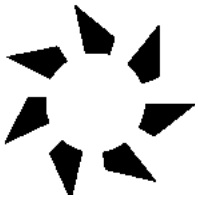
Independent Review of the Transitional Assistance Element of the Product Stewardship for Oil (PSO) Program

Prepared by

Australian Academy of Technological Sciences and Engineering

for the Minister for the Environment and Heritage

March 2004



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EXECUTIVE SUMMARY

The recovery and reuse of used[†] lubricating oils is a challenge that faces all nations. This document is the Independent Review of the Transitional Assistance (TA) Element of the Product Stewardship for Oil (PSO) Program. It has been carried out for the Department of the Environment and Heritage by Fellows of the Australian Academy of Technological Sciences and Engineering.

The recommendations arising from this review are summarised below with limited comment.

Lubricating Oil Sales and Recovery Figures

One of the major difficulties associated with carrying out this review has been obtaining accurate data not only for the amount of oil that is being recovered but, perhaps surprisingly, even for the figures for sales of virgin oil. Figures based on DITR Australian Petroleum Statistics show some unexpected increases in sales of transmission fluids and greases in the last two years against an industry expectation that sales should either be constant or declining in agreement with overseas trends. Based on ATO levy figures, the Australian sales figure for 2002-03 is 521 ML, which industry agrees is credible and is approximately 160 ML less than DITR figures. There is no doubt that the amount of imported oil is increasing due to the closure of local lube base oil plants.

The data collection for used oil also poses problems. Hard data collected for base oil are available on the amount of oil which attracts a benefit, but other collections are difficult to quantify. While research is clearly necessary on how to improve collection of data on the used oil industry and possibly on how to develop a system template to enable ongoing monitoring of the industry, this may not matter in terms of policy direction. A simpler alternative is to review existing data sources on an annual basis to verify consistency and determine emerging trends. Involvement of both producers (through AIP) and recyclers (through Australian Oil Recyclers Association, AORA) in any such program is essential.

We estimate that there is the potential to collect approximately 50 ML of currently uncollected oil (see Section 2). Extensive discussions with suppliers, collectors, state and local government bodies produce the unanimous view that a significant amount of this oil is in regional and remote farms, mines and industry, with used oil stockpiles also an important component. We have not found evidence to suggest that any other country is doing a better job of data collection.

Recommendation 1 (Section 5.1.1 – p39)

The Department of the Environment and Heritage should consider a targeted Transitional Assistance Grant to assist data gathering to establish the feasibility of an integrated collection scheme for used oil and other toxic waste materials from farms. Major oil companies and used oil collection companies will need to help develop a more comprehensive approach to improve collection of used oil from remote and regional farms, mines and industry.

Much of this oil is distributed to consumers in 10-20 litre packs and large steel drums. At present a recoverable deposit is in place on some containers. Recycling of containers is

[†] The term used oil is preferred to waste oil but the latter has frequently been used as a synonym in reports.

voluntary. The agrochemical industry has been making serious attempts to minimise pollution from partially empty containers through its *drum*MUSTER initiatives. A similar initiative may be possible for lube oil containers, and synergies should be sought.

Recommendation 2 (Section 5.1.2 – p40)

The Department of the Environment and Heritage should consult major oil companies and other lube oil suppliers to establish the extent of the issue of 10 and 20 litre oil packs, improve coordination of solutions currently being developed and gain commitment from other companies to also engage in this problem.

The DIY market involves mainly small 5 litre containers. Their numbers are very large and the used containers are dispersed widely and often indiscriminately. The negotiation of a possible TA Grant to the AIP to assist in the implementation of the scheme to maximise the collection of these containers is to be applauded.

The successful roll out of additional local government collection facilities has increased the need to ensure these facilities are well managed to improve efficiency, increase volume collected and reduce contamination. The current follow-up program in each state is also intended to ensure better supervision and management of local government collection facilities. Further use of TA Grant funds could be considered to investigate and develop, with industry and local government support, 'best practice' management techniques for used oil collection facilities.

Recommendation 3 (Section 5.1.4 – p40)

The Department of the Environment and Heritage should consult stakeholders regarding the merits of developing accredited management systems and training programs for management and staff at local government collection facilities.

Products and Markets

Small Industry Markets

A significant but unquantified amount of recovered used oil is used for heating in small industry markets such as the hydroponic and flower industries. There are concerns that many of these small, unregistered furnaces may produce toxic emissions including polychlorodioxins.

Recommendation 4 (Section 5.2.1 – p41)

The Department of the Environment and Heritage should consider use of Transitional Assistance funds to conduct a 'supply side' survey of used oil collectors supplying the greenhouse and hydroponics industries as recommended in the report into this industry by Warnken Industrial & Social Ecology. Based on the results of this survey, discuss with state environmental authorities what joint efforts are needed to promote the responsible burning of used oil in small furnaces.

High Grade Industrial Burning Oils, Including Diesel Oils from Used Oil Cracking

The burning of HG oils does not appear to impose a high environmental cost relative to that of recycling the used oil back to lubricating oils except for immediate rather than deferred greenhouse gas emission against which must be set the energy required to re-refine oils. Improvements in quality of lubricating oils have led to longer lifetimes, decreased sales and a reluctance of major oil companies to use other than their own base oils. Thus the burning option must be taken seriously.

HG oils are currently produced in Australia either by chemical treatment leading to demineralisation (see Section 6.2) or by re-refining involving vacuum distillation (see Section 6.1). The former is a less costly process as the capital cost of equipment and operating costs are lower but the product still attracts the same benefit.

However, both methods leading to HG oils are significantly more expensive than simply filtering and dewatering to produce Low Grade (LG) burning oils. The extra work involved and energy expended in producing HG oils is not compensated for by the level of the benefit paid (5 cpl for HG and 3 cpl for LG oils). The Academy notes that the level of the benefit awarded to this section of the market relative to the other categories will be reviewed in conjunction with re-refined lube base oil issues.

Re-refined Lube Base Oil

The high benefit payment for lube-to-lube processes is attracting attention from existing recyclers and the Academy understands that at least one new TA Grant application is being drafted to support investment to produce lube quality base oil. The closure of existing lube-quality base-oil manufacturing facilities at BP Kwinana (in West Australia) and ExxonMobil Port Stanvac (in South Australia) offers import replacement opportunities for lube oil re-refining. Oil companies point out that the cost of testing lube oils is very high, and base oil specifications from engine manufacturers are strict, and that this is a significant deterrent to their incorporating recycled materials in their products. Oil companies and engine manufacturers should be asked to define the minimum quality standard needed with a view to uptake of the available re-refined lube base oil product. It appears necessary to have large-scale lube-to-lube plants to make them economically attractive. Many re-refiners who operated in North America in the 1970s and 80s have closed and by 1999 only three re-refiners were operating four refineries - Safety Kleen Oil Recovery Division in Chicago and Ontario, Evergreen Oil in California and Mohawk Lubricants Ltd in Vancouver - to produce automotive grade lubrication oils. Other plants refine to lower grade base oils. World-wide trends to use less of higher quality oils in automotive engines must lead to industry imposing even higher standards on the quality of base oil that it is prepared to process.

Recommendation 5 (Section 5.2.5, p43)

> ***The Department of the Environment and Heritage should ensure the Review of the Product Stewardship (Oil) Act 2000 considers the appropriate benefit rate(s) to encourage greater use of recycled base oil and sustain markets for HG industrial burning oils. This should also involve engagement of lube oil producers in a process to identify and eliminate barriers to use of this base oil in lube oil blends, recognising the quality, performance and commercial requirements of lube oil producers.***

The Department may wish to consider commissioning a major study of future used oil market possibilities, by a consultant specialising in the combustion field, to inform government policy strategy.

Heavy Bottoms

Some of the recycling processes in NSW and WA produce heavy bottoms which are currently difficult to utilise or even dispose of. Several claims have been made that this material can enhance the performance of road asphalt when blended into modified and multi-grade bitumen. It is important to verify such claims and eliminate barriers to such use. The

Department of the Environment and Heritage has recently called for Expressions of Interest for a National Solution for used oil bottoms.

Scientific and Technical Advances

Many recent reviews of the oil treatment processes show that no new processes based on major conceptual advances have been introduced in the past decade.

Research into new methods of recycling used oil to base oil for lubricants has focussed mainly on membrane separation processes but other reports describe the use of supercritical propane as an efficient solvent for an extraction process. Membrane technology has led to dramatic improvements in the economy of several industrial processes, for example the electrolytic manufacture of chlorine, and it has the potential also to lead to a significant improvement in the energy of recycling.

Kobe Steel have reported construction and operation of a pilot plant for the treatment of 2000 kg/h of used lube oil which uses brown coal as an adsorbent for metal removal. This process could be of special interest to Australia which has large deposits of brown coal in Victoria.

Improved methods of energy recovery are also being evaluated. The most advanced of these involves the conversion of used oil into hydrogen and electrical energy in Integrated Gasification Combined Cycle Reactions. Conversion of used oil in bioreactors has also been claimed and represents a process which is very attractive from an environmental aspect.

The Department of the Environment and Heritage should ensure that they are aware of any future significant developments.

In several countries e.g. Germany and Austria, there is strong pressure to replace lube oils manufactured from a petroleum base oil with more rapidly biodegradable lubricants which can be made from renewable sources such as seed oils. Recycling of such oils will almost certainly lead to the need for modification of current recycling technologies.

Recommendation 6 (Section 7.2.1, p54)

The Department of the Environment and Heritage should continue to monitor developments in recycling technology using Transitional Assistance funding to commission periodic reports.

Health and Safety Issues

The area of most concern appears to be in the unregulated combustion of used oils in the hydroponics, flower and related industries. The used oil is used as burner fuel to heat greenhouses and is an alternative to higher cost fuels carrying excise levies. The main competitor appears to be gas where a reticulated supply is available. There is an environmental risk since small furnaces do not require formal EPA approval and if used incorrectly can lead to the formation of significant amounts of polychlorodioxins. Dioxin and possibly polyaromatic hydrocarbons (PAHs) formation are serious issues which must be addressed to minimise significant disruption to these valuable industries in the future. State EPAs are currently holding discussions with the Australian Government's National Dioxin Program, seeking ways of addressing this problem.

Environmental Impact

Major spillages are likely to be restricted in size to that arising from a crash involving a collection tanker. Small spillages which enter water systems can have a major impact on water potability as it is estimated that one litre of oil can contaminate up to one million litres of water. In higher concentrations water and soil contamination can lead to adverse effects on soil and water properties with significant impact on flora and fauna. Air pollution arising from combustion of used oil under inappropriate conditions can be a major threat to humans as well as to flora and fauna.

Life Cycle Analyses

Life Cycle Analysis (LCA) is a tool for assessing material and energy requirements and the environmental impact of a product over the whole of its life, from raw material extraction, manufacture and consumption to product disposal. An exhaustive LCA carried out by BHP Pty Ltd on the environmental and economic aspects of recycling lubricating oils in Australia supported the general conclusions that recovery/reuse is preferable to replacement and that re-refining to a lube quality base oil has a marginal advantage over combustion applications. Economic considerations, including subsidies and tax structures, will determine which routes are used in practice. A European Commission Report, which made a critical assessment of four LCA studies, came to broadly similar conclusions. All of these reports comment on the number of approximations which have to be made in the absence of reliable data. In view of the lack of new information since publication of the BHP report, the Academy feels that there is not enough new information at present to justify another analysis.

Recommendation 7 (Section 7.7, p62)

The Department of the Environment and Heritage should consider a further review only when more advanced technologies and /or more detailed operational data become available. More detailed information on the toxic emissions from a range of combustion processes should be included.

Communication Strategy

The Department of the Environment and Heritage Communication Strategy is being developed mainly 'in-house' but with the probable assistance of some future input from an advertising consultancy. A slow start due to administrative problems led to some criticism by state authorities and large producers about lack of interaction. However, the strategy has now been developed with a great deal of success. The communications team has produced worksheets and a video, and has interacted well with state and local government authorities. The video has been shown on national television where it attracted favourable response. Further videos are in preparation highlighting the success of the installation of collection facilities around the country. Indigenous Australians will also be targeted through the Communications Strategy. A web site has been developed and should become interactive in April/May 2004. The team's next major objective is to interact with the major producers, distributors and collectors to further develop the communication strategy.

CONTENTS

1 Introduction

1.1 Structure of the Report – Relationship to the Project Scope Outlined by the Department of the Environment and Heritage (formerly Environment Australia) for the mid-term Review

The Australian Academy of Technological Sciences and Engineering has undertaken to conduct an independent review of the Transitional Assistance (TA) element of the Product Stewardship for Oil (PSO) Program, to identify achievements and advise future priorities. Full details of the Terms of Reference for the review are given in Appendix A. While the Transitional Assistance sub-program is the prime focus of this review contextual detail has been provided in many places to help the reader. The final report resulting from the review will be used to provide strategic direction for the allocation of TA funds through to 2006-07. In order to underpin the identification of future direction, a snapshot of the current state of play is included in the report. Advice is included on new targets and priorities as appropriate.

An extensive review of previous reports relating to the PSO and experience overseas was conducted. Visits were then made to, and interviews conducted with, key members of the oil recycling industry as well as several major oil companies and state government departments. A list of all visits and discussions is given in Appendix H. All main used oil reprocessing plants in Australia were visited.

The key issues have been addressed in the following sections. Sections 2 and 3 establish the current cycle for lubricating oil use in Australia and portray objectives of the Product Stewardship for Oil Program.

Section 4 is concerned with the operation of the Transitional Assistance sub-program and in Section 5 the Academy gives recommendations on priority areas which should be addressed relating to used oil collection, processing and marketing and provides suggestions on how these should be tackled. Section 6 provides background on current technologies applied in used oil recycling and offers advice on future application of technology to encourage lube-to-lube recycle. Scientific and technical comments, especially related to Health and Environment issues and considerations relevant to the need for a further life cycle analysis, are discussed in Section 7. The communication strategy currently being implemented by the Department of the Environment and Heritage is commented on in Section 8.

References are indicated by a superscript number in the text and are listed at the end of each section.

1.2 The Reviewers: The Australian Academy of Technological Sciences and Engineering

The Australian Academy of Technological Sciences and Engineering is one of the four national learned academies. Membership is by nomination and its Fellows have achieved distinction in their fields. The Academy provides a forum for study and discussion, to explore policy issues relating to advancing technologies, to formulate comment and advice to government and to the community on technological and engineering matters, and to encourage research, education and the pursuit of excellence.

The Review is supervised by a Committee Chaired by Dr Ian Blackburne, Chairman ANSTO and Director of CSR Ltd, formerly Managing Director and CEO of Caltex Australia Ltd and Managing Director of Ampol Ltd. Other members were Professor David Trimm, Federation Fellow with CSIRO Petroleum Division and Professor Ian D. Rae, Technical Director ATSE. The review was conducted by two Fellows, Denys Goggin, formerly a Senior Shell Executive with extensive gas plant and oil refinery management experience, and Professor W. Roy Jackson, Centre for Green Chemistry, Monash University. Professor John Agnew, Department of Chemical Engineering, University of Adelaide, gave expert comments on the Life Cycle Analysis data.

1.3 Current Status of the PSO

The Product Stewardship for Oil (PSO) Program aims to establish an effective partnership for the management of used oil, involving oil producers, oil recyclers, states and territories and the Commonwealth. The PSO Program is intended to reinforce existing State and Territory regulations and arrangements in this area.

An initial allocation of $60 million was given to support the program from its inception in 2000 until 2003-04 but these funds have been reduced to $34.5 million and the time period extended to 2006-07. These funds have been used to support the Transitional Assistance Elements of the PSO and a list of projects supported is included as Appendix F.

In addition to the Transitional Arrangement scheme, a levy on lubricating oils was introduced in 2001 and the resulting funds used to provide benefits to recyclers of used oil. The benefit varies with the quality of the recycled oil with a heavy emphasis being place on lube-to-lube recycling.

There has been a smooth implementation of the levy/benefit system with a significant increase in verifiable collection and recycling of used oils. Australian lube oil sales are estimated to be 520 ML in 2002-03 with uncertainty resulting from apparent errors in DITR Australian Petroleum Statistics figures. Collections have risen from 165 ML per year reported prior to the PSO to an estimated 220 ML in 2002-03 (see Section 2.5.2). This is an increase of 33% and represents 81% of used oil generated. The benefits are of obvious assistance to companies in the industry, although there is concern at the impact of the intended excise impost on High Grade (HG) industrial burning oils.

The main focus for approval of Transitional Assistance (TA) Grants has been to local government for collection facilities. Approvals since the inception of the scheme come to $9,776,354, including grants to state bodies in Victoria, Queensland and WA to further increase the number of facilities. From the three rounds of Expressions of Interest, a total of 15 successful grants have been made, to the value of another $2,185,840. The total of all approved grants is $11,962,194.

An application is currently under consideration for $2,500,000 to assist the Australian Institute of Petroleum (AIP) with roll out of their program for collection and recycling of plastic oil containers.

2 The Lubricating Oil Cycle

This section gives background to the industry and develops the 'lube oil cycle' from lubricating (lube) oil production through collection, treatment, processing and sale of used oil. Recycled products are then sold as untreated used oil (energy recovery), treated low grade (LG) industrial burning oil (fuel oil); reprocessed to diesel fuel or high grade (HG) industrial burning oil, competing with virgin fuel oil; or re-refined to lube base oil, suitable for lubricant uses. The full lube oil cycle is detailed in Figure 2.11, p21.

2.1 The Australian Petroleum Industry

The lube oil industry is part of the downstream oil sector of the Australian petroleum industry. The industry is dominated by four major oil companies, which all operate oil refineries and participate in the 'downstream oil' commercial and retail market sectors. The 'oil majors' are:

- BP Australia Holdings Ltd: Refineries at Kwinana WA and Bulwer Island (Brisbane).
- Caltex Australia Ltd: Refineries at Kurnell (Sydney) and Lytton (Brisbane).
- Mobil Oil Australia Pty Ltd: Refinery at Altona (Victoria). A refinery with an associated lube base oil plant at Port Stanvac, south of Adelaide, closed early in 2003. A merger of Exxon and Mobil was completed in 1999.
- Shell Australia Ltd: Refineries at Clyde (near Parramatta in Sydney) and Geelong (Victoria).

In 2002-03 the Australian oil refineries processed 44,546 ML (mega litres – one million litres) of crude oil, of which 36.6% was indigenous crude. Total production of marketable oil products was 42,473 ML with product proportions shown in Figure 2.1.

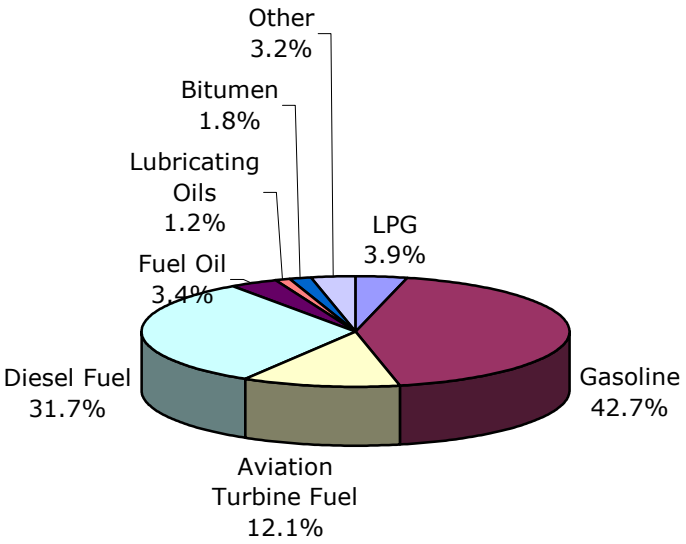

Figure 2.1: Refinery Production, Australia, 2002-03

Source: Commonwealth Department of Industry, Tourism and Resources: Australian Petroleum Statistics, June 2003.

The Figure clearly shows that the major emphasis of the refineries is to produce transport fuels. These fuels are the fractions of petroleum with lower boiling points and are obtained by fractional distillation of the crude petroleum. The refineries can modify their product mix by turning some of the higher molecular weight fractions into transport fuels by a process called

'cracking' which breaks larger molecules into smaller ones by heating, often in the presence of a catalyst.

Lube oils are high boiling materials whose chemical composition is discussed in Section 7. Australian crude oils are 'light oils' and do not have significant fractions of high boiling materials suitable for making base stock. Accordingly, lubricants are manufactured from crude oil imported from the Middle East.

2.2 Properties of Lubricating Oils

Lubricating oils and greases help separate moving surfaces and thus minimise friction and wear. Animal fats and oils were used to lubricate chariot wheels before 1400 BC and together with vegetable oils were the principal lubricants until 1859 when the modern petroleum industry was established and significant production of petroleum oils and greases commenced.

Modern lubricants are to a very large extent prepared from petroleum-derived base oils but there is increasing pressure to use more readily biodegradable lubricants based on naturally occurring oils. Biodegradable lubricants are particularly being used to minimise environmental damage in situations where the lubricant is lost, for example in chain saw lubricants, two stroke engines, rail switches, rock drilling etc.

Base oils are classified into five groups on the basis of their chemical origin and, in the case of petroleum-derived base oils, their properties, viscosity, sulphur content and percentage of saturated hydrocarbons (see Section 7.1.2, p52).

Lubricating oils are prepared by mixing base oils with a range of additives designed to inhibit oxidation rust, foam formation and wear, to modify friction, improve viscosity-index, depress pour points and stimulate cleaning, detergent action. The mixture of additives is designed to produce lubricants with properties most appropriate for the particular application.

The combination of improved base oils and additives has led to dramatic increases in lifetimes and performance for many applications. The recommended interval between oil changes for Volvo truck engines has increased dramatically over the past 15 years (see Figure 2.2).

