life. All of these factors can be used to derive an estimate of the whole-of-life value of the vehicle with appropriate consideration of discounted cashflows and cost of capital.

Application of a whole-of-vehicle life analysis is generally not a suitable indicator for assessing the financial performance of a new technology vehicle.Variations in company policies on operable vehicle life, net fuel costs and capital costs can distort the analysis to the point that it is not useful as a case study. Release of this sort of information is also generally commercially sensitive.

An alternative to the whole-of-vehicle life approach is the conduct of a payback analysis.That is, the time taken to recoup the additional capital cost of the new technology vehicle relative to a conventional vehicle.Under such an approach, standard assumptions can be applied for fuel cost and capital costs, thereby increasing the relevance of the data for the wider road freight community.

6.2 Assessment methodology

An estimation of the typical payback and NPV of technology benefits will be derived based on an assessment of the variations in the capital and recurrent costs of the test vehicle when compared with an equivalent conventional vehicle. In preparing this analysis, a cost price index (CPI) of 3.4% will be assumed and a 10% cost of capital will be applied.The baseline fuel cost used in the analysis will be the average diesel retail price over the trial period (less GST and excise rebates).

Key elements of the financial analysis will be derived in terms of:

- additional capital cost
- changes in vehicle recurrent costs (i.e. fuel, parts and maintenance labour)
- extraordinary costs (i.e. project-related costs and exceptional lost time)
- payload penalties (if applicable).

6.3 Results

The findings of the financial analysis will be reported, together with all core assumptions, in terms of (a) additional capital investment costs, (b) payback on additional capital investment, and (c) discounted net present value over operable life.

7 Summary

The material presented in this paper provides a considered framework for the assessment of the real-world performance of alternative technology for the road freight industry in terms of:

- air quality performance
- GHG performance
- operational performance
- financial performance.

In designing this framework, due consideration was given to the need to maximise the integrity and industry utility of key analysis findings while also minimising the data collection burden and navigating potential commercial sensitivities.