



Camden Council Biodiesel Truck Trial

Final Report

Prepared by Camden Council



March 2005



Camden Council Biodiesel Truck Trial

Final Report

ACKNOWLEDGMENTS

This biodiesel trial was the combined efforts of many individuals. Camden Council would like to take this opportunity to thank the following people who provided invaluable assistance and input during the trial, without which this trial would not have been the success it was:

Jayne Christie, Kevin Douglass, Geoff Green, Tony Grant, Steve Barrett, Bob McHutchison, Danny Dingle, Denise Franovich, Richard Mooney, Kristy Leshone, Bryan Beudeker, Adrian Lake, Gary Dallwitz, Luke Phillips, Wayne Scott, Bruce Dowdell, Jacqui Davies, Kerry Lack, Kelsey Bawden, Brian Crockett, Robert Elsley, Michael Gerace.



Table of Contents

EXECUTIVE SUMMARY	1
1 INTRODUCTION.....	4
2 BACKGROUND	5
2.1 SHORT HISTORY OF BIODIESEL	5
2.2 AIR POLLUTION IN SYDNEY	7
2.3 THE TRIAL	8
2.4 THE PROPOSAL	9
2.5 THE TRIAL PARTNERS	10
3 TRIAL PROGRAM.....	11
3.1 EQUIPMENT	11
3.2 OPERATIONAL ASSESSMENT PROGRAM.....	12
3.3 EMISSIONS TEST PROGRAM AND TEST METHODS	13
4 OPERATIONAL RESULTS.....	15
4.1 VEHICLE PERFORMANCE – FUEL CONSUMPTION AND POWER	15
4.2 FUEL QUALITY	16
4.3 IMPLICATIONS OF FUEL QUALITY	17
4.4 EFFECTS ON ENGINE OIL QUALITY	18
4.5 EFFECTS ON ENGINE WEAR.....	18
4.6 DRIVER FEEDBACK	19
5 EMISSION RESULTS SUMMARY.....	21
6 DISCUSSION OF TRIAL RESULTS.....	22
6.1 OPERATIONAL PERFORMANCE.....	22
6.2 EMISSIONS.....	23
6.3 COST BENEFITS	23
7 MEDIA AND EDUCATION	25
8 CONCLUSION.....	27



APPENDIX A PROMOTIONAL PAMPHLET

APPENDIX B SEMINAR PRESENTATION

APPENDIX C GILBARCO REPORT

APPENDIX D RTA EMISSIONS REPORT

APPENDIX E PAE EMISSIONS REPORT

APPENDIX F TRI- CITY REPORT

APPENDIX G DIESEL GREEN REPORT



Executive Summary

In pursuit of:

- sustainable operation;
- the broader objectives of Council's Strategic Plan – Camden 2025 , and
- the specific objective to “ Reduce greenhouse gas emissions through increasing energy efficiency”,

Camden Council investigated opportunities for reducing its consumption of fossil fuels through initiatives involving alternative / renewable fuels. In particular, Council sought to reduce tailpipe emissions from its diesel powered waste collection fleet.

Biodiesel – an alternative renewable fuel manufactured from vegetable oils, recycled cooking grease, and/or animal fats – was selected as the preferred fuel as it is reported to produce superior emissions quality and is directly interchangeable with conventional petroleum diesel in diesel engines.

A six (6) month trial conducted during 2003/2004 comparing the performance of 100% Biodiesel (B100) to ultra-low sulphur diesel (ULSD), less than 50ppm sulphur, in two (2) of the Council's waste collection vehicles under normal operating conditions was proposed and subsequently implemented.

The objective of this report is to provide a background and overview of the operational process employed during the Camden Biodiesel Truck Trial together with an overall assessment of the trial's effectiveness, a summary of the findings, and the recommendations for the future use of biodiesel for Camden Council.

Technical reports detailing the assessment and analysis techniques used by specialist consultants undertaking testing, together with their review and interpretation are provided, in whole, in the appendix documents.

Measured results obtained under the supervision of the Roads and Traffic authority (RTA) revealed the use of B100 achieved reduction in tailpipe emissions for the following pollutants:

- Smoke (reduced 79%)
- Particulates (reduced 91%)
- Hydrocarbons (reduced 68%)
- Carbon dioxide (reduced 4%)¹.

No significant difference was recorded, at the 95% confidence level, in respect of NOx emissions.

¹ The carbon dioxide reduction noted in the study refers to tailpipe emissions only. Whilst not part of this study, it should be recognised that additional carbon dioxide emission reduction benefits are also provided by biodiesel due to its production from renewable feedstocks.



The affect of the B100 biodiesel fuel on tailpipe emissions of air toxics revealed:

- Emission rates of the priority VOCs were significantly reduced. Styrene increased
- C1 – C3 aldehyde compounds were generally unaffected except possibly acetaldehyde, which showed some decrease
- PAH compounds decreased by 75%, although for both fuels, the PAH levels were generally close to detection limits therefore these observations should be treated as indicative only.

No significant difference was recorded, at the 95% confidence level, in fuel consumption under the controlled test conditions. This result was consistent with the operational trial, which indicated no increase in fuel consumption for the vehicles when measured in litres per hour and a slight increase in biodiesel fuel consumption of 3% for the vehicles measured in litres per kilometre.

A power loss of 17% at 80 kph was recorded under test conditions on the dynamometer. The reported power loss may be attributed to the ester content of the fuel or, more likely, a greater proportion of shorter chain fatty acids in the feed-stocks for the fuel used in the trial, which were sourced from used cooking oil (UCO).

The potential loss of performance attributed to the reported power loss from the biodiesel was not readily observed by the drivers during the operational trial. This was due to the driving mode under which the waste trucks are operated, i.e. the low speed stop-start nature of domestic waste collection, where maximum power is not required.

It is also important to note, that the performance characteristics of each fuel may vary across the operating range of the engines to provide a different power / torque curve for each fuel, but this was not measured on the dynamometer test.

Before the trial, the biodiesel truck engine was dismantled and assessed for condition. Two independent mechanical assessments undertaken at the completion of the trial showed no evidence of abnormal mechanical wear and tear for the biodiesel truck compared with the use of petroleum diesel.

The engine oil in biodiesel vehicle was tested after each service to monitor potential dilution of engine oil. The results showed no dilution of oil with the use of biodiesel compared with ULSD.

A range of operational and fuel quality related issues were experienced during the trial highlighting the infancy of the biodiesel production industry in Australia. This demonstrated the need for consistent achievement and maintenance of fuel quality production standards and the importance of producers knowing and meeting consumer requirements.

The Camden Council Biodiesel Truck Trial was partnered by the private sector and both State and Federal Governments and received funding under the Local Air Improvement Program Grants funded through the Clean Air Fund of the NSW Department of Environment and Conservation.

The results of this study are generally consistent with overseas studies and provide a sound foundation for Camden Council, and other diesel users in Australia, to consider adopting biodiesel, a more environmentally responsible fuel that not only contributes to a reduction in our reliance on the world's ever diminishing fossil fuel supplies but also directly and positively contributes to improvements in local, regional and global air quality issues.