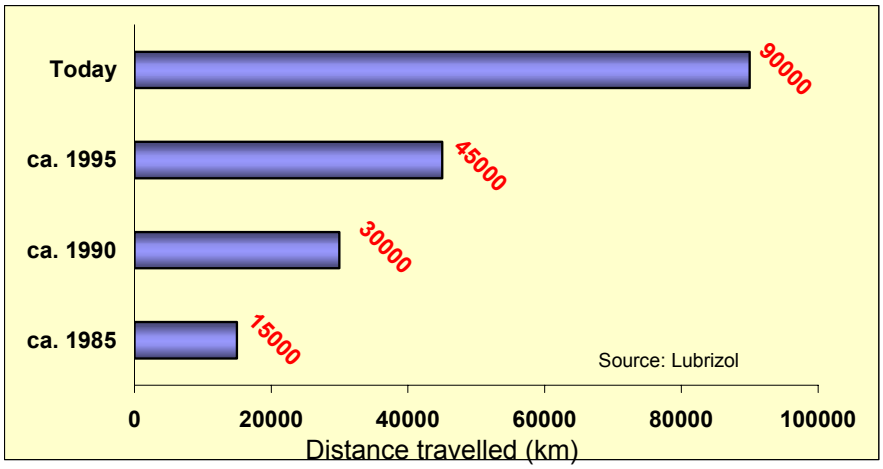

Figure 2.2: Oil Drain Intervals for Volvo Heavy Duty Trucks

A similar trend has been observed for passenger car lubricants where oil drain intervals have continued to increase while engine power outputs continue to grow. Thus, although the number of vehicles in Europe continues to grow (Figure 2.3) the consumption of base oil used for lubricant manufacture has decreased (Figure 2.4)[†].

Re-refined base oils are unlikely to be other than in the lower quality Group 1 base oils and their application is likely to be restricted to the preparation of circulating oils and lower quality engine oils.

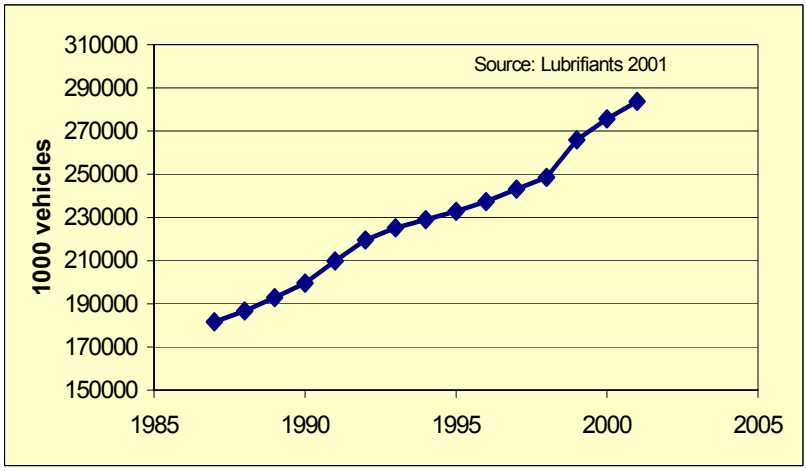

Figure 2.3: European Number of Vehicles

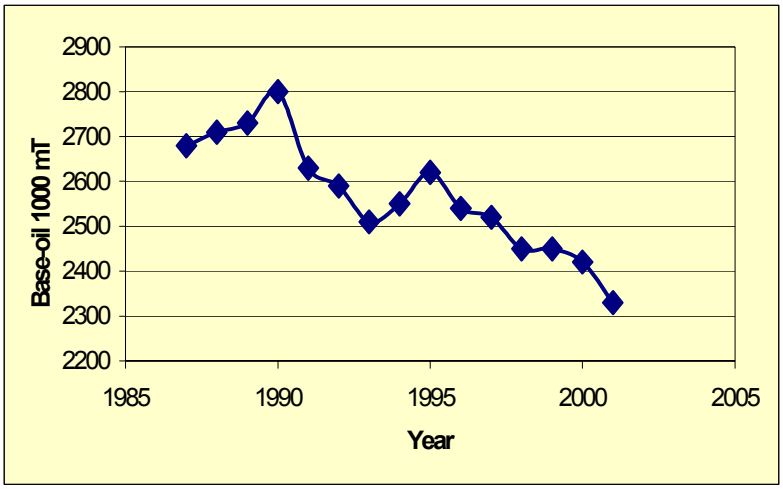

Figure 2.4: Engine Oil Consumption Volume in EU

[†] The data presented in Figures 2.2 to 2.4 come from a EUROPIA Position paper, prepared by Lubrizol Pty Ltd. We thank Robert W. Kaldor-Bull, B.P. Pty Ltd for drawing our attention to this information.

2.3 Lube Oil Industry Structure[1]

Until 2002, four Australian oil refineries were producing lubricant base oils: BP at Kwinana (WA), ExxonMobil at Port Stanvac (SA), Caltex at Kurnell (NSW) and Shell at Geelong (Victoria). BP closed their Kwinana plant in mid-2002 and ExxonMobil closed the Port Stanvac plant early in 2003. The remaining refineries have a combined annual production capacity of about 300 ML (mega litres – one million litres). This represents less than 1% of the total amount of oil refined in Australia. Combined production prior to the closures was about 800 ML.

The capacity of Australian refineries, previously in excess of local demand, which is around 520 ML per annum, is now in deficit. This situation has resulted in a significant increase in base oil imports. None of the Australian refineries is considered 'world scale' and only the Shell refinery is capable of making higher quality Group 2 or Group 3 oils. This refinery currently produces a small amount of Group 3 oil (see Section 7.1.2, p50). Figure 2.5 is a simple summary Life Cycle for lube oils and used oils.

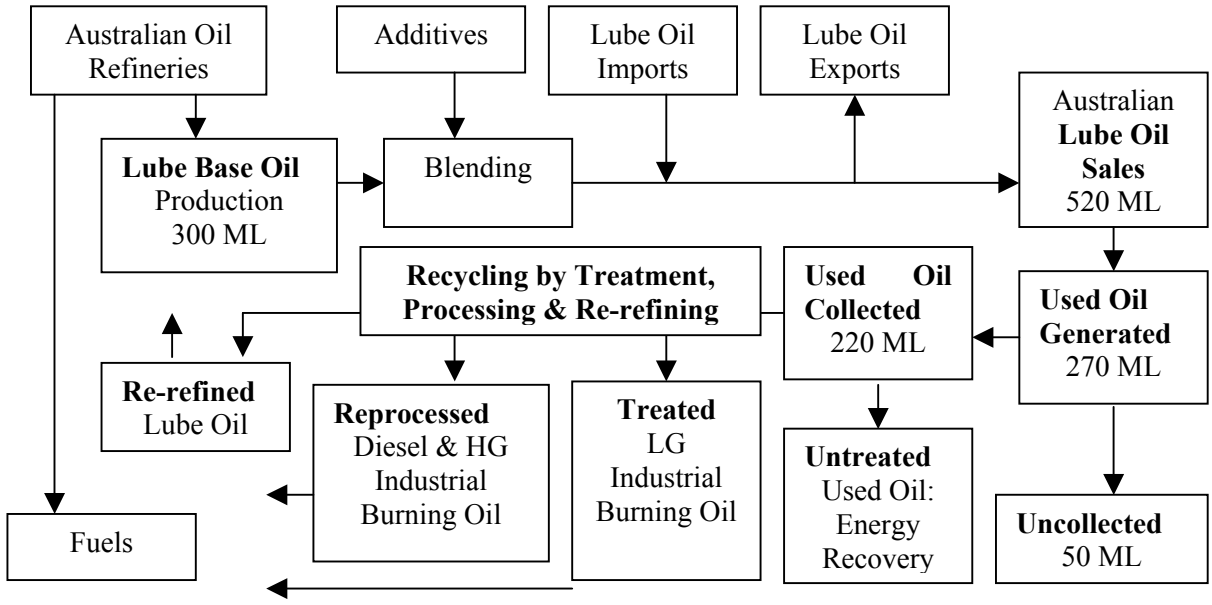

Figure 2.5: Summary Life Cycle - Lube Oils and Used Oils

The lubricant market also includes a number of importers and blenders. These companies utilise Australian and/or imported base stock with customised additives, or import lubricants already fully formulated. Such companies include Castrol, Valvoline, Fuchs and Penrite. Trends in lube oil production and sales volumes for the Australian market are shown in Figure 2.6.

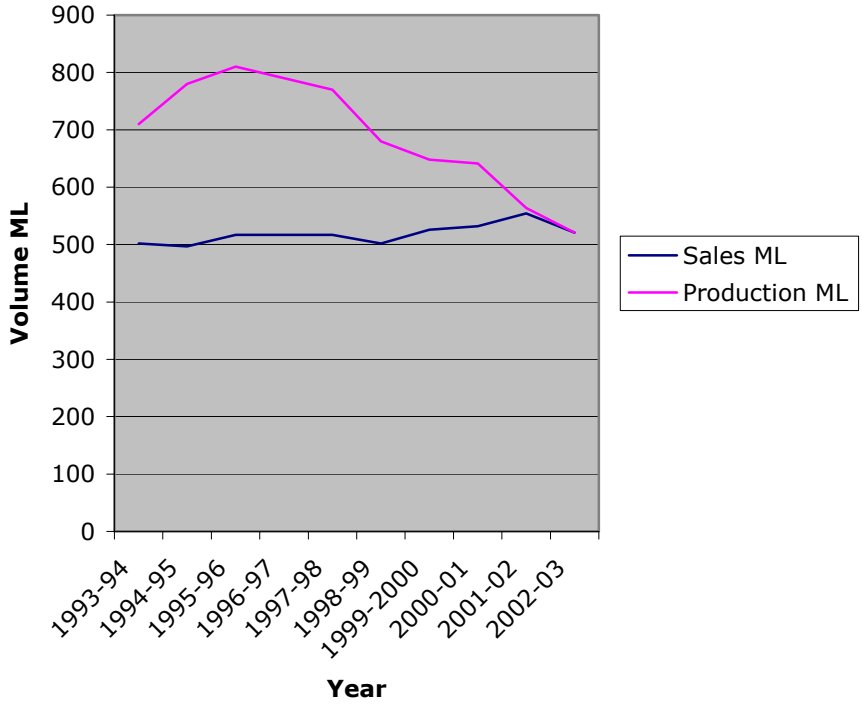

Figure 2.6: Lube Oil Sales & Production in Australia, ML

Sources:

1. Department of Industry, Tourism and Resources, Australian Petroleum Statistics, December 2002 and June 2003.
2. Annual Report 2002-03: Operation of the Product Stewardship Arrangements for Waste Oil (PSO) and Product Stewardship (Oil) Act 2000.
3. *Used Oil in Australia*: Meinhardt Infrastructure and Environment Group. 2002.

Based on the ATO levy figures (excise and customs tariff) from the PSO annual report for 2002-03[2], Australian annual lube oil sales are calculated as 521 ML. However, $2.3 million was paid back to clients for oils exported overseas. This is equivalent to 42 ML, giving net domestic sales of 479 ML. Levies are applied to production and import of base oil and additives, not to final sales, and because a smaller number of companies are involved there is the potential for a more reliable estimate outcome. Prior to the PSO, estimates of lube oil sales were taken from the Department of Industry, Tourism and Resources (DITR) Australian Petroleum Statistics[3]. Appendix B gives an analysis of lube oil production and sales volumes for recent years. There are inconsistencies in the DITR sales volume figures for 2002-03, which is obviously in error at 692 ML as a result of unexpected increases in sales of transmission fluids and greases in the period. DITR advise the error is under investigation. By coincidence, the DITR production figure for 2002-03 is 521 ML, reflecting lube oil plant closures, and is identical to the sales figure calculated from the ATO levy figures. With changes in the industry due to plant closures and the short time the levy has been in operation, it is not possible to rely only on the ATO figures for an estimate of annual domestic sales. The Australian Institute of Petroleum (AIP) advises that Australian domestic lube oil sales are not growing, and agree that current sales are most likely around 520 ML per year or less. After consideration of all available data, the used oil analysis in this report is based on annual domestic lube oil sales of 520 ML.

As seen in Figure 2.6, Australia's annual consumption of virgin lubricant has been relatively stable for the last 10 years. There is no expectation of growth in the foreseeable future. Indeed, the trend by engine manufacturers towards higher specification lubricating oils with longer service intervals is expected to cause a decline in lube oil demand.

About 48% of lubricating oils produced in Australia are automotive engine, gear, or transmission oils. Another 23% is used for industrial purposes, with similar applications. The remainder of the oil is used for base stocks (16%), processing (2.8%), marine (3.5%), greases (3.7%), railroad (1.0) and aviation (1.3%). These proportions are shown in Figure 2.7. Note that some double counting of base oil stock may occur (see Section 2.5.1, p10 and Appendix D)

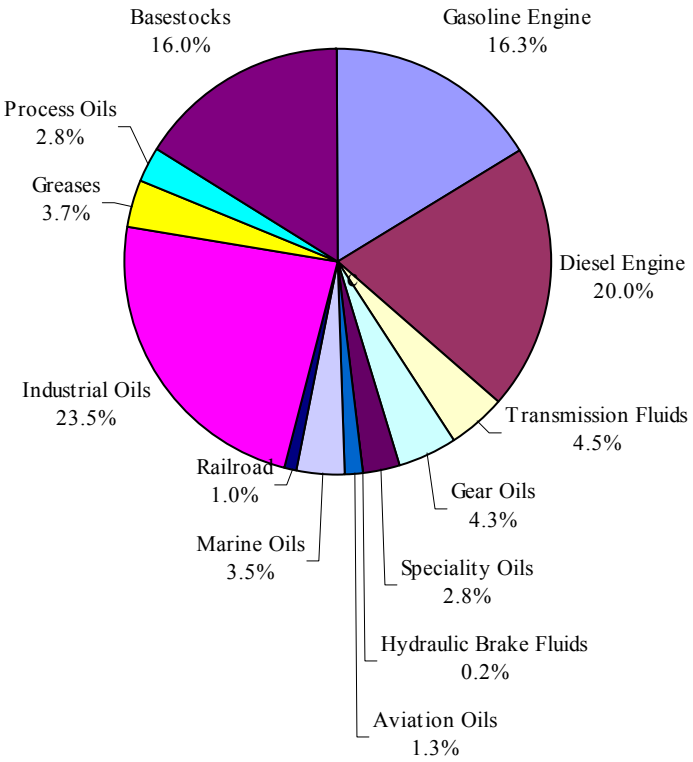

Figure 2.7: Proportion of Lube Oils Sold in Australia by End Use - 2002

Source: Department of Industry, Tourism and Resources, Australian Petroleum Statistics December 2002. Figures adjusted for errors in Transmission Fluids and Greases Categories.

Large industrial, agricultural, mining transport companies and the automotive industry purchase oil in bulk or in steel drums and are responsible for around 90% of lubricant sales. The balance of sales is packaged in plastic bottles and sold through retail outlets and service stations to the do-it-yourself (DIY) and light commercial markets. Packaged lubricating oil sales may be about 60 ML per year[4].

2.4 Product Stewardship for Oil Program

The Product Stewardship for Oil (PSO) Program came into effect on 1 January 2001[2], fulfilling the Government's May 1999 commitment outlined in the Measures for a Better Environment package. The PSO Program has the following objectives:

- providing economic incentives to increase the uptake and appropriate recycling and use of used oil;
- encouraging the environmentally sustainable management and re-refining of used oil and its reuse; and
- supporting economic recycling options for used oil.

The arrangements consist of three elements – the product stewardship levy on oils, product stewardship benefits, and transitional assistance funds.

The product stewardship levy was introduced on 1 January 2001 at 5 cents per litre (cpl) and after indexing has subsequently been fixed at 5.449cpl under general excise indexation arrangements. It is levied on domestic and imported oils, and is paid by oil producers and importers. Under the levy arrangements, no oil is levied twice, no 'eligible' lubricant escapes the levy, imported and domestic oils are treated equitably (to the greatest extent possible), and exported oil is not levied. The levy is collected as an excise by the Australian Taxation Office (ATO) and as customs duty by the Australian Customs Service (ACS).

Product stewardship benefits are paid to recyclers as volume-based incentives to encourage more oil recycling, with improved environmental outcomes. Eligibility requirements for PSO benefits are set out in the *Product Stewardship (Oil) Act 2000*, the *Product Grants and Benefits Administration Act 2000*, and the associated regulations. Benefits are provided at different rates, depending on the type of product produced – the lowest benefit being provided for low grade (LG) burner fuels, and the highest for full re-refining into lubricant base oil. Current benefit rates are shown in Table 2.1.

Table 2.1: PSO Benefit Rates 2001-02
Sourced from the Produce Stewardship (Oil) Regulations 2000

	Category	Benefit (cpl)
1	Re-refined base oil for use as a lubricant or a hydraulic or transformer oil that meets the prescribed criteria*	50
2	Other re-refined base oils (eg chain bar oil)	10
3	Diesel fuels to which the *Excise Tariff Act 1921* applies	7
4	Diesel extenders (filtered, de-watered and de-mineralised)	5
5	High grade industrial burning oils (filtered, dewatered and de-mineralised)	5
6	Low grade industrial burning oils (filtered and de-watered)	3
7	Industrial process oils and process lubricants, including hydraulic and transformer oils (re-processed or filtered, but not re-refined)	0
8	Gazetted oils and gazetted uses as declared by the Minister for the Environment and Heritage. (Payable since 27 March 2003)#	5.449 (levy)

Source: Product Stewardship Levy (excise). Department of the Environment and Heritage.

* The regulations specify a health, safety and environment standard for re-refined lubricants that is comparable with the current requirements for similar 'virgin' products. The purpose of this standard is to protect users of re-refined oil products from exposure to carcinogenic components and toxic heavy metals.

Multi-use oils such as printing inks, paint defoamers and agricultural sprays. These are not available as used oil to be recycled and do not present an environmental risk or hazard.

Transitional assistance funding of $60 million was originally provided for strategic initiatives to increase oil recycling and ensure a sustainable oil recycling industry. It is intended to complement the levy-benefit arrangements and is an interim measure to engender change that will ensure the long-term viability of the oil recycling industry. The transitional assistance funding was originally provided over four years commencing on 1 July 2000, but the total has since been reduced to $34.5 million and extended to 2006-07 following a re-phasing of the program funding (see Section 4.1.1).

The Oil Stewardship Advisory Council (OSAC) provides advice to the Government on the general operation of the PSO Program and possible future directions. Part 3 of the *Product Stewardship (Oil) Act 2000* established OSAC. Members are drawn from a range of backgrounds, so that the oil producing and recycling industries, State and local government, consumers and other non-government interests are appropriately represented and can contribute to formulating advice on the PSO to the Minister. The Environment and Heritage portfolio and the Commissioner of Taxation represent the Commonwealth. Further detail on OSAC, including current membership, is given in Appendix I.

2.5 Used Oil Collection

2.5.1 Used Oil Generation

Used oil is generated from the use of virgin lube oils and in the future will include re-refined lube oils. Different types of use generate different volumes of used oil. Some uses consume all of the oil (see 0% generation for some entries in Table 2.2) while for other uses varying proportions of the oil are recovered. For this report, generated used oil is calculated as around 52% of lube oil sales, based on the analysis below. A figure of 55% is anecdotally quoted as the best recovery that can be expected[5].

Table 2.2 shows lube oil sales for 2002 and a calculation of used oil generated. The generation factors are those used in the Australian Institute of Petroleum (AIP) Survey of Used Oil, 1998[6].

Table 2.2: Lube Oil – Used Oil Generated - 2002

Lube Oil Type	Volume ML	Generation %	Potentially Recoverable Used Oil, ML
Gasoline Engine	92.4	60%	55.4
Diesel Engine	113.8	60%	68.3
Transmission Fluids	25.4	80%	20.3
Gear Oils	24.1	80%	19.25
Specialty Oils	15.7	0%	0
Brake Fluids	1.3	0%	0
Aviation Oils	7.5	90%	6.75
Marine Oils	19.8	0%	0
Railroad Oils	5.3	40%	2.1
Industrial Gear Oils	19.6	75%	14.7
Industrial Hydraulic	54.7	50%	27.35
Metalworking Oils	13.3	20%	2.7
Other Industrial#	44.8	61%	27.3
Greases	21	0%	0
Process Oils	15.9	0%	0
Base Stocks *	89.8	60%	53.90
Total	564.4	n.a.	298.1 (52%)

Source of Sales Volumes: Department of Industry, Tourism and Resources, Australian Petroleum Statistics December 2002.
Volumes are adjusted for errors in the Categories for Transmission Fluids and Greases (See Appendix B for detail).

* It is not known if base stocks are double counted as the total exceeds industry expectation (520 ML or less).

Includes transformer and compressor oils

2.5.2 Collection Volumes

Companies collecting used oil for recycling or reuse must comply with all relevant regulations and codes of practice. Collection of used oil is usually free to the used oil generator. The used oil collection industry is complex, with a few large and many smaller players. Larger collection companies tend to have ties, or other relationships, with major refiners or re-refiners[1].

The Oil Stewardship Advisory Council (OSAC) established a Collection Working Group[7] in 2003. This group conducted a survey of all major collectors in each state, who supplied actual collection figures. Assumptions were made on the quantity collected by smaller collectors. The results of this survey are given in Appendix C and Figure 2.8 shows the percentage collection by State and Territory (NSW includes ACT).

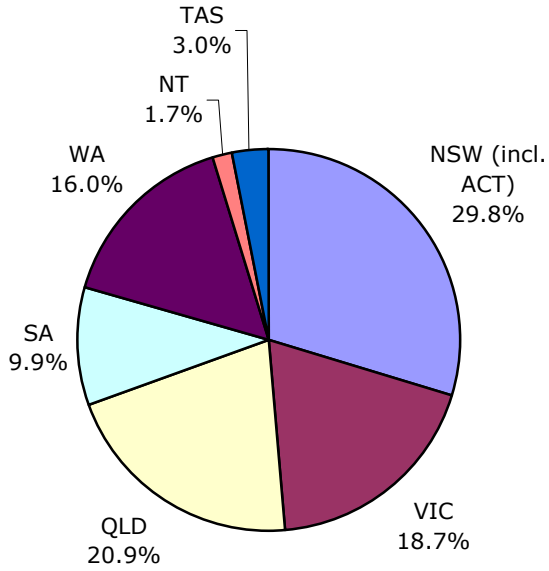

Figure 2.8: Used Oil Collections – Percentage by State/Territory
Source: OSAC Collection Working Group 2003

Used oil obtained by collection companies is stored at facilities owned by used oil recyclers or, in a small number of cases, at facilities owned by the oil majors. Used oil companies are required to license their storage facilities under relevant State and Territory legislation.

Stockpiles of used oil are particularly significant in remote and regional areas and the Meinhardt report on *Used Oil in Australia*[8] reports that approximately 26 ML was stockpiled across Australia in 1999, excluding the Northern Territory, which Meinhardt estimate has a capacity of 23 ML. Anecdotal industry reports in 1999, however, suggested that the stockpile might have been as large as 250ML. Based on current discussions with oil recyclers, it seems that stockpiles have decreased and may now be in the region of 20 ML excluding NT figures.