Camden Council also participated with Newcastle City Council in three seminars organised as part of the trial to inform NSW local government Councils (and other interested parties) of the results of the biodiesel trials in order to promote and facilitate the adoption of biodiesel in local government fleets.

Further information relating to Camden Council's Biodiesel Truck Trial can be obtained from:

JAYNE CHRISTIE

ENVIRONMENTAL HEALTH OFFICER - CAMDEN COUNCIL

Phone: (02) 4654 7777

Email: jaynec@camden.nsw.gov.au



1 INTRODUCTION

Camden Local Government Area (LGA) is located on the urban fringe of Sydney approximately 61km southwest of the CBD. It is a predominantly rural/semi-rural community with low-density urban development and small commercial/industrial activity. The LGA has experienced considerable urban growth in recent years and will continue to be subject to rapid growth over the coming decades with the release of South Western Sydney Urban Release Corridor – development that will bring an additional 300,000 residents to the local area.

In the early 1990's Camden Council began to take particular interest in local air quality issues when independent studies including that of Hyde and Johnson (1990)* and the NSW Government's Metropolitan Air Quality Study (MAQS)** made it abundantly clear that the Camden LGA and particularly the Camden Basin – a geographical basin existing within the LGA - experiences poor air quality arising predominantly from activities outside of Council's geographical and regulatory areas of influence. In fact the MAQS confirmed that a pollution load contributed to by almost the entire Sydney Air Shed passes through the Camden LGA (and Sydney's greater west) daily visiting and revisiting until meteorological conditions suitable for its dissipation prevail.

*Ref: Hyde R. and Johnson G.M. Dec.1990 Pilot Study: Evaluation of air quality issues for the development of Macarthur South and South Creek Valley regions of Sydney. Prepared for the NSW Dept of Planning, NSW SPCC, Commonwealth Dept of Transport and Communications, Domestic Aviation Division. RIR 1885R.

**Ref: Metropolitan Air Quality Study – Outcomes and Implications for Managing Air Quality NSW EPA March 1996 ISBN 0 7310 3755 3

It also became clear that the single most significant source of pollutants in the Sydney Air shed was, and still is, motor vehicle exhaust and that those vehicles operating on conventional petroleum based diesel fuels contributed by far the most harmful emissions in our air - particulates.

In 1999 Council produced a Strategic Plan – Camden 2025* – promoting actions to improve local air quality and supporting sustainability, greenhouse gas reduction and energy efficiency. As operators of a medium sized vehicle fleet and accepting the responsibility of setting an example for the community Council sought to reduce its contribution to local air pollution by reducing its consumption of fossil fuels and reducing tail pipe emissions from its fleet.

REF: *Camden 2025 – A Strategic Plan for Camden Adopted December 1999

Council considered a range of alternative fuels including compressed natural gas (CNG), liquid petroleum gas (LPG) and low sulphur diesels for use within Council's diesel-powered waste collection fleet and determined the use of biodiesel provided a significant opportunity to reduce air pollutant emissions. Biodiesel also presented as an economically attractive option having comparable point-of-sale price to diesel and requiring no costly retrofitting/conversion of vehicles or loss of payload (on waste collection vehicles).

Camden pursued the use of biodiesel as a potential alternative fuel in the anticipation that fuel produced to the Australian Biodiesel Standard would be readily available in commercial quantities from production facilities being constructed in NSW by 2005. Commissioning of a plant on the NSW Central Coast was due for completion in early 2005, with full production of 40 million litre per annum expected by the end of 2005.



2 BACKGROUND

2.1 Short History of Biodiesel

Biodiesel is a renewable, non-fossil, biodegradable, ester-based oxygenated fuel that is typically manufactured from vegetable oils, tallow and/or spent cooking oils.

Although little known, the concept of using vegetable oil as a fuel dates back to 1895 when Dr Rudolph Diesel developed the first diesel engine, which could run on vegetable or mineral oils. The diesel engine was demonstrated at the World Exhibition in Paris in 1900 using peanut oil as a fuel.

Biodiesel in the USA

The production and usage of biodiesel in the US has shown significant growth in recent years with production figures showing increases from approximately 2.3 million litres (500,000 gallons) in 1999 to approximately 104.5 million litres (23 million gallons) in 2003 (USA National Biodiesel Board - NBB). The NBB is the leading organisation for the biodiesel industry in the USA. Its website www.biodiesel.org provides an excellent source of information on the fuel itself and its current status in the USA.

The health and environmental merits of biodiesel have of course contributed to this growth, eg:

- In June 2000, the health benefits of biodiesel were given recognition by the US Federal Government when it announced that biodiesel had become the first and only alternative fuel to successfully complete the health effects testing required by the Clean Air Act Amendments of 1990. *Journal of Environmental Health, 1 Nov 2000.*
- The benefits with respect to air quality were acknowledged by the New York State Energy Research & Development Authority (NYSERDA), when it awarded US\$62000 to trial biodiesel fuel in Niagara Frontier Transportation Authority in its bus fleet in 2001. The President of NYSERDA acknowledged that biodiesel provides a 'cleaner energy technology to improve air quality.' *National Biodiesel Board Website, March 2002.*

There are many good examples of biodiesel use in the US including:

- The U.S. Army, Navy, Air Force and Marines all use B20 at different bases and stations throughout the country in a variety of mostly non-tactical diesel powered vehicles and equipment (NBB Bulletin, 2003).
- The Department of Energy's National Clean Cities Program (CCP), which was established in 1993. The Clean Cities Programs across the USA serve as a public/private partnership designed to promote the use and infrastructure for alternative fuel vehicles (AFV) and provide local air quality improvements. Biodiesel is supported by the CCP and many of its member cities as indicated in APPENDIX A
- A San Francisco Bay-area recycling company runs its trucks on 100 percent biodiesel. The company, which bills itself as implementing "comprehensive recycling and garbage collection



that goes a step beyond other kerbside programs,” was fuelling all of its 94 recycling and garbage trucks exclusively on biodiesel in 2003. In a press release, the company was quoted as saying: “You’ll start to see more people using 100 percent biodiesel, in California especially, because of the air quality laws that are coming into effect shortly.” http://www.worldenergy.net/articles/San_jose.htm.

Further examples of biodiesel use in the USA through the Clean Cities Program can be found at the US Department of Energy’s Clean Cities website at: <http://www.eere.energy.gov/cleancities>.

Biodiesel in Europe

Biodiesel is also used extensively across Europe, and there are many new projects under way in the European Union (EU) as a result of the ambitious EU Biofuels goal (ethanol and biodiesel) of 2% of all fuel by 2005 and 5.75% by 2010. EU governments are endeavoring to promote the use of biodiesel (and ethanol) in response to high crude oil prices and tough targets to cut greenhouse emissions. For example, in February 2005 the Association of German Biodiesel Producers reported that Germany’s biodiesel industry is currently working at full capacity and believes that it is on course to meet the EU biofuels goal.

In early 2004, Germany permitted oil companies to mix biodiesel with conventional diesel fuels and Germany’s Environment Ministry is confident that the new rules on blending biodiesel with conventional diesel fuel has already significantly increased use.

Growth in sales for blending with conventional diesel fuel is forecast to rise from 15 percent in 2004 to as much as 40 percent in 2005 according to the Association of German Biodiesel Producers chairman. The Association estimates Germany’s 2004 biodiesel output at around one million tonnes (largely made from rapeseed) against 720,000 tonnes in 2003 and 550,000 in 2002. With several new biodiesel plants coming into production, Germany’s 2005 biodiesel output could rise to 1.4 to 1.6 million tonnes.

Biodiesel in Australia

Until recently, biodiesel was not commercially available in Australia. However, concerns over the health impacts of diesel emissions, stricter fuel quality standards and air emission limits and policies encouraging greenhouse gas mitigation have spurred the activities to commercialise biodiesel locally. Recent increases in world oil prices, combined with improved production and lower feedstock costs of biodiesel have now made biodiesel more economically competitive further contributing to industry development.

In 2004 the Federal government in Australia provided \$35 million in Biofuels Infrastructure Grants to expedite the commercial production of biofuels in Australia. \$23 Million was awarded to biodiesel production with the rest being given to ethanol production, demonstrating the Government’s commitment to the use of renewable bio-fuels in Australia, especially biodiesel.

In addition to the NSW Central Coast plant, at least four more plants (in NSW, Victoria, South Australia and Queensland) are scheduled for completion by the end of 2006, supplying a total capacity of approximately 280 million litres per annum (approximately 2% of Australia’s total diesel consumption).



Environmental Benefits

Much of the available relevant studies relating to the use of biodiesel have been conducted in the United States. In 2002 the United States Environmental Protection Agency (USEPA) compiled a report that reviewed and analysed available biodiesel emissions data. The report, titled "*A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions*" reviewed eighty (80) separate studies relating to emissions from biodiesel-powered vehicles, many of which were relevant to the Camden trial.

Ref: "A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions" USEPA 2002.

Biodiesel powered engines have a different emission profile to those powered by petroleum diesel. In general, the literature indicates that emissions of particulate matter (PM), hydrocarbons (HC) and carbon monoxide (CO) should decrease and emissions of oxides of nitrogen (NO_x) should increase as a result of substitution with biodiesel.

Tailpipe emissions of carbon dioxide CO₂ are also expected to increase, although over the lifecycle of the fuel (assuming the biodiesel is produced from a renewable resource) emissions of CO₂ should decrease significantly.

The particulate matter produced by biodiesel is mainly unburnt fuel, which is non-toxic compared to carcinogenic diesel emissions. The net health benefit of the reduced particulate emissions, according to the Ames Mutagenicity test, is that biodiesel provides a 90% reduction in cancer risks.

Further, exhaust emissions of sulphur oxides and sulphates (major components of acid rain) from biodiesel are essentially eliminated compared to petroleum diesel.

The literature (USEPA, 2002) also indicates that emissions of air toxics, on aggregate, are expected to decrease as a result of substitution with biodiesel. Individual air toxics are more difficult to consider as data is limited. Biodiesel also reduces polycyclic aromatic hydrocarbons (PAH) when compared to petroleum diesel exhaust.

2.2 Air Pollution in Sydney

Air quality issues can be considered at three levels:

- **Global:** greenhouse gases such as carbon dioxide (CO₂) and the depletion of the stratospheric ozone;
- **Regional:** photochemical smog, sulphur dioxide (SO₂) and fine particle pollution; and
- **Local:** fine particles, carbon monoxide (CO), sulphur dioxide (SO₂), lead and other air toxics.

Air is considered polluted when it is contaminated with substances in concentrations, which are harmful, or likely to be harmful, to the health or amenity of humans and their environment.

The Metropolitan Air Quality Study (MAQS) clearly identified motor vehicles as major sources of pollutants in the Sydney Region noting the disproportionate contribution of diesel vehicles to some



emissions criteria, notably fine particulates and a variety of air toxics, such as benzene, toluene, xylene and polycyclic aromatic hydrocarbons (PAHs).

The 2003 State of the Environment Report published by the NSW Department of Environment and Conservation (DEC) discusses the impacts and growing concerns for fine particle pollution on human health noting the link between the long-term exposure to air pollution, including fine particles, with reduced life expectancy. The major sources of these fine particles in urban areas, in the absence of bushfires, are diesel vehicles, hazard reduction burning and domestic wood heating.

In addition to fine particles, motor vehicles running on fossil fuels release NO_x, reactive hydrocarbons and other air toxics responsible for photo-chemical smog. Motor vehicles contribute approximately 70% of emissions of NO_x and about 52% of volatile organic compounds (VOC) emissions in the greater metropolitan region of Sydney (NSW EPA, 2000).

2.3 The Trial

Having regard to the local environmental circumstances and the potential air quality improvements reportedly afforded by using biodiesel, Council developed and implemented an Operational Trial to assess the viability of using biodiesel in it's waste collection vehicle fleet and to confirm the potential improvements in tail pipe emissions when using biodiesel under local conditions.

The **objectives** of the Camden Biodiesel Truck Trial were to:

- Determine operational performance and emission characteristics of biodiesel (B100) compared with ultra low sulphur diesel (ULSD) with a view to convert the Camden Council diesel fleet to biodiesel.
- Undertake a cost benefit analysis to evaluate environmental performance and risks with the operational costs between conventional petroleum diesel and biodiesel.
- Undertake an emissions verification trial to quantify and compare emissions of both fuels under operational conditions.
- Raise community awareness in the domestic, commercial and government sectors of the potential environmental benefits of using biodiesel as a transport fuel. Showcase the trial and make the findings from the trial public and available for review by other councils and the community subject to a successful outcome.

The objectives were determined to ensure:

- Council's waste vehicle fleet was not put at risk, and
- The performance of the vehicles would not be compromised and unacceptably increasing Council's running costs.

Further, the information obtained from the trial was to be:

- of a quality that could withstand scientific scrutiny, and



- readily transferable to other communities so as to achieve both direct and indirect improvements in Camden's local air quality.

2.4 The Proposal

The trial, as proposed, was to be conducted in two waste collection (garbage) trucks over a period of approximately six (6) months from September 2003 to March 2004. One truck (the test vehicle) was to run on biodiesel (B100 – 100% biodiesel) while the other (the control vehicle) was to run on ultra low sulphur diesel (ULSD), less than 50ppm sulphur. Each vehicle was to operate as normal for approximately three months on each of two designated service routes.

Base information was to be gathered concerning the condition of the vehicles prior to commencement and extensive tests were to be conducted on emissions and engine performance during the trial. The biodiesel truck engine was to be pulled down at the beginning and the conclusion of the trial to assess wear.