An assessment of the total annual 'used oil collected' volume is given in Appendix C. The main basis for the assessment is the volume of oil for which benefits were paid as given in the PSO annual report for 2002-03[2]. This figure is 194 ML but excludes collections where no benefit is paid and no record of volume is available. Due to this uncertainty in the total figure, an estimate of 220 ML is taken as the current annual collection volume on a water-free basis. As water is reported to be up to 10-12% of collected used oil, total liquid collections could be as high as 245-250 ML.

The annual volume of potentially recoverable oil in Australia, based on a generation factor of around 52% derived from the above Table, is estimated to be 270 ML per year based on lube oil sales of 520 Ml per year. The estimated used oil collection figure for 2002-03 of 220 ML is thus around 81% of the potentially recoverable volume. This figure is very respectable when measured against the performance of other Organisation for Economic Cooperation and Development (OECD) countries[9], but data in this area must be treated cautiously. (See Section 4.4.1).

The Oil Stewardship Advisory Council (OSAC)[10] have quoted an informal target of 30% per annum increase in collected used oil compared to 1999-2000 base year collections of 165 ML. Current collection of 220 ML thus shows an increase of around 33% and represents 81% of generated used oil. The 'uncollected' volume is then 70 ML. Collection targets for the future could possibly be set as 250 ML in the short term (2+ years) and 270 ML in the longer term (4+ years).

2.5.3 Oil Recycling Industry

Used oil recycling in Australia has evolved to meet the increasing demands of industry as it has expanded and produced greater volumes of used oil, recognised by some as a recoverable resource. The recycling industry has continued to expand its collection network and has adopted various technologies in value adding to the oil once collected. Companies involved in the collection and recycling of used oil range from large national companies to smaller family owned businesses servicing specific regions.

The Australian Oil Recyclers Association (AORA) was formed in 2003 to assist in development of the used oil recycling industry. It serves to increase awareness of the collection and recycling and its positive environmental contribution, within both government and industry. AORA was developed in 2003 from two earlier industry associations, the Oil Recyclers Association of Australia and the Independent Oil Recyclers Association of Australia.

Recovery and recycling processes range from simple collection and delivery for use as burner fuel to more technologically advanced processes, such as re-refining to lubricant. Bulk tankers range from 4,000 litres up to 90,000 litre road train configurations. All tankers have individual compartments to enable segregation of product and are fitted with positive displacement pumps. It is reported that the used oil industry has an overcapacity of collection vehicles particularly in the capital cities. Current focus is on increasing collections but attention is also being given to adopting strategies to ensure long term sustained markets for product to meet environmental outcomes in line with government policy objectives.

Recycling Technologies in use in the used oil industry include:

- Filtering and dewatering – oily water and solids collected in strainers.
- Dehydration – applying heat to reduce water to <1%. Filter to 10 micron.
- Demineralisation – chemical treatment to remove metals, ash, water & solids.
- Thin Film Evaporation (TFE) with vacuum distillation, producing diesel fuel, base oils and bituminous bottoms.
- Propane de-asphalting (PDA) producing diesel fuel, base oils and bituminous bottoms.
- Thermal cracking – at >300 ^{o} C to produce diesel fuel.
- Solvent extraction – further refining to produce lubricant quality lube base oil.

Information on these processes including product details, specifications and costs are given in Appendix E. The technologies are discussed in more detail in Section 6. Re-refining to lube base oil quality currently uses solvent finishing technology but future developments may include hydrogenation to produce higher quality lubricant base oils, by reducing aromatics and sulphur levels.

Table 2.3 gives a summary of used oil products by benefit category with typical collection and processing costs and product selling prices. Collection costs range from 6 to 12 cpl with

an average of 10 cpl. Some remote collection costs can be as high as 16 cpl as vehicles have to travel vast distances to service remote mining and rural communities.

Table 2.3: Used Oil - Re-refined and Recycled Used Oil Products - Costs and Sales Prices

Product	Volume ML 2002-03	Collection Treatment cpl	Process Cost cpl	Total Cost cpl	Benefit Rate cpl	Sales Price Range cpl	Sales Price Typical cpl
Lube Base Oil	3	20	40	60	50	n.a	55
Other Base Oil	0.2	15	25+	40	10	n.a.	n.a.
Diesel Fuel	26.1	15	25	40	7	35-40	40
Diesel Extenders	0	15	25	40	5	n.a.	n.a
HG Burning Oil TFE, PDA	68.3	15	25	40	5	28-40	35
HG Burning Oil Demineralisation	#	15	15	30	5	28-40	35
LG Oils	96.3	10-15	3-5	18	3	15-20 +	20
Other Oils*	25	10-15	0	13	0	<10-20	15
Total	**220**	**-**	**-**	**-**	**-**	**-**	**-**

#The volume of 68.3 ML includes product from Thin Film Evaporation (TFE), Propane de-Asphalting (PDA) and Demineralisation processes.

*Low grade oil, including oil bottoms from TFE and PDA processes, when sold to cement kilns attracts prices below 10 cpl and in some cases a charge is made for disposal (3 cpl has been quoted as a typical cost). The cost to production will improve with any added value to bottoms.

Note: Different grades of products are stored separately, tested and sold to the various markets. Test results and compliance certificates are required to provide traceability of batches of recycled used oil delivered to customers. Testing must also be done on collection to check for contamination and ensure the used oil is suitable quality for reprocessing.

2.6 Markets for Recovered and Re-refined Used Oil

Collected oil is sold either as 'benefit paid' recycled oil, where volumes can be verified, or as 'zero benefit' untreated or minimum treatment oil into the low quality burning market. In the latter case the volume is not recorded. The volume of 'Other Oils' in Table 2.3 is an 'industry informed' estimate. Typically this market involves sales to small industries including the hydroponics/greenhouses sector. Further details are included in Appendix D: Recycled Used Oil Markets.

Table 2.4 gives a summary of benefits paid and volume of recycling by product category for each of the three years the PSO Program has been in operation. Figure 2.9 shows the relative proportions of the oil recycled based on benefits paid for the year 2002-03. This data is taken from the report: A Tradeable Certificate System for Used Oils, McLennan Magasanik Associates P/L and the BDA Group[11]. This report also comments:

"The bulk of the benefits have been paid for used oil used as burning oil or a diesel fuel replacement. About 85% of the oil recycled has been used as an industrial burning fuel. Very little has gone to higher value uses, despite the higher rate of benefit for these uses. It is

expected that benefits accruing to higher value uses will increase over time as a new "lube to lube" recycling plant has recently commenced operation. Indeed, about 3.0 ML of used oil is understood to have been re-refined as Category 1 lube oil in 2002/03."

Table 2.4: Benefits paid and volume of recycling by product category, 2001-02, 2002-03 and part year 2000-01

Category	2000/01		2001/02		2002/03	
	Payment $'000	Volume ML	Payment $'000	Volume ML	Payment $'000	Volume ML
1. Re-refined base oil	0.0	0.0	0	0.0	1,520.1	3.0
2. Other re-refined base oil	0.1	0.0	7.0	0.1	16.3	0.2
3. Diesel fuel	541.2	7.7	1,763.8	25.2	1,828.7	26.1
4. Diesel extender	76.6	1.5	0	0.0	0.0	0.0
5. High grade industrial burning oil	791.8	15.8	3,291.7	65.8	3,414.3	68.3
6. Low grade industrial burning oil	805.6	26.9	3,103.9	103.5	2,887.6	96.3
Total	**2,217.4**	**52**	**8,166.8**	**195**	**9,667.0**	**193.9**

Source: The Department of the Environment and Heritage (2003), *Product Stewardship Arrangements for Used Oil: Reports for the Period 1 July 2001 to 30 June 2002 and 1 July 2002 to 30 June 2003.* Commonwealth of Australia.

Note: Data for 2000/01 cover the period from when the scheme commenced on 1 January 2001 to 30 June 2001.

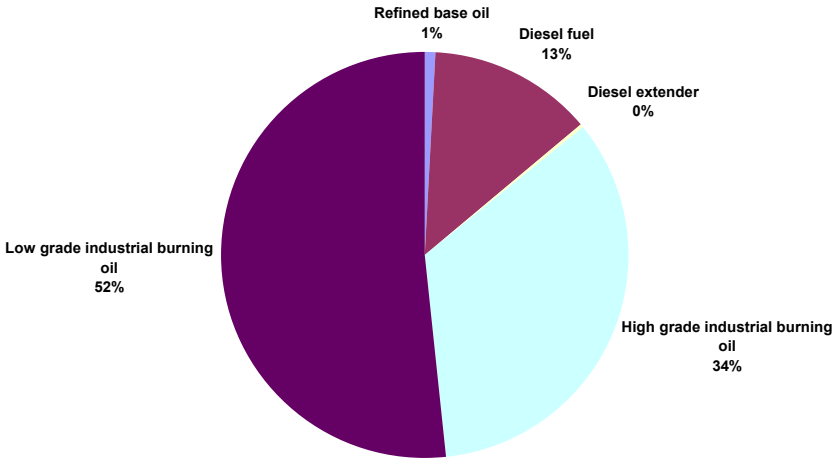

Figure 2.9: Amount of oil recycled under benefits payments, % of total recycled from 1 January 2001 to April 2003

Source: Data from Ref. 11. Note: refined base oils covers category 1 and category 2 components of the benefits payment scheme.

2.6.1 Lube Base Oil (Lubricating Oil Quality)

Sales of re-refined lube base oil were only 3 ML in 2002-03, representing early production from the recently commissioned Southern Oil Refineries plant at Wagga Wagga. A

Transitional Assistance Grant of $1,330,650 was awarded to upgrade the refinery to enable it to produce re-refined lubricant quality base oil. The project is complete and Southern Oil Refineries is the first (and currently only) company in Australia to produce re-refined base oil to PSO Category 1 standard. When fully operational, this plant will have capacity to produce 15 ML of re-refined lube base oil.

Base oil prices for re-refined product can be as much as 10-12 cpl lower than for virgin base oils of similar specification. Based on Industry discussions, total collection and operating cost for re-refined base oil may be as high as 60 cpl. The market is developing only with secondary lube oil producers, as current policy of the major oil companies is to use only virgin base oil. It is likely other recyclers will install facilities to produce lube base oil, attracted by the benefit level. If future production cannot be sold in Australia, markets in South East Asia will need to be explored.

For sound commercial reasons oil companies apply a formal quality standard accredited by the American Petroleum Institute (API). This is based on an extensive testing programme and is specific to the source of the base oil used, with certain crude oils being formally accredited for lube oil production. Use of alternate base oil, including re-refined lube base oil, is restricted to a maximum of 10%. However, due to negative customer perceptions, oil companies are unwilling to risk quality acceptance of their products. This is further discussed in Section 4.5.1 of the Report. Discussions with Australian oil companies confirmed this policy approach, which has also been explicitly stated in an OECD report[5] on used oil markets.

2.6.2 Diesel Fuel

Sales of 26 ML of used oil as diesel fuel (7 cpl benefit) were recorded in 2002-03. The *Excise Act 1921* applies to this category[2]. There is another benefit category 'diesel extenders' (5 cpl benefit) but no sales were recorded in 2002-03. Re-refined diesel fuel seems to compete successfully where it can meet the market quality standards. All re-refining processes produce a diesel fraction but only Nationwide in NSW and Environmental Oil in Victoria sell product specifically as diesel fuel for transport and stationary diesel engines. Other producers sell the product as fuel oil for general burning applications, either direct or blended into HG industrial burning oils. Sales price is around 35-40 cpl net of excise and subject to market competition.

Excise treatment for diesel fuel is rather complicated. For virgin diesel fuel the excise is approximately 40 cpl. If the diesel has a heavy component added, it then attracts an excise of approximately 8.5 cpl when sold as light fuel oil, or blended with heavier fuel oil, for burner applications. This is a long term Customs arrangement and is currently under review. It is common practice for oil recyclers to purchase such diesel and blend with base oil recovered from used oil to achieve the viscosity required for sale to power stations as HG burning oil. The base oil component does not currently attract excise.

For diesel product from used oil recycling plants, there are two alternate excise regimes:

- Used oil contains diesel and gasoline resulting from contamination during use and it is recognised that excise has been paid on these components. If a recycling process other than 'refining' recovers this diesel, it is deemed 'recovered diesel' and is free of excise up to 15% volume of the used oil feed. The gasoline produced is also free of excise to

a limit of 5%. Thin Film Evaporation and Propane De-asphalting qualify for this regime.

- If the used oil is processed through a 'refining' process – for example thermal cracking – the 40.143 cpl excise applies but a 20% remission is provided. The diesel can also be modified for sale as burner fuel at an excise rate of 8.5 cpl also with a 20% remission.

From 1 February 2004, all components of any diesel blend will attract the full 40 cpl excise but customers using it as burner fuel will be able to apply for a grant of approximately 30.5 cpl.

With the introduction of the new National Fuel Standard (Diesel), the mandatory diesel specification for sulphur was reduced from 5000 ppm to 500 ppm in January 2003 and will reduce further to 50 ppm from 2006. The excise rate for diesel with greater than 50 ppm increased to 40.143 cpl on 1 January 2004, as a result of the Diesel Sulphur Excise Differential program. The lower sulphur specification, and the increased excise, will reduce and eventually remove the transport diesel fuel market for used oil derived material. Typical sulphur levels in re-refined diesel are 1000-9000 ppm. Sulphur compounds, such as thiophosphates and benzene sulphonates, are among the substances added to virgin oil in the formulation of lubricating oils and are unlikely to be replaced in the near future. Sulphur compounds are not removed to a sufficient extent by used oil technology currently operating in Australia producing diesel fuels. Applications such as stationary engines, off-road vehicles, earthmoving equipment in remote areas and marine engines, to which automotive standards do not apply, may offer possibilities to sustain the market for recycled product with sulphur levels greater than 50 ppm.

2.6.3 High Grade (HG) Industrial Burning Oils

HG industrial burning oils are typically used in coal-fired power stations as start-up fuel, competing with virgin fuel oil. The benefit rate for HG industrial burning oils is 5 cpl and the requirement is that the product is filtered, de-watered and de-mineralised.

Annual sales are around 70 ML with a price range of 28-40 cpl. In many cases the reprocessed base oil used for this application is mixed with up to equal volumes of diesel to meet the viscosity requirements of the customer. Some diesel is produced from reprocessing with the balance purchased from oil companies. It is reported that remote power stations in WA (Esperance, Broome and Derby) will convert to gas by 2006, thus closing an important market for recycled used oil in that region. This switch to gas will seriously affect the market for HG burning oils in WA. It seems there may be potential to increase sales of HG burning oils into coal fired power stations, although there is strong competition from oil companies selling virgin oil for this application. In addition, the excise change, detailed in section 2.6.2, can also disrupt this market. The impact on re-processors has two elements: firstly the excise will apply to all components in the blend not just the diesel, as is currently the case. Secondly, the full excise of approximately 40 cpl is paid at the time of sale and this imposes an increase in working capital for the re-refiner until payment is made. The buyer can apply for a grant of approximately 30.5 cpl after purchase, regardless of whether or not payment has been made to the supplier. End-users are not restricted as to how often, or when, they may apply for the grant; for example, they could apply weekly as soon as the product is received.

Many of the recyclers interviewed suggest the benefit rate for this category should be reviewed and increased from 5 cpl. Industry members report that, with benefits paid, this

business is only marginally profitable for product from re-processing plants which have an operating cost up to 25 cpl, after collection/storage cost of 15 cpl (see Appendix E). This issue is further complicated by the fact that lower cost 'demineralised' used oil can also compete in the HG industrial burning oils market (see Table 2.3). This process, involving removal of metals and other inorganics from the used oil by chemical means, has lower operating costs of *ca* 15 cpl. A further discussion of these issues is in Section 4.5.2.

2.6.4 Low Grade (LG) Industrial Burning Oils

LG industrial burning oils are used in brickworks, cement and lime kilns and other furnace and burner applications, including some 15 ML as coal spray. Used oil is sprayed on coal to improve coking qualities and it is suggested this practice will cease due to environmental concerns[12]. Lower cost demineralised oils are most likely also included in the upper range of LG industrial burning oils. Sales of LG burning oils are 96 ML with natural gas often reported as the competing fuel in combustion application. Gas is expected to erode markets in the coming years. The Cement Industries Federation advises that total liquid waste consumed in cement kilns for the year ended June 2002 was some 28,000 tonne (approximately 28 ML). The Oil Stewardship Advisory Council Markets Working Group estimates 35 ML of used oil is sold to cement and lime kilns. These figures most likely also include untreated used oil.

Although kilns represent valuable markets for low quality used oil, it competes with other energy sources, particularly gas, and the price offered can be lower than collection cost. Disposal to kilns is environmentally favourable because of the high temperature and long residence time in a typical kiln which leads to complete combustion of polycyclic aromatic hydrocarbons (PAHs) and suppresses the formation of polychlorodioxins. Metals, derived from used oil, are retained in the cement product.

Heavy bottoms, a bitumen-like material, is one of the products from reprocessing units and is blended with lighter oil and, where possible, sold into burning applications usually at low price. There are environmental issues involved in burning bottoms and in some cases a charge is made for disposal – a typical figure of 3 cpl has been quoted. In any case the price obtained is lower than collection and process cost. Several claims have been made that this material can enhance the performance of road asphalt when blended into modified and multi-grade bitumen and more profitable use of this material is discussed in Section 4.5.3.

An assessment of future impacts on used oil markets as reported from various sources, is given in Appendix D. Sales to cement kilns and disposal of low quality oil (including oil bottoms) can be at 10 cpl or less, with cement companies setting tight price requirements. Sales of LG burning oils are reported to be at around 15-20 cpl. The benefit rate for LG burning oil is 3 cpl with a requirement that the used oil is filtered and dewatered[2].

2.6.5 Untreated Used Oil

Little is known about this market, but industry sources report untreated used oil is used in oil burners by small industry, typically hydroponics. This 'zero benefit' market needs to be better understood and encouraged where appropriate, as it is a significant market for recycled used oil. Collectors either do no significant treatment to qualify for benefit payment or consider the time and energy to apply as not worthwhile. The OSAC Working Group estimated 25 ML per year of used oil is burnt in the hydroponics industry, but the Warnken report on the hydroponics and greenhouse industries[13] could only identify around 3 ML. This large difference could be due to a combination of overestimation by OSAC and reluctance on the part of the users to admit they are using used oil, particularly untreated and poor quality

oil. Confidence was expressed in the OSAC Working Group figure at the Public Consultation meetings and the Warnken figure was generally considered to be unrealistically low.

There is therefore an area of concern related to unregulated combustion of used oil in some of these hydroponic, flower and related industries. Small furnaces do not require formal EPA approval and some may use environmentally unacceptable practices. The magnitude of the problem is uncertain as estimates of used oil combustion in small furnaces vary enormously. Warnken[13] reports that liquid fuels provide only 8% of greenhouse heating needs, with 88% provided by gas, LPG and electricity. The Warnken recommendation to conduct a 'supply side' survey of used oil collectors is endorsed.

The volume of used oil consumed by continuous bleeding during vehicle operation has significantly increased over the last decade[14]. Many diesel engines in use in Australian trucks (e.g. Cummins, 2000) use a computerised engine conditioning monitoring system, which continuously bleeds crankcase oil into the diesel fuel and replenishes the crankcase with new oil. The system greatly reduces service intervals and increases engine life. Because the crankcase oil is delivered directly into the same engine there are no problems of environmental contamination except due to compounds of phosphorus and sulphur which are present in the additives. The volume of oil recycled in this way is not known.

In discussion with the re-refining industry, there were some small product streams identified as not receiving benefits. This was either because application was not made or because the ATO has determined that the product is not eligible for a benefit. Individual operators are clarifying eligibility requirements with the ATO.

2.6.6 Product Cost and Sales Price Comparison

Information has been given throughout Section 2 regarding costs to collect, store, treat and process used oil as well as typical sales prices for products produced. While these are only broad 'typical' figures, they do give some overview of where the cost pressures exist. Table 2.5 and Figure 2.10 give a comparison of costs, benefits and sales prices for re-refined and recycled used oil products. The difficult area for profitable operation is for HG burning oil product from processes utilising Thin Film Evaporator and Propane de-Asphalting technology, which is sold typically into the power station market. From industry discussions, it seems there is more price flexibility in the diesel fuel market.

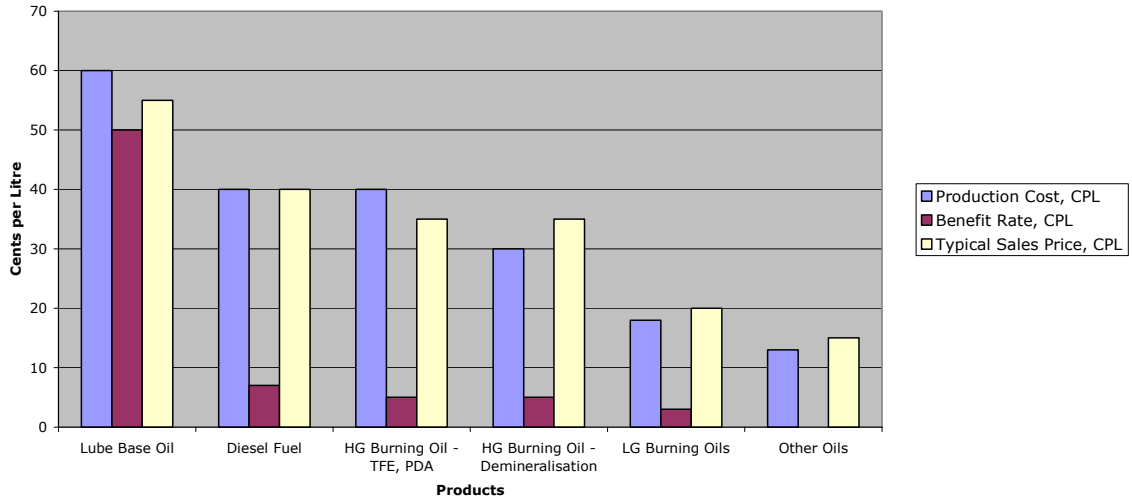

Figure 2.10: Used Oil - Re-refined and Recycled Products: Costs. Benefits and Sales Prices

Table 2.5: Used Oil – Re-refined and Recycled Products: Costs, Benefits and Sales Prices

Product	Collection & Production Cost cpl	Benefit Rate cpl	Typical Sales Price cpl
Lube Base Oil	60	50	55
Diesel Fuel	40	7	40
HG Burning Oil - TFE, PDA	40	5	35
HG Burning Oil - Demineralisation	30	5	35
LG Burning Oil	18	3	20
Other Oils	13	0	15

2.7 The Lube Oil Cycle

The cycle is given in Figure 2.11 on the next page. Explanatory notes are:

- The cycle starts with Australian oil refineries processing virgin crude oil and producing lube base oil, which is blended with additives into 520 ML of lubricating oil – lube oil – sold into the Australian market.
- Used oil is generated from lube oil at a rate of 52% to give approximately 270 ML of 'potentially collectable' used oil against an estimated 220 ML collected in 2002-03.
- Used oil is processed in a variety of ways and sold into appropriate markets.
- Market volumes are based on the above PSO Benefit paid volumes and the benefit rate applicable to each category is shown in brackets, with 'zero benefit' oil estimated at 25 ML.
- For uncollected used oil – approximately 50 ML – a range of priority areas are listed for future action.
- Competing and substitute virgin fuels from refining and gas production are indicated.
- All used oil volumes are quoted on a water-free 'dry' basis.