The engine oil was to be analysed after each service to determine potential impacts of biodiesel on oil quality as other overseas trials had reported a dilution of engine oil when using biodiesel.

The selection of the waste collection (garbage) vehicles was based on the simplicity and impact of their operation. These vehicles operate daily in residential areas, performing repetitious tasks that can be readily monitored, compared and duplicated for validity. The choice of vehicle also afforded:

- opportunities for direct information sharing across local government and through the extensive related commercial waste industry, and
- potential for widespread uptake of the results and benefits.

Each day a typical waste truck in Camden uses approximately 80 to 100 litres of fuel. When multiplied over the waste collection industry within the Sydney basin, the use of cleaner fuels could have significant beneficial impacts on the air we breathe. The availability of an easily adopted alternative for diesel users that achieves this goal was therefore clearly worth pursuing.

The trial was designed to assess levels of tail pipe emissions of oxides of nitrogen, carbon monoxide, particulates, air toxics and smoke together with operational performance and cost. The final emissions testing procedure and test methods were determined in consultation with the NSW Department of Environment and Conservation (DEC) and the Roads and Traffic Authority (RTA).

An educational program was developed for the purposes of disseminating the results of the trial and was integral to the completion of the project. It was proposed to be implemented with a focus on Local Government networks, and included three forums presenting the outcomes of the trial to other Councils on the completion of the trial. Details of the media and education information disseminated are provided in Section 7. A copy of the Camden Council promotional pamphlet is provided as Appendix A and a copy of the PowerPoint presentation given at the forums is provided as Appendix B.



2.5 The Trial Partners

Project management and operation was co-ordinated by Camden Council with specialist input from the selected project partners. The project team included:

- **Camden Council** – (owner / operator of vehicles, reporting, promotions)
- **NSW Department of Environment and Conservation –(DEC)** - (funding)
- **The Australian Biodiesel Consultancy – (ABC)**– (Fuel Supplier, technical advice and project facilitation)
- **Pacific Air and Environment (PAE)**–(Air Quality Consultants – technical management and reporting.)
- **Cummins Engines** – (Engine Manufacturer / technical advice)
- **Tri-City Trucks (NSW) Pty Ltd** –(Vehicle servicing and assessment, technical advice oil analysis)
- **Gilbarco Australia Limited** – (Provider of fuel dispensing equipment, servicing and calibration)
- **Roads and Traffic Authority (RTA)** - (Technical advice, emissions testing and analysis in conjunction with Commonwealth Department of Environment and Heritage and CSIRO, reporting).

Each of the partners participated throughout the trial in a series of technical planning and progress meetings contributing advice, technical support and services from their respective expertise.



3 TRIAL PROGRAM

3.1 Equipment

Test Vehicles

The two test vehicles were International ACCO 2350G waste collection trucks powered by Cummins ISC 250 HP engines and fitted with Allison MD 3560 PR 5 speed automatic transmissions. Both vehicles were manufactured in March 2002 to Australian Design Rule (ADR) 80 for emissions. Both vehicles were fitted with an Engelhard CCX Oxidising Catalyst (for diesel engines).

The trucks were of similar age, with comparable operating hours and kilometres and were less than nine (9) months old at the beginning of the trial. Both vehicles were used exclusively for domestic garbage collection.

Both vehicles were run as standard without alteration or re-tuning to accommodate the use of the alternative fuel.

Fuel

The proposed test fuels were:

- ❑ Automotive Ultra Low Sulphur (<50 ppm) Diesel (ULSD) meeting the Australian standard for automotive diesel set under the Fuel Quality Standards Act 2000; and
- ❑ B100 Biodiesel (100% biodiesel) meeting the Australian standard for biodiesel set under the Fuel Quality Standards Act 2000.

B100 can be made from a range of feedstocks including used cooking oils (UCO), tallows (animal fats) and / or virgin oils. Used cooking oils may contain up to 40% tallow.

The precise composition of the feedstocks used in each production batch is, however, technically very difficult to determine except where a single source of supply is used as all oils and fats have a very limited range of fatty acids and so cannot be readily separated and defined when mixed. Unlike petroleum oils used in petroleum diesel, which may be subject to considerable variability and contamination, fats and oils are far more consistent in their makeup.

All fuels were to be supplied to Council with Certificates of Analysis stating the fuel's specifications and compliance with the relevant Australian Standards.

No additives were used to enhance the operation or performance of either fuel.

Fuel storage was managed in clearly designated separate holdings for each of the fuels. The diesel fuel was supplied through the Council's existing fuel depot. A relocatable stainless steel 15,000 litre tank was purchased by Council and located in the Waste Management Depot for biodiesel storage and distribution.



Fuel Dispensing Equipment

Dedicated basic fuel dispensing equipment for the biodiesel was originally included in the trial proposal and was to be provided by Council. However last minute difficulties with equipment supply were rescued by Gilbarco Australia through the provision of a “Fleetline” T334AV Diesel pump.

Gilbarco subsequently provided servicing, assessment of volumetric accuracy, and evaluation of the compatibility of the pump components with biodiesel, throughout the trial adding unexpected additional scope and value to the overall project and its outcomes. A separate report detailing Gilbarco’s involvement in the trial and their findings is included as Appendix C.

3.2 Operational Assessment Program

Prior to commencement of the trial and selection of the drivers, Council’s Waste Services staff were briefed on the proposal and the background to the selection of Biodiesel as a fuel. Staff co-operation was requested to facilitate the smooth running of the trial and volunteers were sought. The selected drivers were then requested to complete a daily log sheet for their respective vehicle recording information such as kilometres travelled, hours of operation, fuel consumption, number of bins collected, weight of waste collected, tyre pressure and maintenance items to assist in establishing an understanding of variables potentially affecting vehicle performance.

In the original programme, the trucks were scheduled to operate for a total of 600 hours with four (4) servicing periods of approximately 150 hours. At the completion of each period the trucks were to be mechanically serviced and the oil changed. Routine vehicle service intervals are normally scheduled every three hundred (300) hours however it was agreed for the purposes of the trial to increase the frequency of servicing to permit greater opportunity for assessment of performance and information gathering.

At each scheduled servicing the engine oil was changed and analysed to assess the extent, if any, of dilution attributed to biodiesel as reported in some overseas trials.

Originally it was proposed that the trial vehicles would swap collection routes after 300 operating hours i.e. midway. The drivers were to remain with the collection routes not with the vehicle. This was important to ensure that the vehicle operations were comparable over the two halves of the trial and to eliminate potential performance differences attributable to driver technique and/or familiarity with collection routes.

Due to logistic difficulties associated with the midway changeover occurring during the busy Christmas period the changeover time occurred at approximately 400hrs instead of the proposed 300hrs thereby increasing the overall trial period by 100hrs in each half to approximately 800hrs overall. All other factors remained as proposed.

The actual operational timetable is summarised in Table 1.

**Table 1: Program summary**

		First Hrs operation	Second Hrs operation		Third Hrs operation	Fourth Hrs operation	
Test Phase	1			2			3
Truck 1		173 HOURS	220 HOURS		207 HOURS	210 HOURS	
Driver		1	1		2	2	
Fuel		Biodiesel	Biodiesel		Biodiesel	Biodiesel	
Route		A	A		B	B	
Truck 2		167 HOURS	242 HOURS		203 HOURS	185 HOURS	
Driver		2	2		1	1	
Fuel		Diesel	Diesel		Diesel	Diesel	
Route		B	B		A	A	
Emissions Testing for Phase 1 occurred at the end of the first period. Phase 2 occurred in the period from 300 to 450 hours of operation. Phase 3, at the end of the trial, each vehicle was tested on both fuels.							

3.3 Emissions Test Program and Test Methods

The emissions testing program was designed to provide an assessment of the effects on tailpipe emissions of oxides of nitrogen (NOx), particulates (PM), hydrocarbons (HC) and smoke (opacity) when biodiesel rather than petroleum diesel is used. These parameters were intended to be representative of the tailpipe emissions commonly associated with local and regional air pollution in the Sydney basin. Some additional measurements were also to be made to assess the effects of biodiesel on toxic emissions, carbon dioxide and engine power.

It is important to note that all emission results presented in this report are tailpipe exhaust emissions and are not emissions from the lifecycle of biodiesel or diesel usage.

The final emissions testing procedure and test methods were determined in consultation with the NSW Department of Environment and Conservation and the Roads and Traffic Authority (RTA). It was decided by the RTA to monitor carbon dioxide instead of carbon monoxide as originally proposed.

Emission tests were conducted on three (3) occasions during the trial as per Table 1.

Two test methods were employed:

- DT80 –(simplified typical driving cycle), and
- D550 (simulated steady state at 5% gradient and 50km/h)

Fuel consumption, based on the carbon balance method, was calculated from the emissions of total hydrocarbon and carbon dioxide. Maximum power developed at the rear wheels on the dynamometer at 80 kph was measured and recorded at the end of each test. Fuel consumption and power output are indicators of engine performance.



It is important to note, however, the power output of each fuel was not measured across the full operating range of the engines to provide a power / torque curve.

The details of the emission test program and methodology are presented in the RTA report "*Camden Council Biodiesel Trial – Third and Final Progress Report*" as Appendix D.

A comparative analysis of emissions data and a detailed review of the USEPA 2002 report are provided in the PAE study as Appendix E. Other studies were also reviewed by PAE to fill gaps in the data and referenced where relevant.



4 OPERATIONAL RESULTS

This section looks at the results of the Camden Council Biodiesel Truck Trial with respect to vehicle performance and fuel consumption, driver feedback, fuel quality and engine wear.

4.1 Vehicle Performance – Fuel Consumption and Power

The test and control vehicles were operated under comparable conditions with fuel performance being the variable assessed. Tests were conducted on emissions and engine performance and the engine of the biodiesel vehicle was pulled down at the beginning and the conclusion of the trial to assess wear.

For the duration of the trial, the drivers of each of the vehicles maintained daily vehicle logs. The data from the log sheets were tallied and the results are provided in Table 2.

Table 2: Summary of Daily Logs

Parameter	Biodiesel Truck	ULSD Truck
Total hours	810	797
Total kilometers	9953	9970
Fuel Consumption	11488	10894
Total Bins collected	118065	117472
Total Waste collected (tonnes)	1507	1513

Each truck performed approximately 400 hours of work on each of the two (2) nominated service routes, with the biodiesel truck operating for a total of 810 hours and the ULSD truck a total of 797. Total kilometres, total fuel consumed, total bins collected and total waste collected were also recorded to assist in understanding fuel consumption. As can be seen from Table 2 total hours, kilometres, bins collected and total tonnes of waste collected were similar for both trucks.

The fuel consumption of the trucks was calculated in terms of kilometres/litre, litres/hour, bins/litre and litres/ tonne waste. Table 3 presents the fuel consumption results for each of these and shows the percentage fuel consumption of biodiesel compared with ULSD. (Note: one set of anomalous data was removed from calculations due to a suspected recording error.) The results were very similar, with biodiesel showing a fuel efficiency loss of about 0% to 4% across the range of parameters.

**Table 3: Fuel Consumption per unit Parameter**

Parameter	Biodiesel Truck	ULSD Truck	% B100 use vs ULSD
litres/kilometer	1.15	1.12	103%
litres/hour	14.18	14.23	100%
litres/bin	0.097	0.095	102%
litres/tonne waste	7.62	7.32	104%

The Camden operational data recorded actual fuel consumption difference for B100 biodiesel compared with ULSD, in the range of 0% to 4%, based on the average daily logs as indicated in Table 3. The RTA report found no significant difference in fuel consumption (less than 1%) between the B100 and ULSD fuels under dynamometer test conditions.

Fuel consumption was generally expected to increase with the use of biodiesel based on other studies. The USEPA 2002 study predicted an increase of between 4% and 10% in fuel consumption.

Power output from the biodiesel test vehicle was determined on a dynamometer at 80m kph during the RTA emissions testing (refer Appendix D), providing an indication of the fuel performance characteristics. However, the performance characteristics of each fuel were not measured across the full operating range of the engines to produce a power / torque curve.

Under these controlled conditions power losses of approximately 17% were recorded for the B100 biodiesel vehicle. Power losses of 5% to 7% are predicted in the literature (refer PAE report Appendix A). The reported power loss may be attributed to the ester content of the fuel or, more likely, due to a greater proportion of shorter chain fatty acids in the feed-stocks for the fuel used in the trial (pers comms ABC), which were sourced from used cooking oil (UCO).

The measured power loss on the dynamometer from the biodiesel, however, was not notably observed by the drivers during the operational trial. This may be due to the driving mode under which the waste vehicles are operated, i.e. the low speed stop-start nature of domestic waste collection. Power loss was noted by some drivers at the end of the collection run when the trucks were fully loaded and making their way to the landfill.

4.2 Fuel Quality

All of the fuel supplied for the trial was to be:

- provided with a Certificate of Analysis (CoA) to ensure that the quality met the Australian Biodiesel Standard, and,
- independently analysed by the RTA to verify fuel quality and ensure compliance with the Australian Fuel Standards as part of the emissions test program.



The results of the analysis are provided in Table 4.

Regrettably not all biodiesel fuel supplied met the required standards despite "guarantees" to that effect prior to delivery. The parameters that did not meet the Australian Standard are shaded grey in Table 4.

As can be seen from Table 4, the first two samples were close to meeting the Australian Standard for all biodiesel fuel parameters. However, the last sample was "off" Australian Standard specifications for almost all parameters.