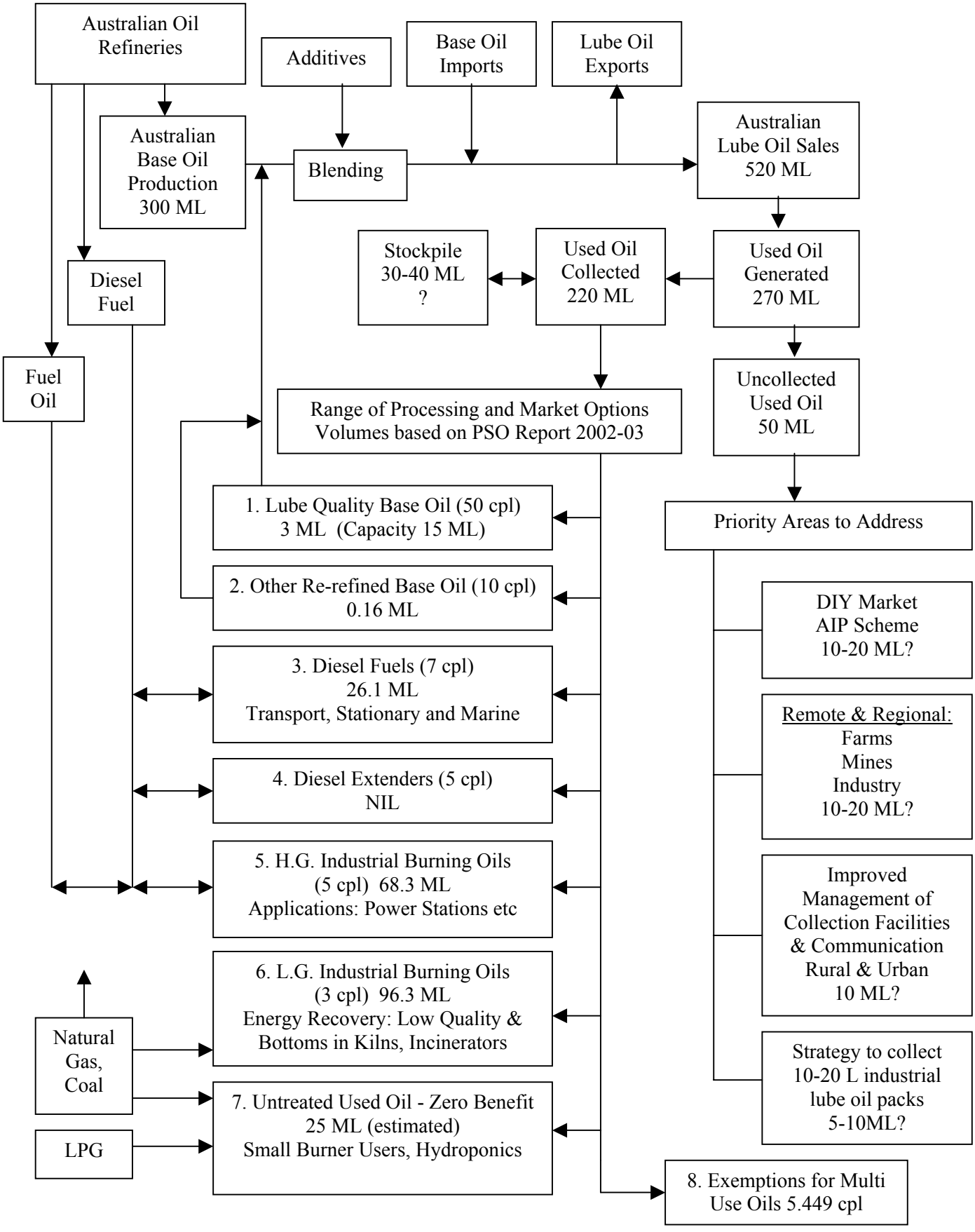

Figure 2.11: The Lube Oil Cycle - Lube Oil to Recycle and Reuse

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3 Current Policy Objectives

On 28 May 1999, the Prime Minister announced the Government's *Measures for a Better Environment - A New Tax System*. Included in these measures was a commitment to fund the development of product stewardship arrangements for used oil and provide transitional assistance to facilitate the uptake of used oil. Prior to this announcement, there was no national policy framework or regulatory system in place to encourage the recycling of used oil.

Prior to 2000, waste minimisation was, and continues to be, a significant issue in Australia. Notwithstanding the independent waste minimisation arrangements of States and Territories, and the coordinated efforts of Australian jurisdictions under the Australian and New Zealand Environment Conservation Council (ANZECC) (now superseded by the Environment Protection and Heritage Council, EPHC), used oil remained a problem. ANZECC's *National Waste Minimisation and Recycling Strategy* (NWMRS) included an objective to change Australian production, consumption and disposal activities through voluntary waste reduction arrangements with industry to:

- achieve ecologically sustainable economic performance;
- minimise the quantity and toxicity of waste and pollution; and
- improve management and control of unavoidable wastes.

ANZECC, at that time, called for Commonwealth assistance in helping to make the recovery and use of used oil more financially and ecologically sustainable. The Product Stewardship for Oil Program (which came into effect on 1 January 2001 as the *Product Stewardship (Oil) Act 2000)* addresses this issue[1]. It comprises three elements – transitional assistance funds (which commenced in July 2000), a product stewardship levy, and product stewardship benefits[2].

The objectives of the Product Stewardship for Oil Program are:

- Provide economic incentives to increase the uptake and appropriate recycling and use of used oil.
- Encourage the environmentally sustainable management and re-refining of used oil and its reuse; and
- Support economic recycling options for used oil.

Transitional assistance is an interim mechanism to engender change that will underpin the long-term viability of the oil recycling industry. This funding was to be provided in four equal tranches of $15 million over the financial years 2000-01 to 2003-04. The total has since been reduced to $34.5 million, extended to 2006-07 and re-phased as follows:

Table 3.1 Transitional Assistance Funding Allocations ($m)

	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
Initial allocation	15.00	15.00	15.00	15.00	-	-	-
Revised allocation	1.32	2.58	8.83	6.40	5.50	5.40	4.47

The funds are used to:

- ensure a sustainable used oil recycling industry;
- accelerate the uptake of used oil from urban and rural Australia;
- facilitate the transition of the industry and the community into effective participants in the Product Stewardship for Oil Program; and
- to the extent possible, address special difficulties that remote Australia has in the recovery and management of used oil for appropriate recycling.

During the Review the following outcomes were noted in relation to the PSO and the Transitional Assistance (TA) element of the PSO:

- Smooth implementation of the levy/benefit system with a significant increase in verifiable collection and recycling of used oils. Collections have risen from an estimated 165 ML per year prior to the implementation of the PSO to an estimated 220 ML in 2002-03, an increase of 33% (see Section 2.5). Accurate data are not available for collected volumes where no benefit is paid.
- Benefits are of obvious assistance to companies in the industry, although it is also felt by some that the benefit level of 5 cpl for the HG industrial burning oils category does not fully recognise the costs of investment and operation required. Refer Section 2.6.3. There is also concern at the likely impact of the intended excise impost on this category when blended with diesel fuel. However, on 31 January 2004, the Minister for the Environment and Heritage, Dr David Kemp, announced that, in response to the review of all excise regulations, the Government is preparing new regulations to create a new benefit category under the Product Stewardship (Oil) Regulations 2000 to ensure that producers of Blended Light Fuel oil continue to receive an equivalent level of benefit and will not be disadvantaged. Blended Light Fuel Oil is the re-refined product.
- ATO figures for 2002-03 report that levies collected totalled some $28.396 million with benefit payments of $9.667 million. There are also some refunds where the levy was not payable. Benefit payments may more closely approach the levy collected as the market matures. The legislative review, to be conducted in 2004, will more closely examine the levy benefit arrangements. The high level of benefit for re-refined lube base oil is designed to encourage production of higher volumes of this category. While there are sound resource stewardship reasons for this, other environmental advantages over burning oil categories are marginal (see Section 7.6). Some industry members feel that benefits should be balanced so as to also support the HG burning oils market.
- TA Grants have seen a major boost to local government collection facilities and they have assisted in establishment of the first plant producing quality lube base oil. Other grants have usefully contributed to understanding of used oil collection infrastructure

and other aspects of the collection and recycling industry. There are 15 awarded grants and, of these, reports are available for three completed projects. It is important that other projects are followed up to ensure reports are produced on completion and that they are analysed and used to inform other initiatives being implemented.

- Most of the oil industry and recycling industry members consulted are comfortable with the levy/benefit system, its introduction and administration. However, they believe adjustments can be made to improve it further. This is preferred over the introduction of a Used Oil Tradeable Certificate System, which is seen as unnecessarily complex for a small and relatively unsophisticated market.

These outcomes go a considerable way to meeting the objectives of the program and there is every reason to believe that further improvement will be achieved. Australia is approaching the level of collection and recycling of used oil achieved by other countries. However, most reuse would be described as low-or medium-level (burning or use as diesel fuel) and serious impediments remain to the uptake of re-refined oil into mainstream lubricating use.

References

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4 Development of the PSO

4.1 Transitional Assistance Grants

4.1.1 Background[1]

Transitional Assistance (TA) is intended to provide funding for strategic projects, which address more fundamental barriers to oil recycling, such as lack of adequate infrastructure or technology. TA funds have been used for local government collection facilities, Expression of Interest rounds, commissioning of specific studies and communication activities. Additionally, the funds are used to cover the operating costs of the entire PSO program – including the relevant running costs of the Department of the Environment and Heritage, the Australian Taxation Office and the Oil Stewardship Advisory Council – and to underwrite the stewardship benefits in the event of revenue shortfalls.

4.1.2 Local Government Used Oil Collection Infrastructure[1]

Recognising that the lack of adequate used oil collection facilities, particularly in rural Australia, was a major barrier to the collection and recycling of greater amounts of used oil, the Minister approved the establishment of the local government Used Oil Collection Infrastructure Small Grants Program. Since the inception of the program in 2001, 244 grants have been awarded to 282 local government organisations with approvals so far totalling $6,049,407. The grants are for the purchase and installation of used oil collection facilities that meet relevant environmental regulations. Many of these facilities have been completed and are operational.

The Government continues to work on follow-up to this scheme. In 2002-03, $550,000 was awarded to EcoRecycle Victoria, $1,489,400 to the Queensland EPA and $1,633,547 to the WA Local Government Association to enable a co-ordinated approach to the purchase and installation of further facilities by local government in those states. This gives an overall allocation to local government of $9,722,354. The local government grants seem to be particularly successful and follow-up should ensure improved coverage of collection centres where gaps exist, particularly in regional and rural areas. The Department of the Environment and Heritage are at an advanced discussion stage to appoint organisations in South Australia and the Northern Territory to do the same. Tasmania is well covered and New South Wales (NSW) opted to not be directly involved. The Department of the Environment and Heritage are managing NSW direct – in some cases clusters of Councils have formed to co-ordinate applications for grants. The Department of the Environment and Heritage are currently evaluating some six NSW local government applications. Review team discussions with the Sustainability Programs Division of the new NSW Department of the Environment and Conservation, formerly Resource NSW, suggest that contacting NSW again on this issue may be productive.

4.1.3 Expression of Interest Rounds

In addition to the Local Government Used Oil Collection Infrastructure Small Grants Program, three rounds of Expressions of Interest were conducted. The first round resulted in 106 applications, the second round 14 and the third round 25 applications. All applications were assessed against criteria set out in the *Product Stewardship Arrangements for Waste Oil – Administrative Guidelines*[2]. To be considered, grant applications had to address the objectives of the program, provide value for money, prove a thorough understanding, sound approach and a demonstrated ability to complete the outlined project. Some applications received were for individual industry expansion measures. These were not considered to meet

the objectives of the program nor to provide value for money. Of the applications received, fifteen successfully met the criteria, with $2,185,840 being allocated.

In line with the initial need to increase used oil collection facilities and infrastructure necessary to underpin further advances in used oil management, the majority of projects addressed the priority areas of 'environmentally responsible management of used oil' and 'community and industry awareness'. A smaller number of applications addressed 'used oil market development' and the more specific area of 'handling and management of filters, drums and packaging' (see Appendix F for details). The total for all grants is $11,962,194. Consideration is currently being given to an application for $2,500,000 to assist the AIP with roll out of their plan for collection and recycling of plastic oil containers.

The largest approval was a $1.3m grant to Southern Oil Refineries to modify its refinery in rural NSW so that it will be able to produce recycled lubricants that meet the standards set out in the *Product Stewardship (Oil) Regulations 2000*. This completed project is an important step in encouraging the market to re-focus on lube-to-lube recycling and to demonstrate the long-term viability of re-refining used oil to lubricant quality base oil. This plant has produced and sold product meeting lubricant quality and is expected to operate at full capacity by end 2003. Southern Oil Refineries is the first (and currently only) company in Australia to produce re-refined base oil to PSO Category 1 standard.

Although there will no longer be open rounds of Expressions of Interest, there will be targeted Expression of Interest rounds. In addition, *ad hoc* applications have always been accepted and this practice will continue. Currently six TA Grant applications, totalling around $10m, are under evaluation. The TA funds have provided improved oil collection infrastructure, helping guarantee supplies of raw material to the used oil processing industry. In discussion with industry, there seems to be a general agreement that any future calls should be on a targeted priority basis. A targeted Expression of Interest round was advertised on 21 & 22 November 2003 for addressing the 'oil bottoms' issue. This review will provide information to assist in determining the priority areas to be targeted in future rounds. Suggestions for new priorities are given in Section 5.

TA funded projects are in various stages of completion. Project proponents are required to satisfy reporting and/or acquittal requirements, depending upon the type of project undertaken. In the case of collection facilities, for example, an acquittal is required, providing evidence that the funds have been used in the manner in which they were intended. No written report is required. Many other project proponents are required to provide written reports on the project. To date, reports are available for three completed projects:

- PPK Environment and Infrastructure: "Achieving Improved Product Stewardship for Waste Oils in Rural and Regional South Australia".
- Delynda P/L: "Feasibility Study for a Dirty Waste Plastics Recycling Plant for Discarded HDPE Oil Containers".
- Warnken Industrial & Social Ecology: "Characterisation and Assessment of Waste Oil Utilisation as a Fuel for Heating in the Hydroponics and Greenhouse Industries".

A further five projects are complete with two having produced guides or protocols, two are preparing final reports and one has no report requirement. Appendix F provides a list of current projects and their status at December 2003. It is important that project reports are produced on completion, analysed and used to inform other initiatives where appropriate.

4.2 Priority Areas for Funding

Priority areas identified under the PSO[2] Program for TA funding include:

a. Improving the environmentally responsible management of used oil;
b. General used oil market development and expansion;
c. Related environmental issues, e.g. handling and management of filters, drums, 'Do It Yourself' (DIY) packaging; and
d. Community and industry awareness of used oil management issues.

Of the 15 approved TA Grants, some 60-70% addressed priority a) *improving the environmentally responsible management of used oil* with the local government program having particular emphasis in this area. It is important to ensure the communications strategy assists local government and to follow-up with programs to ensure professional management of new and existing used oil collection facilities.

Only one TA Grant addressed priority b) *general used oil market development and expansion* directly, and future grants should be considered in this area of market development. A frequent comment from the used oil recycling industry was to emphasise the importance of support and assistance to broaden and develop markets for reprocessed used oil.

Three TA Grants addressed priority c) *related environmental issues,* although the AIP proposal could be the most significant. Its successful implementation will be important in tackling the difficult problem of collection of DIY plastic containers, recovering the oil and recycling the plastics. Information from the other related projects should be made available to the AIP to assist where appropriate.

Some 40% of approved TA Grants can be seen to have some element of community and industry awareness. The Department of the Environment and Heritage Communications Strategy will become increasingly significant in improving community awareness.

4.3 The Objectives of the Transitional Assistance Grants Scheme[2], With Comments on Achievements, Are:

- ***Ensure a sustainable used oil recycling industry.***

  Comment: positive steps have been made towards this objective with the levy/benefit system, and with the increased infrastructure providing more reliable access to used oil for recycling. However, the industry situation is not stable, with market uncertainties from competition and the proposed excise changes. The excise issue has been addressed by an announcement on 31 January 2004 that the Government is preparing new regulations to create a new benefit category under the Product Stewardship (Oil) Regulations 2000 to ensure that producers of Blended Light Fuel Oil continue to receive an equivalent level of benefit and will not be disadvantaged.

- ***Accelerate the uptake of used oil from urban and rural Australia.***

  Comment: the uptake seems to have risen by 33% since commencement of the program, resulting mainly from the impacts of the benefit payment and the increased infrastructure for collection. This has also resulted in verifiable recording of collection

volumes related to benefits paid. Anecdotal evidence indicates more effort needs to be made in used oil collections in regional and rural Australia.

- ***Facilitate the transition of the industry and the community into effective participants in the Product Stewardship Arrangements.***

  Comment: the industry is well involved with the PSO, but implementation of the 'Communications Strategy for Used Oil' is necessary to raise community awareness. Contact with state EPA's is giving a mixed picture of awareness and engagement with the PSO. EPA's are aware of the PSO and are happy with it as a Commonwealth initiative but seem to have limited specific knowledge of activities and achievements.

- ***To the extent possible, address special difficulties that remote Australia has in the recovery and management of used oil for appropriate recycling.***

  Comment: remote farms, mines and industry will need specific initiatives. The increased local government collection facilities will assist in regional and remote areas and there seem to be sufficient collection vehicles available around Australia. It is reported in the Meinhardt Report on *Used Oil in Australia*[3] that stockpiles of used oil are particularly significant in remote and regional areas, with approximately 26 ML stockpiled across Australia in 1999, excluding the Northern Territory, which has a capacity of 23 ML. This equates to a total Australian stockpile of 49 ML. Based on discussions with Oil Recyclers in late 2003, it seems that, with developments in recent years encouraged by the PSO, stockpiles have decreased and may now be in the region of 20 ML. The Academy believes this is a credible figure.

4.4 General Comments on the Current Used Oil Collection Situation:

4.4.1 Comparisons

Based on available figures and estimates for 2000-03, some 220 ML of used oil was collected in Australia and re-refined/re-used. This is a collection rate of 81% of collectable generated oil (52% of lube oil sales), equal or exceeding that of the best performing European countries[4]. Table 1 gives some comparisons for the year 2000. Some of the countries chosen have a lube-to-lube recycle component. The average for 15 European countries is a collection rate of 76.6% at a generation rate of 49%.

Table 4.2: European Community Used Oil Collection, comparison to Australia and New Zealand: ML/year

Country	Lube Sales	Collectable Waste	Collection Rate %	Energy Use %	Re-refined Base Oil %
France	718	368	82%	57%	10%
Belgium	174	76	79%	78%	1%
Italy	681	272	74%	18%	31%
Spain	496	223	47%	31%	11%
U.K.	804	410	86%	85%	n.a.
Australia	520	270	81%	75.6%	1.4
New Zealand	52	21	77%	77%	n.a.

Source: European Commission: Taylor Nelson Sofres S.A. Critical Review of Existing Studies and Life Cycle Analysis on the Regeneration and Incineration of Waste Oils. (December 2001). Page 29. All percentages are calculated on collectable waste.

4.4.2 Uncollected Volumes

As reported in Section 2.3, based on 2002-03 collections of 220 ML, the 'uncollected' used oil volume is around 50 ML. Collection targets for the future could possibly be set as 250 ML in the short term (2+ years) and 270 ML in the longer term (4+ years). However, a continued decrease in lube oil sales could lead to lower targets (see Section 2.3)

The Oil Stewardship Advisory Council (OSAC) Collection Working Group[5] reports that, apart from the DIY market, which is a problem in all areas, the remote and regional areas in all states have potentially the most uncollected used oil. The regional cities have regular collections by local collectors or by the larger collectors who service these areas on a regular basis. In other cases, collectors service a large area and transfer the collections to storage facilities strategically placed in regional locations. Only the larger collectors service the remote parts of Australia due to the cost involved and the need to develop viable calling schedules. The Working Group also promotes the idea of collection 'hubs' integrating local government facilities with other regional storage facilities, which can be serviced by oil collection companies on a regular basis. The aim would be to develop these 'hubs' to ensure a financially viable operation.

Interviews conducted as part of this review indicated a positive product stewardship response from oil companies producing lube oil, who are in a position to positively influence customer behaviour in relation to used lube oil management. However, there is an impression that payment of the levy takes care of product stewardship responsibilities for lube oil producers and that close engagement in recycling is not necessary. It is the belief of the Academy that a long-term effective oil recycling industry with minimum government intervention will only result with close involvement of all stakeholders. It is therefore important that ongoing efforts be made with the lube oil producers, especially Oil Majors, to better engage them in collection and recycling issues, involving them with AORA (Australian Oil Recyclers Association) and other stakeholders (state recycling bodies, local government etc) to achieve improved co-ordination of collections and to better identify where improvements can be made to increase volumes collected.

Based on previous consultant reports[3,6,7], and discussion with industry, the following priority areas should be addressed to close the gap between targets and actual collections (volumes are informed guesswork):

- ***Retail DIY market: 5-10 litre plastic container: 10-20 ML.***
- ***Remote and regional farms, mines and industry: 10-20 ML.***
- ***Improved management of collection facilities and communication: 10 ML.***
- ***Commercial market: Collection and recycle of larger lube oil packs: 5-10 ML.***

Details on how these areas should be tackled are given in Section 5.1. Following is further comment on some aspects of used oil collection, obtained during the review:

Remote and Regional Farms:
One of the remaining issues in used oil recovery is the management of disparate sources of used oil on farms and related industries in remote, rural and regional Australia. To develop a cost effective solution to this problem will initially require knowledge concerning use of lubricants and generation of used oil in these areas. Strategic partnerships can possibly be developed with the National Farmers Federation, Rural Agencies and Distributors, industry organisations as well as state recycling organisations, the Australian Local Government Association (ALGA) and other industry recycling groups, e.g. ChemCollect, *drum*MUSTER and Kerbside Recycling. Oil companies and their distributors will have accurate details of all their customers and be able to facilitate a program to increase collection from these sources. From some informal inquiries, it has been reported that farmers are becoming increasingly conscious of their environmental responsibilities on issues such as waste disposal. It is also noted that an increasing proportion of farm machinery maintenance is now done centrally because of its complexity. It is likely that farmers will easily cooperate with strategies to improve practices and collections in rural areas.