Table 4: Fuel Parameters of B100 Biodiesel Used in the Trial

Parameter	Unit	Batch 1	Batch 2	Batch 3	Australian standard
Density @ 15°C	kg/m ³	881.1	881.3	886.9	860 - 890
Sulphur	Ppm	19	40	50.3	50
Cold Filter Plugging Point	°C	1	6	9	
Flash Point	°C	150	105	67	120 (min)
Viscosity @ 40°C	mm ² /s	4.660	4.725	6.254	3.5 - 5.0
Sulfated Ash	% (mass)	< 0.005	< 0.010	0.005	0.020 (max)
Carbon Residue	% (mass)	0.02	0.05	0.13	0.050 (max)
Water & Sediment	% (vol)	< 0.005	< 0.010	0.15	0.050 (max)
Copper Corrosion		1A	1A	1A	3 (max)
Total Contamination	mg/kg	0.88	11.1	124.2	24 (max)
Acid Value	mgKOH/g	0.27	0.08	0.95	0.80 (max)
Cetane Number		55.0	59.5	52.7	51.0 (max)
Distillation T90	°C	353	355	420	360 (max)
Ester Content	% (mass)	93.2	92.8	80.0	96.5 (min)
Total Glycerol	% (mass)	0.20	0.28	0.70	0.25 (max)
Free Glycerol	% (mass)	0.014	0.006	< 0.001	0.02 (max)
Phosphorus	Ppm	4	3	1	10 (max)
Oxidation Stability		1	1	0.4	6 hours @ 100°C (min)
Ca, Mg	Ppm	1.3	< 2	< 1	≤ 5 (max)
Na, K	Ppm	3	< 4	< 1	≤ 5 (max)
Alcohol Content	% (m/m)	< 0.02	0.23	0.44	< 0.20

^a Shaded parameters indicate that the batch did not meet the Australian standard specifications

4.3 Implications of Fuel Quality

The trial was originally scheduled to commence in September 2003. However, problems occurred when the initial batch of biodiesel, which did not meet the cold filter plugging point requirements for the local area, met with unexpectedly cold spring weather causing the B100 fuel to "wax" resulting in a vehicle breakdown due to fuel filter blockage. The biodiesel fuel and fuel filters were replaced and the following six weeks of the trial were used as a settling in period.

This initial set-back highlighted the importance of ensuring the cold filter plugging point of biodiesel, like diesel, is suitable for the climatic conditions in the area where the vehicles will be used, especially when using B100 biodiesel. This is an issue biodiesel producers will need to manage carefully when producing and supplying biodiesel fuel.



The trial was restarted in mid October 2003 and proceeded well until mid March 2004, when a batch of B100 fuel that did not meet specification was supplied on a verbal clearance without a Certificate of Analysis (Batch 3 in Table 4). The fuel contained unreacted fats and methanol. As a result of the poor fuel, the B100 truck suffered several breakdowns and problems with the fuel filters and the fuel injection system. Replacement B100 fuel was obtained and the filters were again replaced to complete the trial.

No other fuel problems were experienced between October and mid March, when the fuel met specification apart from a slightly lower than required ester content in Batch 1 & 2, and a slightly higher than required total glycerol in Batch 2.

The apparent low ester content may be attributed to uncertainty associated with the methodology for the testing of esters. Subsequent inquiries with the Intertek Laboratory, who undertook the biodiesel trial fuel analysis, indicated that the methodology, which is adopted from the European Standard, was designed for analysis of new canola oil specifically (C17 methyl ester), and not other feed-stocks with a higher or lower number of carbons. Intertek have indicated in response to questions regarding the low ester content that the methodology is likely to have underestimated the ester content for the fuel supplied for the trial.

Steve Howell, a US expert responsible for the development of the US ASTM (American Society for Testing and Materials) Biodiesel Standard, has advised that the US ASTM Standard does not test for ester because of the lack of precision and bias in the European methodology for ester when used on a variety of feed-stocks, especially used oils, as suggested in the previous paragraph.

The US Standard, therefore, considers low levels of mono-di-triglycerides as well as free glycerol to be some of the most important parameters of a biodiesel specification. For this reason the US ASTM has a specification of 0.24% maximum total glycerin (this covers mono-di-triglyceride and free glycerol) and 0.02% max free glycerol.

It was also reported by Steve Howell that free glycerol is almost never a problem, but the total glycerol has been found to be out of specification in a few cases in the US, usually with the start up of new plants. This is an issue that will need to be managed carefully by producers as the industry is established in Australia.

4.4 Effects on Engine Oil Quality

At each of the service intervals the engine oil was changed and the engine oil for the biodiesel trucks was analysed by Tri-City Trucks to determine if there had been any abnormal dilution in the oil. No abnormal dilution of oil quality of the biodiesel truck was reported.

4.5 Effects on Engine Wear

An initial inspection of the biodiesel truck engine was carried out by Cummins to determine the condition of the engine prior to commencement of the trial. This assessment verified there were no faults or anomalies. The ULSD truck engine was not inspected as the truck was less than a year old



and it was agreed by the trial partners that as engine wear from petroleum diesel was already well understood an inspection was not necessary.

Unfortunately, Cummins were unable to provide the resources to maintain involvement to the end of the trial. Tri-City Trucks as well as an independent expert diesel engineer, Diesel Green Australia Pty Ltd (DGA), were engaged to undertake the final engine inspections. The assessment reports are provided as Appendix F and Appendix G.

Signs of discolouring on the pistons due to uneven fuel spray and abnormal combustion in the cylinders due to some blockage of the fuel injectors were detected. Both effects were consistent with, and attributed to, the poor quality fuel used in the vehicle in the last few weeks of the trial. The problem was remedied by service of the fuel filters and injectors and no abnormal engine wear was reported.

After further testing and examination of the engine by DGA, the DGA report concluded that:

- The hardness level of the pistons was acceptable and well within the manufacturer's specifications (using Brinell hardness rating on the Rockwell "C" scale).
- The engine did not require any repairs other than normal service requirements,
- The biodiesel trial could continue with full confidence.

4.6 Driver Feedback

Prior to the commencement of the trial, the drivers were briefed about the operational program as proposed including the need to swap vehicles midway and the importance of maintaining accurate daily logs for data collection. The role of the drivers and their input was invaluable as they provided direct monitoring of the use of the biodiesel fuel on the performance of the vehicle under operational conditions, vehicle maintenance and refuelling, all of which are critical to user acceptability and uptake of the product.

With respect to general vehicle performance the overall response was that the drivers discerned a slight loss of power in the biodiesel vehicle compared with the ULSD vehicle, particularly when fully loaded. The reported loss of power was not considered enough to affect the truck's ability to do its job, given the nature of the duties performed, or discourage the drivers from using the biodiesel fuel. One driver commented that had he not been aware of the test vehicle's performance on conventional petroleum diesel prior to the trialling of the biodiesel fuel, the loss of power would not have been an issue and would have been accounted for in gear selection.

No negative driver feedback was made with respect to vehicle maintenance.

Refuelling, however, was the subject of considerable frustration when dealing with inferior fuels, and in cold weather conditions, when unacceptable gelling of the fuel greatly slowed or stopped the delivery of the biodiesel fuel into the vehicle, delaying the commencement or completion of the shift.



At worst, inappropriate cold temperature gelling and/or inferior fuel quality during the trial completely prevented vehicle operation at the commencement of the shift or caused mechanical breakdown during the shift. These difficulties and delays required mechanical attendance and servicing, which were disruptive to the fleet operations and completion of Council's servicing obligations and driver confidence.

The problems with the fuel were largely attributable to the infancy of biodiesel production with respect to the fuel supplied for the trial. This highlights the importance of biodiesel producers ensuring good fuel quality as the industry develops in Australia.



5 EMISSION RESULTS SUMMARY

A comparative analysis of the emissions data obtained from the Camden Trial by the RTA and CSIRO with that of overseas data was undertaken by Pacific Air and Environment (PAE). The RTA and PAE (with CSIRO) reports are presented, in full, as Appendix D and Appendix E respectively. The results of the studies are summarised below in Table 5.

Table 5: Percent Difference Between End of Pipe Emissions (Biodiesel Vs Diesel)

PARAMETER	RESULTS FROM THE CAMDEN TRIAL	RESULTS FROM USEPA 2002 STUDIES
Particulate matter	91% decrease	47% decrease
Oxides of nitrogen	no significant difference ¹	10% increase
Unburnt Hydrocarbons	68% decrease	67% decrease
Carbon dioxide	3.8% decrease	2.9% increase
Benzene	0.77 mg/km decrease	0.013 mg/km decrease
Toluene	0.37 mg/km decrease	0.078 mg/km increase
Xylenes	0.13 mg/km decrease	0.14 mg/km decrease
1,3 Butadiene	0.012 mg/km decrease	0.0030 mg/km decrease
Formaldehyde	0.40 mg/km decrease	2.2 mg/km decrease
Acetaldehyde	2.4 mg/km decrease	1.0 mg/km decrease
Propionaldehyde	0.020 mg/km increase	0.14 mg/km increase
Napthalene	0.15 mg/km decrease	0.056 mg/km decrease
2-Methylnapthalene	0.16 mg/km decrease	0.085 mg/km decrease
Acenaphthylene	0.010 mg/km decrease	0.0084 mg/km increase
Phenanthrene	0.0080 mg/km decrease	0.015 mg/km decrease
Fluoranthene	0.0015 mg/km decrease	0.0098 mg/km increase
Total PAH	0.34 mg/km decrease	0.34 mg/km decrease
Fuel consumption	no significant difference	4.6% to 11% decrease
Power output	17% decrease	5% to 7% decrease

Note 1: An analysis of variance test to a 95% confidence level by the RTA showed that statistically there is no significant difference between the B100 biodiesel and ULSD.

In summary, the emission test showed that B100 provided significant reductions in particulate, unburnt hydrocarbons and toxic emissions, with the exception of oxides of nitrogen (NOx). Such reductions could assist in improving local air quality if biodiesel were to be widely adopted across the waste collection vehicle fleet in Sydney.

The results showed no statistical significant difference in NOx emissions between the fuels, which was less than the expected when compared with overseas USEPA data.



6 DISCUSSION OF TRIAL RESULTS

6.1 Operational Performance

The results of the trial indicated that B100 biodiesel could be used as an alternative fuel for conventional diesel powered vehicles in the Camden Council waste collection fleet (and subsequently any similar diesel vehicle) but with some performance sacrifices of power. The B100 fuel used in the trial indicated a loss of power of about 17% at 80 kph for the dynamometer test. However, there was no noticeable difference in operational fuel efficiency of B100 compared with ULSD during the trial, which was consistent with the RTA dynamometer data.

The driver feedback on the use of B100 indicated that the loss in power was not readily noticeable due to the low speed stop start driving mode of domestic waste collection vehicles and hence the fuel was considered acceptable having regard to the type of operations performed, where maximum power performance is not required.

The vehicle timing was not altered to accommodate use of biodiesel. It has been suggested that vehicle timing may be altered to improve power output. However, this would lead to a comparable increase fuel consumption.

Operational issues related to the quality of the fuel have been discussed in the results. Of considerable interest is that the quality of the fuel used does not appear to be directly related to the level of air quality improvements achievable based on the measured results recorded from tailpipe emissions.

The quality of the biodiesel fuel used did not achieve the required standards at all times during the trial yet very significant improvements in tailpipe emissions for particulates and hydrocarbons over and above those of fossil-based petroleum diesel were consistently recorded at each of the three (3) emissions testing phases. The composition of biodiesel even when used at a quality less than that required by Australian Standard afforded significant advantage in the quality of emissions achievable.

The problems with the fuel were largely attributable to the infancy of biodiesel production in Australia. This highlights the importance of new biodiesel producers ensuring the consistent production of high quality fuel as the industry develops in Australia.

Inferior quality fuel can lead to operational breakdowns due to fuel injector blockages, which caused uneven burn and piston discolouring. There was no abnormal engine wear as result of the short-term use of the inferior fuel. However, the implications of long-term use of inferior quality fuels on engine wear and tear cannot be concluded from the findings in this study.

Operational issues associated with cold filter plugging (gel point) of the biodiesel fuel were a problem when ambient temperatures fell below 10 degrees Celsius. While the relationship between the fuel feedstock and temperature sensitivity is understood within the industry, consumer awareness of the variability of fuel supplied was not addressed in advance, thereby creating unnecessary and avoidable operator difficulties.



The problem of cold filter plugging could be a source of potential operational uncertainty during the colder months in temperate regions unless understanding and agreement with respect to a minimum operating temperature is reached between operator and supplier prior to production of fuels and certified prior to delivery.

Whilst the occurrence of difficulties relating to the use of inferior quality fuel and inappropriate cold filter plugging points proved to be beneficial learning opportunities within the context of the trial, their occurrence highlighted that:

- fuel quality is critical to the successful use of biodiesel,
- non-complying / inferior / inappropriate fuel should neither have been dispatched or received under any circumstances and the procedures for guarding against this unacceptable practice were not in place. The biodiesel production industry had not, at the time of the trial, established a level of credibility in its quality control practices or its ability to meet performance standards for verbal confirmation of batch compliance with the Australian Standards (ahead of written evidence) to be a guarantee of the product supplied, and
- unnecessary operational difficulties arising from the supply of inferior fuels will undermine consumer confidence in the product, thereby threatening or delaying the uptake of the fuel and the potential improvements achievable in air quality.

Biodiesel producers and suppliers must therefore provide absolute assurance to customers regarding the quality and appropriateness of the fuel they supply to ensure broad scale adoption of the fuel.

6.2 Emissions

In addition to the results of the Camden trial confirming that the use of biodiesel is likely to produce reductions in tailpipe emissions of diesel powered vehicles for a range of indicators the trial has produced a scientifically reliable body of information capable of building on overseas studies. It is also intended that the results of the emissions testing and operational trial provide the foundations for a biodiesel emission database and for further emissions testing and studies on biodiesel in Australia.

Further opportunities to improve the emission reduction of NO_x (e.g. through the use of additives and/or retuning) and CO₂ should be considered and investigated.