The OSAC Collection Working Group[5] also comments that farmers do not know that oil can be collected, provided that quantities are sufficient to warrant the trip for collection. The oil is generally stored in 205 litre drums that have been there for some years and can be in poor condition. Handling these drums is an issue for a farmer to take them to a collection facility. A communications strategy is important to ensure farmers know what collection facilities are available.

The Academy believes that a collaborative effort, involving a survey of oil usage to establish quantities available for collection and then development of strategies to establish viable remote collection services, can potentially provide an increase in collection volumes.

Information has been obtained from Oil Drop Pty Ltd relating to their concept of a scheme known as “LandMates on farm waste collection services”. This scheme aims to address the volumes of used oil generated in remote, rural and regional areas (farms and industry) by combining the needs of the used oil sector with that of the agricultural and veterinary chemicals sector. Whilst the Academy offers no opinion on this proposal, it is encouraged by the willingness of the commercial sector to become involved in the management of used oil.

Consultation by the Academy produced the following picture of management of used oil in regional Victoria, where farms are not remote from servicing and collection services. Most on-road vehicles are serviced in conventional workshops and used oil passes into normal

collection channels. Tractors are usually serviced on the property by specialist contractors, who remove the oil and direct it into the collection system.

A small minority of farms service their vehicles on the farm and, in some cases, the used oil is stockpiled in 205 litre drums, which are hard for the farmer to deliver to collection centres. Visits from collectors may be necessary to gather this used oil. A small proportion of this used oil, particularly on less prosperous farms, is used to treat fence posts (where the obvious alternative, treated pine, is not used) and even for dust suppression. Both practices are environmentally unacceptable and are being phased out as farms give more attention to such matters.

Several collectors have drawn our attention to the financial problems associated with collection from remote sites. Collection costs rise significantly with distance eventually becoming higher than the sales price. The use of Government funding to subsidise such collections is difficult to achieve without conferring competitive advantage to an individual firm but this is an issue that needs to be addressed.

Remote and Regional Mines and Industry:
Discussion with oil companies confirmed that for commercial customers – one company quoted having around 1000 large and small customers – there is still scope for improved management of used oil. Oil companies are generating their own initiatives[8] but indicated a willingness to cooperate with the Department of the Environment and Heritage initiatives, including the communications strategy.

Oil companies have extensive databases of customers all over Australia buying fuel and lubricants. The companies advise that many farms, mines and industry – small, medium, large – have good practices but, from their customer knowledge, there is still scope for improvement. They advise there is a need to target a collection and recycling approach to industry sectors – not just consumers. Oil companies can integrate government initiatives and information with their commercially driven schemes.

One company reported they have customers located up to 2000 km, or some instances more, from a licensed recycling facility. These large distances are often compounded by slow and unpredictable (seasonal) travel on poor road surfaces. In such situations collection costs can be of the order of 12 cpl which, when added to the levy in the original oil purchase price, presents a significant impost to the operating cost of their business. These customers are challenging their supplier to assist them to achieve a financial return from the levy. Of particular interest are opportunities for customers to develop their own infrastructure, which will enable them to re-use used lube oil on-site for applications such as locomotion, power generation and explosives manufacture. Not only would this practice reduce demand for diesel, it might also enable their qualification as used oil recyclers and hence make them eligible to receive benefits.

Commercial Market – Larger Oil Packs:
Several oil companies advised that containers in the 10-20 litre size range are supplied to many industrial and mining companies and are widely used in the underground mining industry. It is reported by one oil company that, when discarded, these may contain up to 5% unused oil. Both plastic and tinplate containers are used, although there is a trend to replace the 20 litre tinplate containers with plastic pails to facilitate full recycling. At least one

company is developing an initiative to develop larger container recycling, aimed not only at oil and container recovery but to assist the company to build a competitive advantage.

Vehicle Wrecking:
During the consultation, concern has been expressed at times regarding the oil content of 'end of life' motor vehicles, which are demolished for scrap. The Academy received the following information from the Sims Group:

"Almost all motor vehicles received at our premises come from auto wreckers or other sources and as a result the oil and transmission fluid (along with most valuable parts) have been removed prior to processing. There are two main reasons for this. Firstly, Sims have very strict operational policies of not receiving any waste materials or hazardous components, which include fuel, oils, closed vessels along with a number of other items. Secondly, payment of materials received by us is based on the commodity value of the incoming material and the form it is in. If a motor vehicle is brought in whole, then only steel value is paid. Since steel is about $20-40/tonne as compared to aluminium at $1600/tonne and copper at $2400/tonne, auto wreckers almost always remove bell housing and part of the engine block (aluminium) and the radiator (copper). Along with this process, the fluids to which you refer are removed or lost. Only cars dumped outside our premises, which would be one to two a week, compared to the approximately 100,000 cars we process each year, would have any liquids in them. When this happens, hazardous materials are removed prior to shredding as part of our rigorous inspection procedures. The only waste oils remaining on cars are very small amounts of the C16-C32 type heavy oil residue on the undercarriage, which can only be removed though degreasing or steam cleaning. These oils are, as you will be aware, not very mobile and end up being adsorbed on the waste stream (flock), which is disposed off to appropriately classified landfill."

Peter Netchaef, General Manager, Recycling Solutions.

An inquiry to one of the wrecking firms confirmed that generally in the industry oil is removed from vehicles and collected by recycling firms.

Inquiries to auto servicing firms in Melbourne confirmed that used oil filters are collected but it was not clear whether oil was subsequently recovered from them. This is a possible source of release of oil into the environment, especially in regional Australia, so oil recovery should be encouraged.

Auto Parts Recycling Association of Australia was awarded a Transitional Assistance Grant of $53,000 to address the issue of improving used oil outcomes in the auto dismantling and parts recycling industry. The project description aimed to increase awareness of used oil management issues in the auto dismantling industry, which processes 500,000 end of life vehicles a year, and to encourage appropriate responses at the individual business level. The project is complete and an environmental best practice guide for auto recyclers and a directory of used oil collectors have been produced. (Appendix F).

Other Used Oil Services:
An interesting aspect of used oil recovery came out of discussion with several oil recyclers relating to 'laundering' of specific oil streams. In two cases hydraulic oil is circulated through filters and cleaned for re-use in the same service. A third related to rolling oil in the aluminium industry where a contract service was established to rejuvenate the oil for re-use. In all cases a small-scale but mutually profitable process was established. Other oil recyclers

also reported diversification into areas such as collection of oily waste, filters, tank bottoms and sludge where a fee for service is charged. Two recyclers also build and install used oil tanks and other equipment designed to meet specific customer needs. These add to the overall profitability of the companies concerned as well as contributing to effective collection of used oil.

4.5 Markets for Recycled Used Oil

Reference: Appendix C: Collection Details and Appendix D: Recycled Used Oil Markets.

The following diagram shows the current (2002-03) market destinations for recycled used oil in Australia. This is based on the market data in Appendix D, which was assembled by the OSAC Working Group on used oil markets using information from industry members, particularly from AORA. Note that the base oil category is not a current actual sales figure, but relates to base oil feed to the Southern Oil Refineries plant for re-refining to lube base oil, and represents the final capacity volume for this plant, expected to be achieved by end 2003.

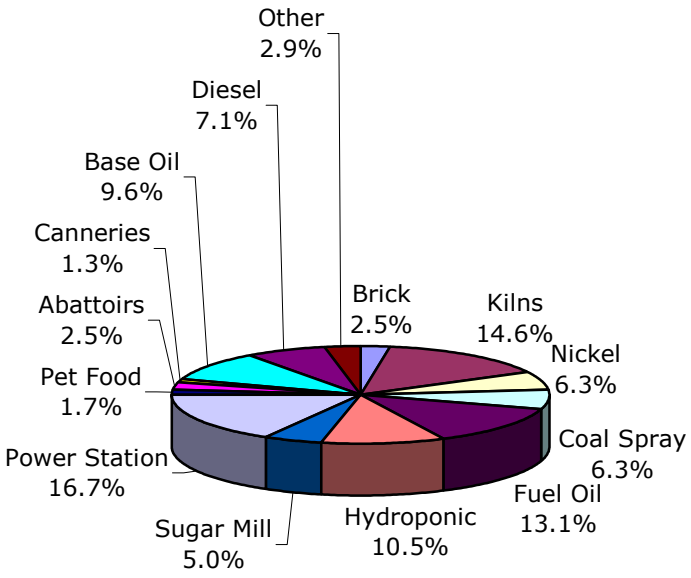

Figure 4.1: Recycled Used Oil Markets, 2002-2003

Burning markets dominate and there are similarities with the European used oil markets. A recent OECD report[9] "Improving Markets for Used Lubricating Oils" gives a good summary of the European situation with most of the points being equally relevant to Australia:

"…Where air quality legislation permits, used lubricating oil is traded as feedstock for a variety of uses:

- *Fuel in small-scale space heaters*
- *Fuel in industrial-scale processes such as power stations and cement kilns*
- *Re-processing to various fuel oils*
- *Re-refining to base oil suitable for lubricant uses*

The market demand for burning the used oil directly in small-scale space heaters and in industrial scale processes is potentially very much greater than the supply. Consequently, depending on local regulations, the price paid for the used oil is close to its nearest substitute of coal or medium to heavy fuel oil. This market works efficiently.

Several governments have introduced policies to promote re-refining in preference to the direct burning of used oil. They do so in order to conserve a non-renewable resource and to avoid air quality issues arising from direct burning. Investors in this market confront several market barriers, some of which are common to market entrants using either crude oil or used oil as feedstock to manufacture base oil. These barriers are: information failure relating to waste quality; risk aversion to using re-refined base oils; certain technological externalities and the market power of incumbents."

4.5.1 Lube Base Oil

The current gap between the benefit rate for lube base oil (50 cpl) and HG industrial burning oils (5 cpl) is intended to stimulate the move towards lube oil recycling. The term 'lube base oil' is used in this report to indicate used oil re-refined to full lubricating oil quality standard. Southern Oil Refineries have a capacity to produce 15 ML of re-refined lube base oil. If two other manufacturers also upgrade their plant there could be capacity to produce 40-45 ML in the next two years. This is close to 10% of the Australian lube oil market and represents around 18% of generated used oil. Few countries exceed this percentage and Italy has achieved a recovery level of 18-19% of lubricant sales as base oil only after several decades of favourable government policies[9].

While this volume technically can be absorbed in Australia, replacing imports of base oil, it is most unlikely to happen due to current oil company policy. If production is from several small plants then quality variation will make testing programs and agreement with oil companies costly and it will be difficult to achieve a satisfactory outcome. It will be easier if there is one larger plant and a single uniform quality. Discussions with oil companies and recyclers suggest that there is an export market in South East Asia for re-refined lube base oil, which could possibly absorb recycled lube base oil not sold in Australia. However, it is important to ensure maximum Australian sales to achieve full lube-to-lube recycle and replace imports of virgin base oil. With the closure of BP Kwinana WA (mid 2002) and ExxonMobil Port Stanvac SA (early 2003) lube base oil manufacturing plants, Australian production capacity has dropped from some 800 ML to around 300 ML per year, with resulting base oil imports. Only Shell and Caltex now manufacture base oil in Australia.

To develop this recycle lube base oil market it is necessary to engage the major lube oil manufacturers in dialogue to agree terms under which re-refined lube base oil can be used in the Australian lube oil market. This should be on performance merit and it will also be essential to address the issue of customer perception that recycled lube oil means poor quality. Discussion by the reviewers with several oil companies indicates a willingness to engage in dialogue on this subject.

Some 25% or more of the lube oil market is for premium automotive lubricant applications requiring the higher grade API specified products for which re-refined base oil would not be acceptable. However for the balance of the market, oil companies should be asked to define the minimum quality standard needed with a view to uptake the available re-refined product.

The oil industry considers that severe hydrofinishing is needed to produce lube base oil of the required quality. The Viscolube plant in Milan[9], which opened in September 2003, is quoted as an example of this technology. Similar plants are now operating, or are under construction, in Indonesia, Poland and Pakistan. Careful thought will need to be given to the mix of benefit rate and TA Grants required to encourage investment in a large re-refining plant, addressing the issues discussed above. Government could also consider 'leading' the market by specifying use of re-refined lube oils in some government supply contracts. Informal discussions with oil companies suggest that they would work to comply with such a requirement.

4.5.2 Industrial Burning Oils

It is reported[10] there is potential to increase sales of HG industrial burning oils into power stations. However there is strong competition from oil companies selling virgin oil and also a general market expectation that products derived from used oil should sell for a lower price than virgin oil products. A further difficulty is the price variation resulting from changes in the international crude oil price. Used oil has fixed cost components relating to collection and processing. Most recyclers suggest the benefit rate for this category should be reviewed and increased from 5 cpl, and this seems to be supported by the cost data obtained by the review team (see Section 2.6.3).

A substantial market for HG industrial burning oils is as startup fuel in coal fired power stations. The OSAC Markets Working Group[10] estimates Australian sales as 40 ML per year. Liddell, at Muswellbrook, NSW, is a large coal-fired power station with a need for liquid fuel for boiler start-up. This occurs around 2-3 times per month and the annual demand for fuel oil is less than 5 ML. Currently recycled used oil is used for this purpose. The oil purchased must meet the Macquarie Generation specification, which is set to ensure EPA licence conditions for stack emission are met. The supplier is required to provide evidence that delivered oil meets the specification. A delivery sample is taken and kept for reference, with random analysis carried out to check compliance. Oil is used primarily for start-up and not as a supplementary fuel. There are, however, limited occasions when oil is used to achieve flame stability. Diesel is used for other purposes on the site and can also be a back-up fuel to used oil, although it is more expensive. If reticulated gas was available this may be used in preference if a cost effective supply contract could be negotiated. Gas suppliers usually require a minimum supply volume and peak demands for start-up purposes can attract penalty pricing. Burner management systems would also need to be re-engineered to suit gas characteristics. Large coal-fired power stations such as Liddell are planning for long term operation and so should continue to provide a stable market for recycled used oil, assuming competitive pricing can be maintained.

Some power stations consume recycled used oils as supplements to coal. For this application, price is an important component and will relate to the lower quality recycled oils. Liddell Power Station burns significant quantities of this very low quality used oil. This typically seems to be residue from used oil processing and can contain up to about 30% water. This material is unsaleable and would otherwise need to be disposed in other ways (e.g. by bio-treating). The requirement set by the NSW EPA for combustion of this oil is that it must have a minimum calorific value of 5 MJ per kg. The supplier pays a fee for combustion of the oil and the fee varies with the calorific value of the oil – a lower cost for higher quality. Liddell also burns other waste materials, particularly biomass which is a preferred alternate fuel as it earns greenhouse credits. Liddell will explore with the Australian Greenhouse Office whether credits are deserved for burning of low quality used oil. Combustion takes place at some

1300^{o}C. Liddell currently process annual volumes approaching 20 kT – a substantial quantity representing around 10% of used oil collected. EPA requirements specify sampling and testing of all incoming loads.

As a philosophy, environmental sustainability considerations suggest that encouragement should be given to production of HG industrial burning oils as well as lube base oils. This is because the HG oils, particularly when produced from reprocessing plant, contain lower contaminant and ash levels, imposing less environmental burden on the consuming furnace. Quality is comparable to virgin fuel oil and use of HG oils has the environmental advantage of reducing consumption of a non-renewable resource. The price paid for the used oil is close to its nearest substitute of coal or medium to heavy fuel oil. However it is also important to protect markets at the lower quality end of the burning market. Gas is a threat to many of the used oil burning applications and will erode markets in the coming years. This is particularly in areas where newly reticulated gas becomes available. The market demand for used oil in small-scale heaters and industrial scale processes is recognised in Europe[9] as potentially much greater than the supply. The Warnken report[11] on the Greenhouse and Hydroponics industry recommends to conduct a 'supply side' survey of used oil collectors supplying this industry and this is strongly supported as a way of gaining further insight into small burner market potential.

Cement kilns[12] offer an environmentally sustainable method for burning low quality recycled used oil. Higher quality used oil has difficulty competing with other energy sources, particularly gas. Cement production is characterised by an extremely high-temperature combustion process, necessary for heating and fusing the raw materials. The fuels most commonly used in Australia for this combustion process are coal or gas. Because of the relatively long residence times in the kiln, and because of the high temperatures required for the process (1450-1500°C in the kiln burning zone), very favourable conditions exist for the complete combustion of organic material in the fuel. Any solid residue of the combusted fuel becomes a raw material for the process and is incorporated into the clinker product. The recycling of used oil as an alternative kiln fuel provides a safe waste disposal option for the community and reduces the use of non-renewable resources in cement production. Used oil will only be processed if price is competitive with other fuels, typically gas and coal. As price to kilns can be less than collection cost, recyclers prefer to seek a higher price in other burner markets. This can leave only very low quality oil for disposal in kilns, at an even lower price. One kiln operator has advised that fuel storage and pumping system upgrades to cope with this low quality used oil can impose extra costs that may not be economically justified. Recyclers would then have to find other disposal routes or pay for disposal.

4.5.3 Oil Bottoms

This is one of the products from reprocessing units, including re-refining to lube base oil, with typically 15-20 % yield, and effectively there is a cost for disposal. The 'oil bottoms' issue needs to be resolved and this is a priority of the Department of the Environment and Heritage. During the review process, information was provided that this material does enhance the performance of road asphalt when blended into modified and multi-grade bitumen. Major producers have concerns relating to fuming on application and leaching from the road asphalt. A testing program is required to resolve these issues and enable use of re-refined used oil bottoms on a performance basis. This could be achieved by development of an industry standard Code of Practice. Such work could be considered for TA Grant funding and details of established processes for this to proceed are given in Section 5.2.4. A targeted Expression

of Interest round for resolution of the oil bottoms issue was advertised by the Department of the Environment and Heritage on 21 & 22 November 2003.

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5 New Priorities for the PSO

While the basic aims of the PSO remain valid, this section lists a number of new priority areas for consideration. The Academy believes the key priority is to maximise collection of used oil to avoid contamination of the environment by dumping in sewers, rivers and on land. Australia seems to be performing well in this regard but areas of further possible gain have already been highlighted and are briefly referred to again in this section. In implementing strategies to target these areas it will help to have better data available on used oil collection and recycling. The final focus is then on how to process the used oil and market for reuse or recycling in an environmentally sustainable way, at the same time maintaining an effective and profitable collection and processing industry with minimum government intervention.

5.1 Used Oil Collection

We have noted that TA funding has aided the development of improved collection schemes. The Academy believes that further expenditure of TA funds is necessary to build on this.

The Academy recommends the following priority areas should be addressed to close the gap between targets and actual collections and suggestions are given on how these should be tackled.

5.1.1 Remote and Regional Farms, Mines and Industry

As reported in Section 4.4.2, an important issue is the management of disparate sources of used oil on farms and related industries in remote, rural and regional Australia. The Academy believes that a collaborative effort, involving a survey of oil usage and then development of strategies to improve collection of generated used oil, can potentially provide an increase in collection volumes. A productive target for TA funding could be to support a project to ensure collection of sufficient data to commence such a scheme. It will be important to ensure the information is then available publicly for free access to all potential commercial operators.

Major oil companies agree they can do more with customers in the commercial market. Larger customers challenge oil companies to assist in recycling and they claim they are responding, endeavouring to close the gap between delivered and recovered oil. It would seem to be useful to engage all major oil companies and oil collection companies in dialogue to pool knowledge of a general nature and build synergy between government initiatives – particularly the Department of the Environment and Heritage communication strategy and development of local government collection facilities – and oil company initiatives. With the significant increase in local government collection facilities there is scope to consolidate oil collection volumes at these facilities so that viable schedules can be developed for oil collection companies to pick up oil on a regular basis and also visit larger farms and industries in the area.

Recommendation 1

The Department of the Environment and Heritage should consider a targeted Transitional Assistance Grant to assist data gathering to establish the feasibility of an integrated collection scheme for used oil and other toxic waste materials from farms. Major oil companies and used oil collection companies will need to help develop a more

comprehensive approach to improve collection of used oil from remote and regional farms, mines and industry.

5.1.2 Collection and Recycling of Larger Lube Oil Packs

These include 10 (plastic) and 20 litre (plastic and tinplate) lube oil packs, as well as large 205 litre steel drums. The challenge to collect and recycle these packs can be addressed in parallel with that of remote farms, mines and industry, but has some unique characteristics requiring specific solutions. Plastics recycling issues can be informed by the proposed AIP scheme. Hagen Oil in Tasmania has also done work, using funds from a successful TA Grant for $110,000, to pilot a container recycling scheme. Consultation should take place with the major oil companies who have extensive knowledge of this issue. Some companies have a recoverable deposit on containers. During the Review some companies reported that, as part of their Product Stewardship responsibilities, they are currently developing recycling initiatives.

Recommendation 2

The Department of the Environment and Heritage should consult major oil companies and other lube oil suppliers to establish the extent of the issue of 10 and 20 litre oil packs, improve coordination of solutions currently being developed and gain commitment from other companies to also engage in this problem.

5.1.3 DIY Market

The expansion of collection facilities promoted by PSO funding will help increase the collected volume of both used and unused DIY oil. The proposed AIP Action Plan to collect plastic oil bottles up to 10 litres in capacity will also address this issue. The AIP proposal is a 3-5 year program, costing $5 million, and will be funded by member companies and potentially supported by a $2.5 million Transitional Assistance Grant from the Department of the Environment and Heritage (the AIP application is currently under consideration). The Communication Strategy also intends to target cohesive groups of users such as the fishing industry and car enthusiasts.

5.1.4 Improved Management of Collection Facilities and Communication

This can impact on urban, regional and remote areas. With the roll out of additional local government collection facilities the challenge is to ensure these facilities are well managed to improve efficiency, increase volume collected and reduce contamination. Furthermore an extensive communications program is necessary to inform lube oil consumers of collection centre availability and motivate them to use the facilities. The Department of the Environment and Heritage Communication Strategy aims to address this issue and the strategy is currently being implemented. The development of collection hubs, as proposed by the OSAC Collection Working Group, should also be given serious consideration. Further use of TA Grant funds could be considered to investigate and develop, with industry and local government support, 'best practice' management techniques for used oil collection facilities. This could result in preparation of accredited management systems and training programs for management and staff at facilities. The Academy notes that at least one comprehensive training program has been instituted, by EcoRecycle Victoria. In the EcoRecycle Victoria scheme, "each Council that receives a collection facility under the program enters into a Memorandum of Understanding (MOU) with EcoRecycle Victoria. It is a condition of infrastructure provision that at least one staff member for each site attends the training session."

Recommendation 3

The Department of the Environment and Heritage should consult stakeholders regarding the merits of developing accredited management systems and training programs for management and staff at local government collection facilities.

5.2 Used Oil Processes and Markets

5.2.1 Small Industry Markets

The Department of the Environment and Heritage should review with State and Territory authorities and, where appropriate, implement better regulation of small industry (typically hydroponics) used oil burning, to eliminate environmentally unacceptable practices. This market needs to be better understood and encouraged where appropriate, because it is a significant market for recycled used oil (see Section 7.5).

Recommendation 4

The Department of the Environment and Heritage should consider use of Transitional Assistance funds to conduct a 'supply side' survey of used oil collectors supplying the greenhouse and hydroponics industry as recommended in the report into this industry by Warnken Industrial & Social Ecology. Based on the results of this survey, discuss with State environmental authorities what joint efforts are needed to promote the responsible burning of used oil in small furnaces.

5.2.2 HG Industrial Burning Oils

The forthcoming independent review of the *Product Stewardship (Oil) Act 2000*, should consider if the level of PSO benefit to HG industrial burning oils (currently 5 cpl) is appropriate. The question is whether benefits should be raised, as required, to sustain and develop this market or whether benefit level is maintained at current levels to encourage a volume move toward lube-to-lube recycling. There is an argument that burning of HG oil does not impose a high environmental cost and is therefore an acceptable outcome but against this is a strong argument for resource conservation. The Academy draws attention to the point that insufficient support will tend to move reprocessing away from HG burning oils to lower quality industrial burning oils.

5.2.3 Re-refined Lube Base Oil

The Academy believes that there is a need to review how TA Grants can be used to encourage re-refining of used oil to lube oil quality base oil. It is recommended that early government support and funding should be directed to elimination of barriers and hurdles for this market. It will become evident then if incentive for investment is necessary or whether investment will follow on a normal commercial basis without government intervention.

There are barriers and hurdles to blending of re-refined used oils into lube oil due mainly to the perception that lube oil incorporating recycled lube base oil is an inferior product even though it meets minimum technical standards. While product from the new Southern Oil Refineries plant is being sold to smaller companies for lube oil production, it is not accepted by major producers. This is said to be for quality reasons and customer perception. There is a rigid industry process requiring API (American Petroleum Institute) accreditation for premium lube oil, based on performance testing but also taking into account the source of the base oil feedstock. To achieve a broader market for recycled base oil it will be necessary to engage with lube oil producers in a process to agree on the environmental benefits of lube-to-lube recycling, identify barriers and develop an agreed program of research and testing. TA Grant funding can be considered to assist this process.

5.2.4 Oil Bottoms

Barriers and hurdles to blending of 'oil bottoms' from re-refining of used oils into bitumen should be eliminated. The 'Sustainability Programs Division' of the new NSW Department of the Environment and Conservation, previously Resource NSW, has a 'Recycled Road Materials Liaison Unit', which oversees steering committees comprising essential stakeholders to achieve particular objectives. Currently a steering committee exists to utilise technically proven scrap rubber asphalt. This involves identifying objectives, devising a program of testing, seeking funds from stakeholders for the work and managing the process to completion. In 1995 an investigation into the fuming of SBS (styrene-butadiene-styrene) bitumen was undertaken in Australia and this led to an Australian Asphalt Paving Association SBS Code of Practice. The proposed Code of Practice for the Manufacture and Handling of Asphalt containing Scrap Rubber Granulate will be prepared along the same lines and a similar process can bring together the necessary stakeholders to achieve acceptance of asphalt incorporating 'oil bottoms' as a performance product, including resolution of HSE concerns relating to fuming and leaching. These are reported as barriers to acceptance. As the Department of the Environment and Heritage have recently called for Expressions of Interest for a National Solution for used oil bottoms, no specific recommendation is made.

5.2.5 Long Term Burner Markets for Recycled Used Oil

Burning options are essential markets for used oil and some markets are under threat as has been mentioned earlier in the report. Appendix D details the outcome of the OSAC Markets Working Group and also gives summary comments from previous consultant reports on used oil markets. If all possible losses and gains are collated, a net loss of 40 –70 ML (say 50 ML) could be foreseen in the next 4-5 years. In the same period it is expected there will be gains in collection of some 50 ML. This gives an overall shortfall of 100 ML in recycled used oil markets. Western Australia seems particularly disadvantaged regarding market opportunities and currently significant quantities of used oil are stockpiled, reportedly up to 6 ML on an annual basis in recent years.

The diesel fuel transport market will be affected by the reduction in the specification for sulphur. Industry members selling recycled diesel fuel appear confident that there will be alternate markets for off-road vehicles, stationary engines and possibly marine applications. Diesel can also be sold into the lower price fuel oil market.

If the PSO benefit rates are able to support a competitive position for used oil then key markets can be maintained, assuming no imbalance from changes in the excise regime. This particularly relates to the power generation industry where there will be a demand for many years for fuel oil for startup and supplementary fuel needs. Both the power and the cement industries have given commitments to assist in use of recycled oil in their fuel mix. The main market threats are from increased gas infrastructure development and promotion of clean and renewable fuels.

Experience in other countries demonstrates that upgrading to lube oil standard will only absorb at best approximately 20% of lubricating oil sold or approximately 35-40% of used oil generated. It is important to also foster burning markets, which are an important outlet for recycled used oil, particularly in the lower quality and small industry sectors of the market. It is possible there may be growth possibilities in these areas.

Information in this report gives a better understanding of all markets. This will inform policy strategy and assist in supporting sustained markets for placement of recycled used oil products

in 10 years time and beyond. This could possibly be supplemented by commissioning a consultant, knowledgeable in industry combustion requirements, to conduct a major study of local and overseas current practices and future trends. Close dialogue with State environmental agencies could be used to encourage burning applications that are environmentally sustainable. Where this is not the case, a regulatory approach may be required.

Figure 5.1 gives a possible future market break-up, based on production of 40 ML of lubricant quality base oil and developments in other markets with a notional total volume of 250 ML (see section 6.6 for further detail). For comparison, Figure 5.2 gives the market break-up for 2002-03 based on PSO benefits paid and for a total volume of 220 ML.

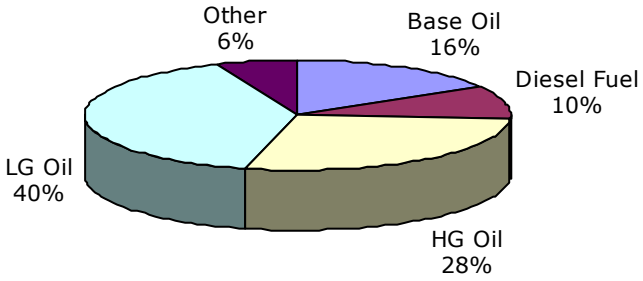

Figure 5.1: Recycled Used Oil Markets Future

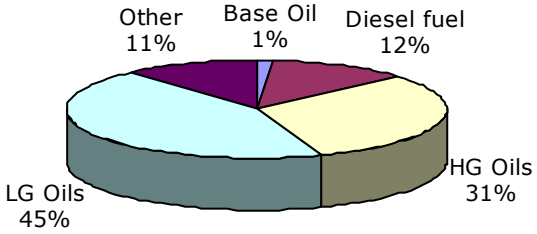

Figure 5.2: Recycled Used Oil Markets 2002-03

Recommendation 5

The Department of the Environment and Heritage should ensure the Review of the Product Stewardship (Oil) Act 2000 considers the appropriate benefit rate(s) to encourage greater use of recycled base oil and sustain markets for HG industrial burning oils. This should also involve engagement of lube oil producers in a process to identify and eliminate barriers to use of this base oil in lube oil blends, recognising the quality, performance and commercial requirements of lube oil producers.

The Department may wish to consider commissioning a major study of future used oil market possibilities, by a consultant specialising in the combustion field, to inform government policy strategy.

6 Current and Future Technologies

Technology issues are addressed in Section 7: Scientific and Technical Advice. However, some interesting observations on used oil technologies resulted from the review and are reported here. Used oil recycle technologies operating in Australia are detailed in Appendix E.

6.1 Recycling Plant

Reprocessing plants located in NSW, Victoria and Western Australia were visited as part of this review and are summarised below[1].

Table 6.1: Australian Reprocessing Plants

State	Company	Technology	Capacity ML	Products
NSW	Nationwide	Propane de-Asphalting PDA	30	Diesel* HG burning oil Bottoms
NSW	Australian Waste Oil Refineries	Thin Film Evaporation TFE	20	Diesel# HG burning oil Bottoms
NSW	Southern Oil Refineries	Thin Film Evaporation + Solvent Extraction	22	Diesel# Lube base oil – 2 grades Bottoms
Victoria	Environmental Oil	Thermal Cracking	10-12	Burner fuel Diesel*
Western Australia	Wren Oil	Thin Film Evaporation	12	Diesel# HG burning oil Bottoms

* Sold as diesel fuel; # Sold as burner fuel

Propane de-Asphalting (PDA) is a process[1] to separate additives, metals, and other undesirable waste from de-watered used oil. The product is then processed through a vacuum distillation unit for further separation. The PDA process relies on the greater solubility of the paraffinic and naphthenic (i.e. essentially the base oil) components versus the contaminated waste material in a stream of propane. It is a continuous process with propane contacting the used oil in an extraction column. The propane extracts the base oil and, being lighter, flows out through the top of the column. The propane insoluble material flows from the base of the column. Propane is vaporised from both streams, recovered and re-used. The base oil is further processed in a vacuum distillation column. The bottoms stream from this column is mixed with the waste component from the extraction column to produce an asphaltic 'oil bottoms' material.

Thin Film Evaporation (TFE) is a form of high vacuum distillation[1] under thin film conditions with recovery of several products of different boiling range. De-watered used oil

is also required for this process. The used oil feedstock is heated in a furnace and flows as a mixture of vapour and liquid to the heated vacuum distillation column with an internal rotating blade, providing a thin film on the column wall. Hot vapours rise, cool, condense and flow downwards. Similarly, some of the downward flowing liquids are re-vaporised by contacting the rising hot vapours. The column is fitted with special draw trays for removal of light, medium and heavy oil. The 'oil bottoms' from the vacuum tower contains the heaviest molecules, including additives and other waste products and is a bitumen-like material.

For both the PDA and TFE processes, a further process step, such as solvent finishing or hydrofinishing, is required to produce PSO Benefit Category 1 lubricant quality base oil.

Thermal cracking of used oil to gas oil produces up to around 80% yield of diesel fuel and 10-15% of a lower quality fuel oil. After removal of water, the oil is cracked at a temperature in the range 350-400^{o}C and a separation process produces several grades of product. Support for this process has been published in a recent article[2]. The sulphur level in the diesel is lower than that produced by other re-refining processes but still well above the national standard for transport applications. Both producers of diesel fuel seem confident that there are markets suitable for their product quality.

6.2 Demineralisation

Demineralisation plants are operated by Nationwide in Queensland (2), Western Australia (1) and Victoria (1) with a combined current capacity of around 50 ML per year. As it is a batch process, flexibility is available by extending operating hours to increase capacity. Demineralisation[1] is a process involving removal of metals and other inorganics from the used oil, with a mild form of sulphuric acid treatment. An acidic sludge is produced as a waste stream and this must be treated and disposed of in an appropriate manner. When operated as a 'stand-alone' process, these plants produce only HG industrial burning oil, although with a higher ash level (0.3%) than the reprocessing (<0.05%) and at significantly lower operating cost, up to 10 cpl less than PDA and TFE processes. Demineralisation can also produce a feedstock for further re-refining in an integrated process.

6.3 Used Oil Quality and Water Removal

Used oil feed for reprocessing operations needs to be of good quality for production of HG industrial burning oils and base oil. All operators have techniques in place to provide quality assurance. In particular used oil is obtained from reliable sources especially automotive workshops and other well managed industries. As collection volumes increase further, especially through local government collection points, good management practices are vital to ensure oil is good quality with minimum contamination. There is also the risk that such oil will otherwise be sold to alternate, environmentally inappropriate, burner applications.

All operators report around 10-12% water in collected used oil, either emulsified or as free water. This is removed in a batch process. After water draining, the used oil is transferred into a process vessel and circulated through a fired heater back to the vessel till the required temperature is reached[1]. Water is drained from the base of the vessel and the oil is transferred to storage, as feed for the re-refining process. As a 'stand-alone' process, dewatering is a very basic used oil treatment producing burner fuel oils of variable quality, which are also filtered to meet the PSO Benefit requirement for LG industrial burning oils.

6.4 Base Oils

The major product of reprocessing plants is base oil, typically 60% of feed, and this is produced either at two different viscosity levels or as a mixed stream. It is designated HG industrial burning oil and sold typically into coal-fired power stations as a start-up fuel, sometimes after blending with diesel fuel for viscosity adjustment. Some power stations can burn the base oil direct and the product is then free of excise, but others require viscosity adjustment with diesel up to 50% and this triggers application of excise discussed earlier in the report. Demineralisation plant product, despite the higher ash level, is also acceptable in this market. With the current benefit structure and proposed excise changes, economic drivers encourage reprocessing operators to upgrade to produce lube quality base oil as operation of reprocessing plant to produce HG burning oils is seen as only marginally profitable.

Upgrading base oil produced by re-refining plant to high quality lube base oil can be done by a variety of routes[3]:

- Solvent extraction – as used at Southern Oil Refineries, with good results;
- Hydrotreating[4] – reportedly the best to compete with virgin base oil;
- Sophisticated membrane systems – new technology.

Solvent extraction[1] is a finishing process consisting of mixing the solvent (e.g. furfural or N-methyl pyrrolidone) with the base oil from vacuum distillation, allowing the mixture to settle into two liquid phases. The solvent is then removed from each phase and re-used. The major impact of solvent extraction is an improvement in colour and stability of the base oil due to the removal of aromatic compounds. These aromatics, when recovered from the solvent, can be used as a fuel.

Hydrotreating is a hydrofinishing process where the base oil from vacuum distillation is heated and passed through a bed of catalyst with a hydrogen stream. The object is to convert aromatic molecules into non-aromatic compounds and to convert any unsaturated hydrocarbons (alkenes) into saturated hydrocarbons (alkanes). Sulphur is also removed in the process. The process is complicated by the need for high purity hydrogen, high pressure operating conditions and production of hydrogen sulphide, which is highly toxic. A difficulty in Australia is the small scale of operation and, with potentially three producers of lube base oil, there will not be one uniform product quality. This will create a further hurdle for full acceptance into quality lubricating oil. It is preferable to have large-scale lube-to-lube plants to make them economically attractive. Many re-refiners who operated in North America in the 1970s and 80s have closed and by 1999 only three re-refiners were operating four refineries which produce automotive grade lube base oil; Safety-Kleen Oil Recovery Division in Chicago and Ontario, Evergreen Oil in California and Mohawk Lubricants Ltd in Vancouver[5]. Other refineries produced lower grade oils. In Indonesia, Evergreen has been operating a plant with a capacity of 56 ML per annum and Viscolube a plant with similar capacity. Viscolube report the construction of similar plants in Poland and Pakistan.

It is generally acknowledged that government support is necessary to achieve commercially viable production of re-refined base oil. Higher value sale of the oil bottoms product into bitumen will assist, but serious discussion with all industry stakeholders is need to determine the best long term direction. As already canvassed in this report, there are environmentally acceptable burning options available at lower cost. A preliminary assessment by the review team of a hydrotreater investment option is given in section 6.6.

In a very interesting future development, Shell[6] and Qatar Petroleum have announced an agreement to build the world's largest Gas to Liquids (GTL) plant in Qatar to be commissioned in 2009. The GTL plant will have a capacity of 140,000 barrels per day. As well as the core products – naphtha and gasoil – the plant will also produce n-paraffins and lubricant base oils. Production of these base oils involves distillation and catalytic de-waxing producing very high quality product and setting new standards for premium lubricant base oil. See also section 7.1.2.

6.5 Re-processed and Re-cycled Product

Based on information in Table 6.1 and product yield data provided by the industry, Table 6.2 gives a summary of main product volumes from reprocessing and demineralisation plants around Australia. Production figures represent plant capacity capability and not necessary current production levels.

Table 6.2: Used Oil - Reprocessed and Recycled Product

Product	Benefit cpl	NSW ML	Vic* ML	Vic# Qld# WA# ML	WA ML	Australia Total ML	Benefit Total $ Million
Diesel Fuel	7	4.5	10			14.5	1.02
Diesel- HG Burning Oil	5	6.5			1	7.5	0.38
Lube Base Oil	50	15				15	7.5
Base Oil – HG Burning Oil	5	28		50	7	85	4.25
Bottoms	3	11			3	14	0.42
Sub-Total		***65***	***10***	***50***	***11***	***136***	***13.6***
Other LG Oils	3		1			84+	2.53
Total						**220**	**16.1**

* Thermal Cracking
# Demineralisation
+ Filtered and de-watered

6.6 Re-refined Lube Base Oil – Future Considerations

In Australia, reprocessing plants operate in NSW with a combined feed of around 72 ML per year, when operating at capacity. There is one Propane de-Asphalting plant and two plants with Thin Film Evaporator technology. Allowing for 10% feed water content and with a typical yield of 60%, base oil production capability in NSW is then around 43 ML per year. Only the Southern Oil Refineries plant, with a solvent extraction unit and a capacity of 15 ML per year, is currently producing product to lube base oil quality standards.

Government policy is to encourage lube-to-lube recycle but to achieve this to any significant degree product quality must be very good and uniform. To gain full acceptance by major oil

companies the lube base oil should ideally be hydrotreated in one processing unit. A speculative long-term scenario is described here for a single hydrotreating option processing all available base oil from existing re-refining plants in NSW – see Figure 6.1.

The capital cost of such a Hydrotreating unit is taken as $20 million. An approximate estimate of unit cost of production is 75 cpl which includes: base oil production cost (40 cpl); capital financing @ 20% (10 cpl); logistics – feed & product movement, testing (5 cpl); process operating cost (15cpl); Hydrogen supply (5 cpl) – 1 tonne per day of hydrogen is required @ up to $6000 per tonne.

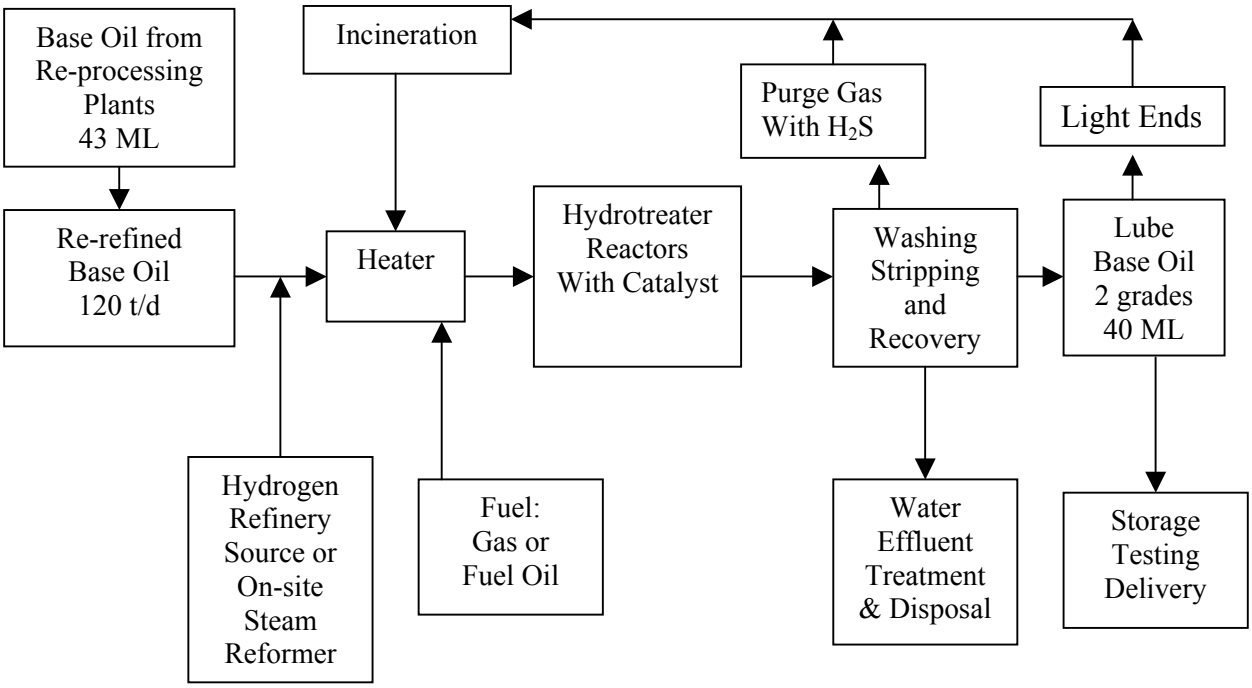

Figure 6.1: Hydrotreater for production of Lube Base Oil - Annual Production 40 ML

The Academy believes that a single large hydrotreater located in NSW, to access the existing available base oil, will provide the best option to achieve a high lube-to-lube recycle component, in line with government policy. As well as benefit payments for qualifying product, capital support will also most likely be necessary. Preference should be given for a large single plant rather than TA funds dispersed over several smaller projects.

In discussion at the Public Consultation meeting it was pointed out that it would be difficult, if not impossible, to produce base oil of constant high quality if products from different treatment plants were processed. It was proposed that the option of constructing and operating an integrated processing plant and hydrotreater be considered. The use of Transitional Assistance funding should be considered, balancing the problems of commercial advantage against benefits to Australia.