6.3 Cost Benefits

The cost benefits of using biodiesel will depend on a number of factors including:

- the direct cost per litre of B100 compared with diesel,
- the performance (power output and/or fuel efficiency) of the fuel per litre, and:
- the reduction in externality costs associated with improved air quality and health, reduced greenhouse emissions, increased sustainability, community values and public profile.



The cost of biodiesel and whether it will be competitive with diesel on price per litre alone, will depend on the cost of the respective raw materials at the time of purchase. As the prices of both fuels are subject to some volatility, the price comparison should be based on the average price over a period of time.

The competitive price of biodiesel will also depend on the ability of the biodiesel suppliers, as a new industry, to provide bulk volume discounts to large user groups as the production volumes will initially be quite small by comparison to petroleum diesel.

Camden is also a member of the Cities for Climate Change Program. There are implications of this membership with respect to investments required by Council to reduce greenhouse emissions, which may justify a small premium for greenhouse friendly fuels such as biodiesel.

There is precedence by Camden for paying a premium for environmentally friendly products with the purchase of green power, the special purchase of low sulphur diesel before it was readily available in the marketplace and the installation of catalytic converters on the waste collection vehicles.

Camden Council has indicated that it would be prepared to pay a small premium to use biodiesel based on the results of the trial. The extent of this premium will be determined following further investigations.



7 MEDIA AND EDUCATION

The project was officially launched in September 2003 with Council, local members and invited guests attending an introductory presentation and media announcement. The Trial was then reported locally in a number of papers, on local radio and television, including:

- ABC Television's National & Asia Pacific News (14 September 2003),
- SBS television's Insight program (27 November 2003),
- Sydney Morning Herald newspaper article (7 July 2003),
- Waste Management and Environment Journal (September 2003 and February 2005),
- Local Government Focus newsletter (October 2003),
- NSW State Government News (October 2003).

ABC Television News has expressed interest in producing a follow-up segment dedicated to reporting the results of the trial.

Information brochures and posters were produced and distributed through Council outlets including the Camden Show. A copy of the promotional pamphlet is attached in Appendix A.

Council further informed the local community concerning its pursuit of sustainable practices by boldly featuring the project through sign writing of the trial B100 vehicle (refer photo on Report cover page).

In January 2004, articles were published in:

- The NSW National Roads & Motoring Association (NRMA) member's magazine, The Open Road promoting biodiesel and the Camden Council Trial, and
- BioEnergy Australia Newsletter.

The wider government and commercial sectors were targeted directly through government publications as indicated above.

Three (3) half-day seminars were also held in conjunction with Newcastle City Council (NCC) to present the findings of the trial to primarily Local Government audiences at:

- Richmond Council (September 2004),
- Port Macquarie Council (November 2004), and
- Wollongong Council (December 2004).

Notification of the seminars was forwarded directly to all Council's in NSW via the Department of Local Government (DLG) Internet directory. The decision to present the trial findings jointly with NCC (who conducted a trial using B20) was made principally to ensure the most comprehensive distribution of information, results and experience concerning the Biodiesel Trials was provided to the growing body of interested potential fuel users.



Unexpected opportunities for promotion were also gained by way of:

- an invitation to present Council's trial at the Department of Energy, Utilities and Sustainability (DEUS) 2004 Biodiesel Forum in October 2004. This was then also reported widely in Thomson Environmental Manager (Issue 505, Oct. 2004)
- Camden's success in winning Division B – Energy Efficiency / Greenhouse Award at the 2003/2004 Local Government Excellence in the Environment Awards,
- Camden's success in winning the Keep Australia Beautiful (NSW) Metro Pride Program 2004 Sustainable Communities Award,
- SEDA Green Globe Awards booklet publication in 2003, via the way of the New Technology and Innovation Award won by the Australian Biodiesel Consultancy.

The final 'Camden Council Biodiesel Truck Trial' report will be posted on the Department of Environment and Conservation (DEC) website and Camden Council web site at:

- http://www.camden.nsw.gov.au/page/biodiesel_trials.html,

Additionally, all NSW Local Government Areas will also be advised of the final report's completion. The final report will also be followed by a final seminar in Camden in 2005 targeting the local and Macarthur Region business communities.



8 CONCLUSION

The results of the Camden Council Biodiesel Truck Trial indicated that B100 biodiesel could be used as a suitable alternative fuel to ULSD to achieve significant tailpipe emissions reductions from Council owned waste collection vehicles operating in the Camden Local Government Area (and subsequently any similar diesel vehicle). Some performance sacrifices of power may be expected. The B100 fuel used in the trial indicated a loss of power could be about 17%, however, there was no noticeable difference in fuel efficiency. These results were consistent within the range of US data (USEPA, 2002).

Driver feedback on the use of the fuel was positive, with the lower power output of the B100 fuel not readily noticeable during the domestic waste collection operations, due to the low speed stop start nature of the waste collection vehicles.

Before the trial, the biodiesel truck engine was dismantled and its condition assessed. Two independent mechanical assessments after the trial showed no evidence of abnormal mechanical wear and tear for the biodiesel truck compared with the use of petroleum diesel.

The trial also concluded that there were operational issues associated with B100 made from used cooking oils (UCO) and animal tallow relating to the cold filter plugging point of B100, particularly when ambient temperatures start to fall below 10 degrees Celsius, providing potential problems during the colder months in temperate regions.

The RTA and PAE studies concluded that the Camden trial showed the use of B100 biodiesel in the waste collection vehicle fleet is likely to lead to reductions in particulates, smoke, hydrocarbons, CO₂, VOCs and PAHs, and that emissions of NO_x are not expected to change noticeably. The relevant US literature on biodiesel emissions cited in the PAE study generally supports these findings. The PAE report also states the results indicate that the adoption of biodiesel for widespread use in waste collection vehicles is likely to improve air quality in the region.

Before B100 biodiesel can be adopted as an alternative fuel, Camden Council will need to balance the sacrifices in performance against the cost of the fuel, the cleaner emissions and the positive benefits this would have on human health and air quality. The cold filter plugging point is also an important issue to consider.

To address these issues, Camden Council is considering operating the waste vehicle fleet on a B20 biodiesel blend initially while at the same time undertaking further investigations using higher biodiesel blends, such as B30 or B40. Biodiesel blends in the waste collection fleet have the potential to provide an acceptable balance between the power loss, the cold filter plugging point, the cost of the fuel and the cleaner emissions. Subject to available funds, Camden is exploring, as part of the investigation, further emission tests to determine with greater certainty the emission benefits of using biodiesel blends.

APPENDIX A

Promotional Pamphlet



APPENDIX B

Biodiesel Forum Presentation



APPENDIX C

Gilbarco Report



APPENDIX D

RTA Report



APPENDIX E

Pacific Air & Environment Report



APPENDIX F

Tri-City Truck Engine Wear Report



APPENDIX G

Diesel Green Australia Engine Wear Report