As further background to the above long-term scenario, Table 6.3 gives a possible market summary for a future market of 250 ML per year of recycled used oil in 4+ years time (2008). This includes 40 ML of lube base oil and indicative volumes of other products listed by PSO Benefit category. A reduction in 'zero' benefit product is envisaged as recyclers upgrade to

achieve benefit payment. Other products stay at existing volume representing a combination of growth and decline in sectors of the market. HG burning oil production will be reduced, as base oil will be re-refined to lube base oil quality. It is envisaged that this can be offset by increasing oil production by demineralisation and possible de-bottlenecking of reprocessing plant (TFE & PDA processes). On current PSO benefit rates, total benefit payment would be approximately $28 million, but these rates will be studied in the forthcoming independent review of the *Product Stewardship (Oil) Act 2000.*

Table 6.3: Recycled Used Oil Markets – Current and Future (4+ years)

Benefit Category	Current PSO Benefit, cpl	Market 2002-03		Market 2007-08	
		Volume ML	Benefit $ '000	Volume ML	Benefit $ '000
1. Lube Quality Base Oil	50	3	1,520.1	40	20,000
3. Diesel Fuel	7	26	1,828.7	25	1,750
5. HG Industrial Burning Oils	5	69	3,414.3	70	3,500
6. LG Industrial Burning Oils	3	97	2,887.6	105	3,150
7. Untreated Oils	0	25	0	10	0
Total	**n.a.**	**220**	**9,650.7**	**250**	**28,400**

Notes:

1. The table has been simplified by excluding low volume (0.2 ML) 'benefit category 2' product (other base oils) and zero volume 'benefit category 4' product (diesel extender).

2. If Southern Oil Refineries produce to lube base oil capacity of 15 ML in 2004 and volumes of other benefit category products remain unchanged, benefit payments will increase by $6 million to $15 million.

References

1. *Waste Oil Treatment Processes.* SWB Consulting – Client: Environment Australia. January 2003.
2. D. Kress, *A New Threat?*, Lubricants World, January, 2000, p. 33.
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4. *Hydrofinishing Process for Re-refining to Base Oil.* Information from Viscolube Italiana SpA, available at www.viscolube.it/viscoprocess.html.
5. K. Carnes, *Rolling into the Field of Battle,* Lubricants World, November 1999, p. 20.
6. *The Qatar Shell Gas to Liquids Project.* Speech given by Sir Philip Watts and Neils Fabricius in Doha, Qatar on 20/10/2003. Shell in Qatar website.

7 Scientific and Technical Advice

7.1 Chemical Composition of Lubricating Oils

7.1.1 Reference Sources

The Society of Automotive Engineers of the USA commissioned a companion volume on lubricants to their volume on fuels and this appeared in 1996[1]. The authors had extensive experience in the lubricant field with Exxon Corporation and its subsidiaries and in this volume cover most aspects of lubricant syntheses and use including health and environment considerations.

Whilst this volume served as a major introductory source of information, the Academy has also searched Chemical Abstracts locating published work which reflects the continued interest in improving lubricant quality.

7.1.2 Base Oils

Base oils, the major constituent of lubricating oils, are produced in five groups of varying quality as summarised in Table 7.1.

Table 7.1: Properties of Base Oil Groups 1-5

Group	Sulphur Content %	Saturated Hydrocarbons %	Viscosity Index	Manufacturing Method
1	> 0.03	< 90	80 - 120	Solvent freezing
2	< 0.03	> 90	80 – 120	Hydroprocessing & refining
3	< 0.03	> 90	<120	Hydroprocessing & refining
4	Poly-alpha-olefins (PAOs)			Chemical synthesis
5	All other including esters			Chemical synthesis

Source: wwww.lubes-n-filters.com/faq/oil-base-stock.html

Group 1 base oils are prepared from a 300-500^{o}C bp fraction of crude petroleum from which most of the aromatics have been stripped by a solvent wash (phenol, furfural or N-methyl-2-pyrrolidone). The oil is also dewaxed by dissolving in a solvent (usually methylethyl ketone, methylisobutyl ketone or mixtures of these ketones with toluene) in which the wax is insoluble at low temperature and can be filtered off.

In many cases (e.g. Shell's Hydrex unit at Geelong) the base oil is hydrogenated to reduce reactive aromatics to naphthenes (saturated cyclic hydrocarbons) and unsaturated alkenes to alkanes. Saturated hydrocarbons are much more stable and resistant to oxidation. In addition, some sulphur compounds are removed by this treatment. This hydroprocessing and refining unit can produce either Group 2 or Group 3 base oils depending on the severity of the treatment. Only small amounts of Group 3 and no Group 2 oils are currently produced in the Shell refinery.

Although liquid petroleum-based feedstocks are still the main source of feedstocks, other specialist base stocks have been used, including hydrocarbons synthesised from synthesis gas (H_2+CO) by the Fischer-Tropsch process, olefin oligomers and alkylated aromatics. These hydrocarbons involve similar chemical bonds to those present in petroleum derived base stocks. The base oils generated from poly-alpha-olefins are designated as Group 4 base oils and are of very high quality, being used in specialist applications or in blends with other base oils. Shell plans to invest $5 billion to develop the world's largest gas-to-liquids plant in Qatar which will produce large amounts of high quality lubricant base oils of at least Group 2 quality. All other oils are classed as Group 5 base oils.

Base oils involving polyethylene and polypropylene glycols, silicones, phosphate esters and chlorofluorocarbons are used for specialist applications. Natural fats, waxes and oils are included in this group. These compounds are organic esters of long chain carboxylic acids with glycerol. They are prone to decomposition at high temperatures but have the advantage of being much more readily biodegradable than purely hydrocarbon based oils. There is increasing pressure to use these biodegradable oils in appropriate applications where a long lifetime is not required, and there is release to the environment, for example two-stroke engines, chain saw oils etc.[2]

Similar esters of long chain natural organic acids, with neopentylic alcohols as opposed to glycerol, are much less prone to decomposition and are being increasingly used as additives to improve the performance of other base oils.

7.1.3 Additives

A range of additives with varying functions are added to the base oil. The additives are added as oil solutions. The weight of the solution is 20-30% of that of the base oil and the additives themselves can contribute 5-10% of the weight of the lubricating oil. The additives function in many ways, but among them are pour point depressants, anti-foam agents, viscosity modifiers, detergents, suspension agents, ash-free dispersants, antioxidants and anti-wear reagents. A very large number of additives have been and are being used[2] and a survey of the chemical literature using the SciFinder Scholar search engine recorded 3662 references to lube-oil additives over the past 60 years. Interest is being maintained, as evidenced by the fact that 23 references were detected for the period June-September 2003.

7.1.4 Commonly used additives[3]

The chemical types of additives include:

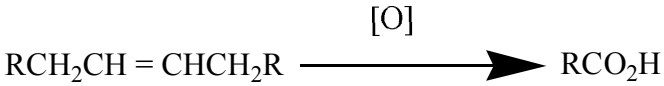
- Polyesters as pour point depressants and anti-foam agents. These materials co-crystallise with waxes and inhibit crystal growth. Polyolefins (for example, polyisoprene, styrene-butadiene) are also added as viscosity modifiers. These polymers are more soluble at high temperatures and thus change the temperature-viscosity relationship of the oil.

- Zinc dialkyldithiophosphates are the predominant anti-wear additives and are added in significant amounts (> 0.5 wt%).

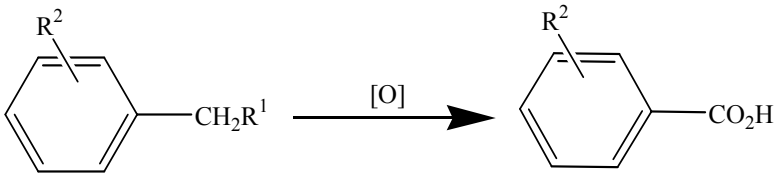
- Calcium and magnesium salts of alkylbenzenesulphonic acids are added as detergents usually 'over based' with the carbonates or hydroxides which neutralise any acids generated during usage and which otherwise might cause wear.

7.1.5 Used Oils

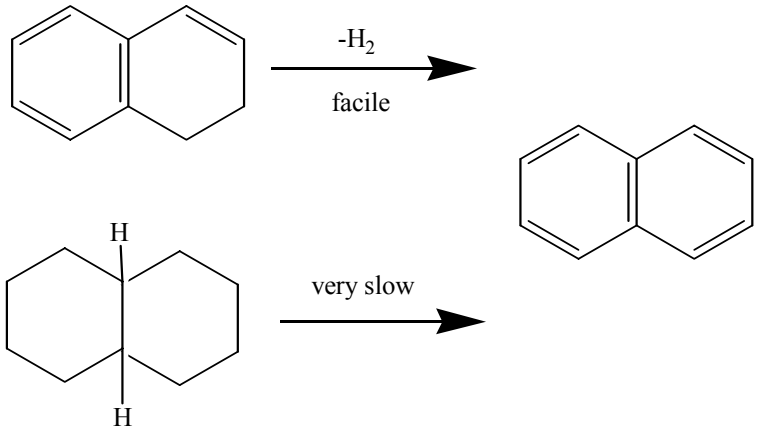
The chemical composition of used oils varies with the quality of the original lubricating oil and with the history of its use. In general the presence of alkenes i.e. unsaturated carbon-carbon bonds is more likely to lead to the formation of carboxylic acids by oxidation reactions.



Acids can also be formed by oxidation of alkyl aromatics, for example

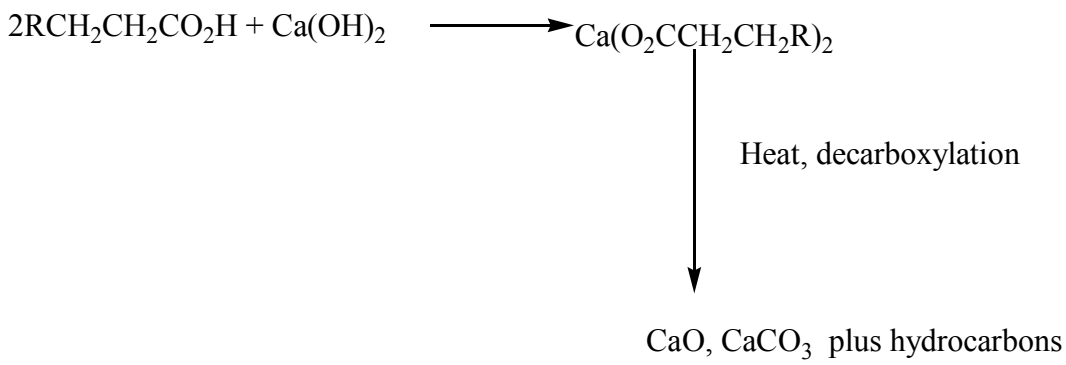


Similarly the presence of alkenes in cyclic systems facilitates dehydrogenation which with larger ring systems can lead to the formation of polycyclic aromatic hydrocarbons (PAHs).



The formation of PAHs has been shown to be much more likely to occur in spark engines than in diesel engines[4,5].

The metal-containing additives are present either in their basic form or as salts of organic acids. Specifically some of the calcium and magnesium hydroxide or carbonate additives will react with any carboxylic acids formed by oxidation to form salts which may themselves decompose under high temperature conditions.



Other metals can be present in varying amounts due to engine wear. Examination of analyses of used oil samples by Australian re-refineries shows traces of iron, copper, lead, aluminium, tin, chromium and nickel all at levels of less than 100 ppm. In contrast the added metals, zinc, calcium and magnesium together with phosphorus, can be in the range of 500 – 2000 ppm.

The element which causes most problems is sulphur. Sulphur compounds are present in most base oils and are added, for example as zinc dialkyl and diaryl dithiophosphates. Volatile organosulphur compounds and hydrogen sulphide all have highly unpleasant odours and even in trace amounts can cause community concerns. Hydrogen sulphide can be detected as one molecule in 10^{19} by the human nose. It can thus raise concerns at concentrations very much less than where its toxicity becomes a threat.

7.2 Recycling Used Oil

7.2.1 Current Status

A report on Waste Oil Treatment Processes has been prepared for The Department of the Environment and Heritage[6]. The subject has also been reviewed by workers of many nationalities, for example British[1], Polish[7], Italian[8] and Saudi-Arabian[9]. Modifications of existing technologies are being studied, for example Korean workers describe a new process in which used oils are mixed with crude petroleum atmospheric distillation residues and vacuum distilled. More than 95% of hazardous heavy metals were relegated to vacuum residues which were converted into road asphalt[10].

One of the most advanced technologies is that developed by Viscolube in Italy, involving propane deasphalting followed by severe hydrotreatment using an advanced proprietary catalyst. A Viscolube plant capable of reprocessing 50 ML of used oil is currently operating in Indonesia and the company's web site (http://www.viscolube.it/) claims their plants are also operating in Poland and Pakistan. Very high quality base oils are obtained after this severe hydrotreating but at significant cost.

Research is being carried out into new technologies which are being or are capable of being applied to oil recycling. These include:

- Membrane separation processes[11] – considered by many to have potential to significantly reduce the cost of reprocessing.
- Supercritical propane extension[12] – proposed as a more efficient solvent extraction methodology.

- Brown coal as an adsorbent for demetallation. Kobe Steel[†] are operating a pilot plant in which lube-to-lube recycling is achieved by heating the used oil to 300-350°C to remove HCl and treatment of the dechlorinated material with brown coal at 100-140°C. Solid-liquid separation gives re-refined oil with a very low metal content and used coal which can be used as a fuel.
- Bioreactors – there is a major problem with green waste in Australia and research on bioreactors which recover energy in an environmentally friendly manner is occurring. The possibility of using bioreactors to process oil either alone or as blends with green waste has been stimulated by the announcement of a fast acting Biological Oil Decomposer System by Innoways GmbH (http://www.inoways.de/pdf/Biological Oil Decomposer System.pdh).
- Integrated Gasification Combined Cycle (IGCC) – this technology can be used to convert hydrocarbon materials into electrical energy and hydrogen. Large pilot plants for coal conversion are operating in the USA and smaller commercial plants for conversion of petroleum residues are operating in Italy. The hydrogen generated is currently used in refineries but could be used in hydrogen fuel cells in the future. No commercial IGCC plant is operating in Australia but extensive research has been carried out, for example by HRL Pty Ltd, Melbourne and the CSIRO.

  Of these new technologies only the first three are applicable to lube-to-lube recycling. Introduction of membrane technologies has had a dramatic impact on the economies of several major industrial processes for example electrolytic chlorine production and thus developments must be closely monitored. The Kobe Steel process is attractive in that the recovered metal adsorbent (coal) can be used as a conventional solid fuel.

Recommendation 6

The Department of the Environment and Heritage should continue to monitor developments in recycling technology using Transitional Assistance funding to commission periodic reports.

7.2.2 Australian Recyclers

Much of the collected used oil is separated from non-suspended water, filtered and sold as a low grade fuel which attracts the 3 cpl benefit. Some hydraulic oils can be 'laundered' by simple treatments such as centrifugation so that they can be reused. The advanced treatment plants have been summarised in tabular form by Nationwide Oil as shown in Appendix E.

7.3 Health and Safety Issues - New Lubricants

7.3.1 Toxicology Studies

Used Base Oils: Base mineral oils have low toxicity both by inhalation and skin absorption. Synthetic base oils similarly show low toxicity. A number of studies have been carried out of which the CONCAWE report 5/87[13] is often quoted as the most substantial. Skin irritation sometimes leading to dermatitis is the most likely problem arising from prolonged exposure to oils.

[†] We thank Masaaki Tamura, General Manager, Coal & Energy Project Dept., Technical Development Group, Kobe Steel Ltd., for alerting us to this process.

Potential carcinogenic properties of lubricating oils have been extensively studied[14]. All of the evidence suggest that any carcinogenic activity is associated with the presence of polycyclic aromatic hydrocarbons (PAHs) in the base oil. Such compounds are not present in base oils in significant amounts and thus it is not surprising that acute toxicity and irritation levels are low for both mineral and synthetic base oils.

Material Safety Data Sheets for lubricating oils are available from suppliers in Australia. Shell and B.P.'s data sheets are available on their web sites www.epc.shell.com and www.bp.com.au/msds. Re-refined oil data sheets are available from all of the Australian manufacturers.

Additives: Most lubricant additives are classified as non-dangerous toxicological agents. The Technical Committee of Petroleum Additive Manufacturers in Europe (ATC) has classified additives into a six broad classifications, each with individual classes[4] and has published risk and safety phrases for each of these[15, 16].

Only zinc dialkyl dithiophosphates and some calcium arylalkylsulphonates are classed as 'irritants' under European legislation[13] (Table 7.1).

Table 7.1: Acute Toxicity of Petroleum Additives

Additives[a]	Typical LD50		Typical Irritancy Classification [b]	
	oral (rat) mg/kg	dermal (rabbit) mg/kg	eye	skin
Zinc dialkyl dithiosphosphate	≥2000	>2000	irritant	irritant
Zinc alkaryl dithiosphosphate	≥5000	>2000	non irritant	non irritant
Calcium long chain alkaryl sulphonate	>5000	>3000	non irritant[c]	non irritant[c]
Calcium long chain alkaryl phenate	>10000	>2000	non irritant	non irritant
Calcium long chain alkaryl phenate sulphide	>5000	>2000(rat)	non irritant	non irritant
Polyolefin amide alkeneamine	>10000	>2000	non irritant	non irritant
Polyolefin amide alkeneamine borate	>2000	>3000	non irritant	non irritant
Olefin/alkyl ester co-polymer	>10000	>3000	non irritant	non irritant
Polyalkyl methacrylate	>15000	>3000	non irritant	non irritant
Polyolefin	>2000	>3000	non irritant	non irritant

Notes:
a) The additive names are based on the nomenclature system developed by the Technical Committee of Petroleum Additive Manufacturers in Europe[15].
b) Eye and skin irritancy potential is classified according to the EU criteria.
c) This comment is anticipated to be updated.

Commercially Available Lubricants: Experience has shown that hazards to human health and the environment of commercial lubricants are roughly equal to the contributions from each of the individual components. The acute toxicity of petroleum additives as summarised above in the CONCAWE report[13] shows that the level of zinc dialkyldithiophosphates is the key indicator to human health hazards of lubricants. Lubricating oils sold in Australia contain so little of these compounds that they are all classified as non-hazardous according to the criteria of NOHSC.

Used Oils: The major concern with used oils is the carcinogenicity of polycyclic aromatic hydrocarbons (PAHs) which have been formed during the oils' use. Used oil from diesel engines has been shown to show no increase in PAH content relative to that of the unused oil, whereas used oil from spark ignition engines is significantly carcinogenic[4, 5]. Appropriate hygiene precautions are now recommended to minimise the possibility of skin cancer.

The composition of used oils is extremely variable and thus it is impossible to make general predictions about their overall toxicity. In general, metals from the added metal-containing compounds (mainly Zn, Mg and Ca) are now present as benign salts. Sulphur compounds are usually present in small amounts of volatile, highly odorous organic sulphur species.

Contaminated Oils: Accidental or wilful mixing of used transformer fluids with used lubricating oils has led to the introduction of polychlorobiphenyls (PCBs) into the used oils. Identification of these extremely harmful substances in samples of used oils collected for re-use has occurred in Germany in the 1980s and in Victoria, Australia in 1999. The banning of the use of PCBs and the potential for severe penalties being imposed on collectors who distribute PCB contaminated oil has significantly reduced the risk of future PCB contamination. Collectors interviewed conducted PCB analyses prior to using or selling the used oil.

7.3.2 Ecotoxicology Studies

Base Oils: Biodegradation is often identified in three broad classes

- Primary – any biologically induced change in molecular structure.
- Ultimate – conversion to the end products of normal metabolic processes, mainly carbon dioxide and water or metal carbonates.
- Acceptable – degradation to the extent that undesirable properties are removed.

There is considerable debate as to the general applicability and usefulness of the various tests which are used[17]. Ecotoxicological studies reported in two recent CONCAWE reports have used a variety of tests[18,19]. These lengthy reports contain a large number of references to environmental degradation of oils and studies of their impact on flora and fauna. Biodegradation is slower for more viscous materials and, for oils of similar viscosity, those with the higher content of paraffin rather than napthenic structures (that is, chains rather than rings of carbon atoms) degrade the faster.

The rate of biodegradation of base oils from natural sources, that is, those based on esters of long chain organic acids with glycerol, are much faster than those of mineral oil derived base oils.

Used Oils: A CONCAWE report[18] claims that although the biodegradation of used oils and their additives has not been studied, it can be expected that the hydrocarbon constituents will not be readily biodegradable but are inherently biodegradable.

Refined Used Oils: The CONCAWE report[18] divides refined used oils into two classes on the basis of the refining technology which has been applied.

Distilled oils - Vacuum distillation followed by further treatment by solvent extraction or hydrogenation gives hydrocarbons of the same toxicity as those present in the original base oils and thus these hydrocarbons are classified as non-toxic. Their biodegradation will also be similar i.e. inherently possible but slow.

Non-Distilled Oils - Used oils that have been re-refined by technologies not involving distillation (for example various chemical treatments) have unpredictable toxicities which will depend on contaminants arising from the original base oil or the additives.

7.4 Health and Safety Issues Associated with Reprocessing

The waste streams from reprocessing plants carry with them health and safety issues. The issues vary from one plant to another but the currently operating plants are all operating with approval of the relevant EPA.

7.4.1 Waste Water

Standard practices for reduction of the concentrations of dissolved organic and inorganic compounds to acceptable levels are in place in all of the reprocessing plants.

7.4.2 Heavy Bottoms

Heavy bottoms are currently consumed in high temperature furnaces, preferably in cement kilns but with minimal return to the recycler. An alternative disposal source is sought and acceptance as a bitumen/asphalt is being considered. Extensive testing some years ago showed that efficient blending with some types of asphalt could be achieved[20]. More recent interest is demonstrated by a patent application in 1998[21].

7.4.3 Heavy Metal Sludge

The Nationwide demineralisation plant in Dandenong produces a small amount of heavy metal sludge which is disposed of in a secure landfill.

7.4.4 Volatile Emissions

The closure of the Dominion Oil Plant in New Zealand and of a recycling plant in Birmingham U.K. have been ascribed to unfavourable economics and extensive criticism from the local communities of the smells emanating from the plant. The authors of this report have visited all of the advanced recycling plants in Australia and neither encountered unpleasant odours nor heard of community complaints. Modern de-odourising technology appears to be equal to the task.

A case study, for the proposed expansion of an existing used oil re-refinery in the San Francisco Bay area has been published[22]. Full details of the human risk assessment for the expanded plant air permit are discussed. California State environmental laws are notoriously stringent. In respect of Occupational Health and Safety, operatives at each of the Australian plants had been given clear warnings as to the hazards associated with the materials that they

were handling and clear instructions as to how to deal with emergencies. The plants all showed good standards of cleanliness.

7.5 Health and Safety Issues for the General Public

This issue is of widespread concern wherever in the world used oils are being re-refined. Dangers of used oil to users and to the environment have been discussed in several recent reviews from a range of countries including Bulgaria[23], Italy[24] and the U.K[25]. A particularly disturbing report has been published on neurotoxic affects from residential exposure to chemicals from an oil and chemical waste reprocessing facility which operated in the period 1966-1983. It is possible that stringent environmental standards were not imposed at that time[26].

Of particular concern in Australia is the burning of used oils in inefficient furnaces especially in the hydroponics industry. Although the chlorine content of used oils is not high, the possibility of the formation of polychlorodioxins as a result of inefficient combustion is high. The toxicity of polychlorodioxins is of major international concern and the Australian Government's National Dioxins Program[27] is involved in protocols being laid down by the Stockholm Convention[28]. Clearly, more careful monitoring of the efficiency of small furnaces is required. State EPAs are currently in discussion with members of the National Dioxins Program Team.

7.6 Environmental Impacts

The major visible impact is that associated with water pollution where one litre of oil can visually contaminate up to one million litres of water. Higher concentrations have adverse affects on water and soil chemistry and biology. A review[25] draws attention to possible inhibition of plant development, changes in microbial communities, mutagenic effects on bacteria and reduction of production of phytoplankton. In water used oil can damage shellfish and act as a mutagenic agent. Used oils containing PAHs are embryotoxic to birds eggs. Many papers deal with specific examples of adverse effects arising from soil and water contamination. An example of adverse effects of soil contamination is the inhibition of bioluminescence of soil bacteria implying formation of toxic metabolites[29]. Water contamination at sufficiently high concentration completely prevents metamorphosis of tadpoles of the green tree frog, *Hyla oinerea,* to frogs[30].

It has been noted that soil contamination can lead to deterioration of the quality of the soil itself with a reduction in ion exchange[31] and water binding capacity[32].

Attention has been drawn in the above (see Section 7.5) to the dangers arising from the use of inefficient furnaces for the combustion of used oils and these can obviously affect fauna and flora, as well as humans, through air and subsequent soil and groundwater pollution.

7.7 Environmental Benefits of Lube-to-Lube Recycling vs. Energy Reclamation

7.7.1 Energy Reclamation

The use of recovered used oil as a combustion material for the provision of useful energy in place of virgin oil has little effect on the total amount of oil consumed. In this simple analysis there is little environmental benefit to recycling *versus* energy reclamation. If, however, the energy generated is additional to national needs then there is a serious penalty for extraction

of the natural resource to produce the virgin lube oil feedstock. The analysis is of course more complex as the used oil now contains significant amounts of metallic compounds which have been deliberately introduced as additives or result from engine wear. In addition, lube oil usage can result in the conversion of some of its components into carcinogenic polycyclic aromatic hydrocarbons (see Section 7.3.1).

Life Cycle Assessment (LCA) is an environmental decision-making tool which can be used to evaluate the environmental impact of the various treatments and uses of recovered used oil. Australian and International LCA's have been carried out on used oil reprocessing and these have been summarised in Appendix G.

In this Section the data presented in Appendix G is summarised with respect to the use of recovered used oil in Australia.

Table 7.2: Environmental Issues for Australian Used Oil Reprocessing Plants and Combustion Units

			Environmental Issues				
	Processes	**Company**	**Resource Energy**	**Waste Water**	**Volatiles**	**Heavy Bottoms**	**Solid Waste**
1	Direct Combustion	Mining companies in remote areas	Low	Low	Medium	Nil	-
2	Filter Dewater (Low Combustion)	e.g. Hydroponics	Low	Medium	High	Nil	Medium
3	Filter, Dewater High Temp. Combustion	e.g. Cement Kilns	Low	Medium	Low	Nil	Medium
4	Demineralisation	Nationwide	Low	Medium	Medium	Nil	High
5	Thin Film Evaporation	Wren Oil Australian Waste Oil Refinery	Medium	Medium	Medium	Medium	Low
6	Interline Deasphalting	Nationwide	Medium	Medium	Medium	Medium	Medium
7	Wipe Film Evaporation Solvent Extraction	Southern Oil Refineries	Medium	Medium	Medium	Medium	Low
8	Thermal Cracking	One operator in Australia	Medium	Medium	Medium	Nil	Very Low

The four processes (1-4) which do not involve distillation units obviously use little resource energy relative to those which do (entries 5–8).

All processes except direct combustion (entry 1) produce waste water but the technologies available appear to be adequate to ensure that after treatment the waste water streams meet EPA requirements. The volatiles emitted from the combustion processes depend on the type of furnace used. High temperature combustion (entry 3) leads to energy recovery with very low concentrations of hazardous organochlorine compounds e.g. the chlorodioxins in the

volatiles. This is not always the case in low temperature furnaces (entry 2) which when operating at less than maximum efficiency represent a potential source of such undesirable materials.

The distillation and cracking processes (entries 5-8) all generate volatile organosulphur compounds to some degree. It appears that modern technology is capable of reducing the concentration of these highly malodorous compounds to acceptable levels.

Heavy bottoms are produced from the three processes involving distillation without cracking (entries 5-7) and an appropriate use of these materials is the subject of a current enquiry.

Solid waste is rated as a high environmental issue for the demineralisation plant (entry 4) in that, although relatively small amounts of solid waste are generated, it is necessary to dispose of it at a secure landfill site. The small amount of solid waste material from the cracking process (entry 8) is acceptable for road making and may be treated for metal recovery in the future.

All processes have some advantages and drawbacks. In comparing them in real life situations it is important to consider what alternatives are competing with them. Thus the combustion of HG burning oils compares favourably with coal combustion but not with natural gas.

7.7.2 Lube to Lube Recycling

Only process 7 in Table 7.2 leads to a lube base oil and this is of the lowest quality. It is recognised that it will probably be necessary to hydrotreat the appropriate fractions from the other potential processes (i.e. those in entries 5 and 6, Table 7.2) in order to obtain a high quality lube base oil acceptable to a wide range of distributors (see Section 6.6). It must be noted that the preparation of lube oils from petroleum distillates also involves a solvent extraction and/or a hydrotreatment process and thus the environmental impact of introducing a hydrotreater in a used oil re-refining plant is nearly neutral.

7.7.3 Summary

The recycling of used base oil back to lube-quality base oil at the very least does not attract severe environmental penalties relative to energy reclamation options. A recent environmental assessment of used oil management methods in the U.S. claims that lead and zinc emissions are the primary contributors to terrestrial and human toxicity and that their impact potentials are 150 and 5 times higher, respectively, for used oil combusted as fuel than for re-refining or distillation[33].

In addition, to these considerations the attraction of operating an easily monitored closed-loop makes this alternative an attractive one.

7.8 The Need, and if Appropriate, the Viability, of a Further Australian Life Cycle Analysis (LCA) on Waste Oil Uses

Whilst it would be useful to update the BHP report with current information on re-refining plant data, it is doubtful whether further Life Cycle Assessment at this stage would add anything substantial to what has already been found both in Australia and in Europe in terms of relative environmental impacts, as operations in Australia have not changed substantially over the past three years.

Recommendation 7

The Department of the Environment and Heritage should consider a further review only when more advanced technologies and /or more detailed operational data become available. More detailed information on the toxic emissions from a range of combustion processes should be included.

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8 Communication Strategy

8.1 Background

Communication with all interested parties is an essential feature of the Transitional Assistance Program. All government department communications strategies must, however, be approved by the Ministerial Committee on Government Communication. The initial strategy proposed by The Department of the Environment and Heritage, which relied heavily on external consultants, was rejected by the Council. These problems led to a fragmented approach to communication with state and local government authorities and no direct contact with major suppliers of lubrication oils. The Ministerial Council stipulated that more of the communication strategy should be developed within the Department. To this end, two officers were appointed in July 2003 to develop the communications strategy and good progress is now being made.

Millward Brown Australia carried out market research in 2002 and submitted their report in August 2002. The Millward Brown research found The Department of the Environment and Heritage's draft communications strategy is generally in line with market and industry expectations. It highlighted the need for a staged information-based approach to communications, with an initial focus on raising awareness about the issues involved with used oil and communicating the Government's efforts to improve Australia's recycling rate.

The research recommended that communications activities emphasise what people can do 'now' to recycle oil as well as provide information about plans to improve national collection infrastructure. Reassurance about the quality of re-refined products is also required to encourage community use.

In an effort to promote national consistency in message delivery, the research recommended The Department of the Environment and Heritage take responsibility for managing communications activities on a national basis. However, State EPAs and councils are considered integral to conveying information at a local level.

The research also found special consideration should be given to the specific communications needs of ethnic and Indigenous audiences.

8.1.1 Key Messages

- Used engine oil is hazardous to the environment (earth and water) and human health. There are both short and long term effects.
- Used oil is also valuable and can be used again, but it has to be kept pure and returned to a licensed recycler, so that the contaminants can be removed.
- Many Australians are already returning their used oil, but many millions of litres still 'go missing' every year. The Commonwealth Government is working to lift Australia's oil recycling rate by establishing more collection facilities across the nation.
- How to safely handle and store used engine oil until it can be returned or collected.

8.1.2 Proposed Communications Approach

Implementation of the communications strategy will largely be determined by the availability of infrastructure, such as national collection points and re-refining facilities. As such, communications activities are being conducted in two phases –

- Phase one – will run until June 2003 and focus on general awareness raising of the used oil issue among key stakeholder groups such as industry, local government and consumer organisations. This phase will also promote the Government's efforts to improve Australia's oil recycling performance and will inform people about what they can do now to assist with oil recycling.
- Phase two – from July 2003 onwards communications activities will focus on a community advertising/information campaign and a media 'push' to inform people about oil collection points and recycling facilities and to encourage behavioural change. This stage will involve consultation with the Ministerial Committee on Government Communication.

8.2 Achievements

Much has been achieved in a very short space of time by the in-house team who deserve to be congratulated. The achievements can be summarised as follows:-

8.2.1 Logo

A logo has been approved which will help identify and promote the Product Stewardship for Oil Program.

8.2.2 Phone/Website/email

A website, www.deh.gov.au/oilrecycling, email, oilrecycling@deh.gov.au and phone 1800 803 772 have been established as information sources for the Product Stewardship for Oil Program. The website has already achieved a large number of hits following the television broadcasting of a video segment (see below) and it is aimed to make the website interactive in April/May 2004.

8.2.3 Fact Sheets

Some attractive fact sheets have been produced which have been widely circulated to State and Government bodies associated with the program. It is proposed to produce a brochure and a pack of fact sheets to be distributed through regional organisations.

8.2.4 Television

A 10-minute video has been produced and screened on Prime Television's (Channel 7) *On the Land* program. The program was based on the benefits of responsible management of used oil to a Queensland coastal community. Other segments are proposed which will focus their appeal on other identifiable areas within Australia. A 30-minute educational video is also planned.

8.2.5 Indigenous Australians

Aboriginal communities frequently use diesel generators and are thus regular users of lubricating oils. Development of a communications strategy focussing on these communities and of programs for Indigenous radio is under way.

8.2.6 Interaction with State and Local Government Authorities

The audio-visual material described above will be evolved and distributed with the help of state and local government authorities. The Department of the Environment and Heritage was involved in Eco-recycle Victoria's launch of its oil recycling program held in Ballarat in November 2003 and in the Western Australian Local Government Association's Municipal Waste Advisory Council Used Oil Program.

To maximise the efficient use of this material approval for a professional advertising consultancy has been obtained.

Special Interest Groups

Part of the planned communication strategy is to alert special interest groups such as the fishing industry, car enthusiasts etc, for example, by advertising in their specialist magazines.

8.2.8 Interaction with Major Suppliers and Distributors

A significant portion (35-50%) of all lubricating oils is used by large consumers in the mining and industry sectors. It is planned to involve the major suppliers, for example Shell, BP, Valvoline and possibly distributors in communication programs aimed at contacting the big users of lubricating oils.

Appendix A: Terms of Reference

Note: This is an extract from The Schedule in the Agreement between the Commonwealth of Australia and the Australian Academy of Technological Sciences and Engineering.

The consultant will conduct an independent review of the Transitional Assistance element of the Product Stewardship Arrangements for Oil (the PSO) to identify achievements and advise future priorities.

Note that a full review of the *PSO Act* and levy/benefit system will be conducted in 2004. This mid-term review will, inter alia, inform the levy/benefit review.

A steering group established by the Department will provide direction and advice on the mid-term review. The steering group will include representatives from the Department of the Environment and Heritage (formerly know as Environment Australia) (Peter Burnett, Assistant Secretary and Paul Dworjanyn, Director Automotive Waste Resources Section) and the Chair of the Oil Stewardship Advisory Council (Mike Williamson).

In undertaking the review and developing the final report the consultants will include advice on new targets and priorities as appropriate. The consultants will address the following issues:

1. Transitional Assistance Sub-program:
This is the prime focus of this review. The final report resulting from this review will be forward-looking and will be used to provide strategic direction for the allocation of TA funds through to 2006-07. In order to underpin the identification of future direction, a snapshot of the current state of play is required, as follows:

a) The PSO's achievements and outcomes to date. These should be reviewed against the stated objectives of the PSO scheme.
b) The appropriateness of the existing long-term target for the proportion of waste oil to be recycled in Australia and advice on new targets should this be necessary.
c) Current and future markets for petroleum-based lubricating oil (including both virgin and recycled products).

The report will then provide an assessment of:
d) The efficiency and effectiveness of the activities and projects funded under the Transitional Assistance sub-program to date.
(This review is not required to undertake an economic modelling process. Rather, it will identify and clarify specific assumptions and figures, which are required for input into a revision of a modelling exercise being undertaken by ABARE. Details regarding input required will be forwarded in the near future. Results from the modelling will be provided to inform the review.)
e) The continuing appropriateness of the existing Transitional Assistance priority areas and advice on new priorities as appropriate.
f) Opportunities to increase the collection of waste oil and the proportion of waste oil recycled.

2. General

In assessing the above issues and producing the report, there are several points which will be incorporated throughout the report as sub-issues relating to several broader issues. These sub-issues include:

a) Potential partnerships with relevant organisations (community, business, government) that may improve the collection of waste oil and/or reduce the risks associated with waste oil;
b) Waste oil collection infrastructure and possible synergies with associated waste streams; and
c) Identification of current and future technologies that may affect oil production, waste oil recycling and associated waste streams.

3. Scientific and Technical Advice

In addition to advice on future direction, the Department requires expert, independent opinion regarding a range of issues related to the collection, recycling and reuse of waste oil. The findings on these issues may also inform thinking on various other issues to be covered under the terms of this project. This section will not require a full life cycle analysis – it is expected to be undertaken through a review of existing literature, discussions with industry stakeholders and existing technical expertise.

a) The environmental and health impacts/risks of waste oil.
   This section will provide answers to a range of questions, including:
   - What are the chemical and other components of waste oil?
   - What are the health and environmental risks associated with these materials, and under what conditions?

   (Note: External consultants are currently researching implications of using waste oil to heat greenhouses. The Department will provide input for assessment of this issue as it becomes available.)

b) Environmental benefits of lube-to-lube recycling vs. energy reclamation.
   This section will encompass environmental benefit and detriment for each eligible process and use. Expert opinion is sought regarding the
   - conversion efficacy of each process;
   - the by-products of each process; and
   - the comparative environmental benefits of each recycled end product (that is, recycled lube, low grade heating oil, high grade heating oil, etc).

   (As part of this section, for example, the consultant will address the issue of ‘bottoms’. Industry’s capacity to treat and utilise oil 'bottoms' is an outstanding issue. In consultation with appropriate stakeholders the consultant will be required to clarify the nature and size of the problem and advise the Department on potential strategies to manage oil bottoms. It is expected that there will be a range of other issues encompassed within this section which will require similar analysis.)

c) The need, and, if appropriate, the viability, of a further Australian life-cycle analysis (LCA) on waste oil uses.
   (The Department will provide several LCA documents for review and analysis. The analysis will include an assessment of the applicability of international experience to Australian circumstances. Employing your own experience and research, your expert opinion is required regarding whether the time and cost involved in undertaking a further Australian LCA are justified.)

Appendix B: Australian Lube Oil Production and Domestic Sales Volumes.

Following are production, import and export figures for lubricating oils, greases and base stocks for recent years based on Department of Industry, Tourism and Resources (DITR) statistics compared with volumes based on ATO figures for levies received and with DITR Australian sales statistics. It is obvious there is considerable confusion in the figures in 2002-03. However, over many years sales statistics are in excess of the figure calculated from production, imports & exports. The ATO figure is more in line with the latter in 2001-02 but lower in the 'confused' year of 2002-03.

Table B1: Lube Oil Production and Australian Domestic Sales Volumes. Annual ML

Fiscal Year	DITR Production	DITR Imports	DITR Exports	Imputed Sales	ATO Levy Sales	DITR Sales
1999-00	648.5	82.4	257.8	473.1	N.A.	526.4
2000-01	640.8	33.2	278.3	395.7	N.A.	532
2001-02	564.3	54.8	162.7	456.4	459	554.9
2002-03	521.1	211.7	160.7	572.3	479	692
1st half '03	246.8	80.1	74.6	252.3	N.A.	361.8

Comments:

a). Sales based on ATO levies are calculated from data in the PSO annual reports for 2001-02 and 2002-03. DITR figures are from the relevant 'Australian Petroleum Statistics' monthly reports: Production – Table 2; Imports – Table 4; Exports – Table 5; Sales – Table 3A.

b). Recent import increases result mainly from large imports in December 02 (96.6 ML) and February 03 (44.6 ML), presumably as a result of the BP Kwinana closure mid 2002. Imports will increase even further since Mobil Port Stanvac closure early in 2003.

c). DITR and AIP are investigating a big increase in sales in the transmission fluids and greases categories in 2002-03 resulting from incorrect returns from one or more companies to DITR. AIP are checking if sales are overstated due to double counting of base oil sales.

d). Oil companies and the AIP confirm a sales figure of around 520 ML is a credible figure and may be even lower. They advise that lube oil sales have been declining in agreement with overseas trends, contrary to the trend of DITR figures for 1999 to 2001. One oil company has suggested the Department of the Environment and Heritage survey all lube oil producers, on a confidential basis, to confirm actual Australian sales volume.

e). The ATO levy collection for 2002-03 was $28.4 million, comprised of $25 million levied on domestic production and $3.4 million customs duty on imported oils. This is off-set by $2.3 million paid back for exported oils, giving a net figure of $26.1 million, equivalent to 479 ML of domestic lube oil sales. For 2001-02, total collections were $24.93 million, with no export offset reported, giving net domestic sales of 459 ML.

Appendix C: Collection Details

Estimates of re-refined used oil sales and collections.

Table C1: Estimate of Collection Volumes from Various Sources[1,2]. All figures in ML/year (Note c)

Benefit Category	PSO 2001-02	PSO 2002-03	OSAC WG Collections	OSAC WG Markets
Re-refined Base oil 50 cpl	0	3.04		23 Note d
Other re-refined Base oils 10 cpl	0.1	0.163		
Diesel fuels 7 cpl	25.3	26.1		17
Diesel extenders 5 cpl	0	0		
HG industrial burning oils 5 cpl	65.8	68.3		90
LG industrial burning oils 3 cpl	103.5	96.25		102.6 Other: 7
Subtotal	***194.7***	***193.9***	***183.5***	***239***
Est. Re-refined oil benefit not paid-see Note e	5-10	5-10	5-10	
Est. Collected oil Zero benefit & Hydroponics sales (Note f)	Note b 20-30	Note b 20-30	Note b >15 <25	Note a (25)
Less duplication			-5 to -10	-20
Total	**220-235 Say 220**	**220-235 Say 220**	**190-215**	**219**

Notes:

a. Sales into the hydroponics market are estimated at 25 ML by the OSAC Markets Working Group (WG), but this is thought to be a high estimate.

b. The estimated 'collected oil' figures, including duplications, were determined in discussion with the convener of the OSAC Collections WG.

c. All collected volumes are recorded on a 'water free' basis. All collectors report around 10-12% water in collected used oil. This means that for a net collection of 220 ML, total collected volume is some 245 ML. The OSAC collection volumes are inclusive of water content and the total understates the likely collection total.

d. The re-refined base oil market volume of 23 ML, recorded by the OSAC Markets WG, is potential sale of used oil to a re-refining plant to produce around 15 ML of lube oil grade base oil.

e. Some re-refining plants are not receiving benefits for diesel and bottoms streams so volumes are not recorded in PSO figures.

f. Oil bottoms streams are blended as necessary and burnt in furnaces or cement kilns with capability to meet air quality regulations. Producers report that in most cases they must pay for disposal.

Table C2: Collection Survey Result: OSAC Collections Working Group, 2003.

State	Lube Oil Sales[3] 2002, ML	Usage*: 60 % Availability, ML	Collections ML	% Collected
NSW (& ACT)	125.5	75.3	54	72%
Victoria	116.7	70.0	36	51%
Queensland #	183.8	110.3	38	35%
South Australia	40.3	24.2	18	74%
Western Australia	81	48.6	29	60%
Northern Territory	7.3	4.4	3	68%
Tasmania	9.5	5.7	5.5	96%
Total	**564.1**	**338.5**	**183.5**	**53%**

* Note: The OSAC survey used a used oil generation factor of 60% while the Academy review has used a factor of 52%.
# OSAC comment that the Queensland lube oil sales figure appears to be high. This is possibly the result of sales from the Shell Brisbane lube oil blending plant into NSW.

OSAC Collections Working Group Comment on the Results: The Victorian result is disappointing. However a quantity of used oil is collected and stored by actual consumers to be used for heating of their premises during the colder months of the year, which in Victoria are longer than in other states. The quantity of used oil collected and burnt in this market is unknown at this stage. It is also understood that oil companies include the southern part of NSW in Victorian sales figures, where as the survey reported on state by state boundaries. Should this be the case approximately 2 ML collected would transfer from NSW to Victorian figures.

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Appendix D: Recycled Used Oil Markets.

An analysis of current and future markets for recycled used oil in the light of information provided by the OSAC Working Groups (WG) on Collections and Markets[1] and information in previous consultant reports.

Table D1: USED OIL MARKETS (2002 in ML) as estimated by the OSAC Markets WG

Market	NSW	VIC	QLD	SA	WA	TAS	NT	TOTAL
Brick		3		3				6
Kilns	7	10	5		6	4	3	35
Nickel			15					15
Coal Spray	10			5				15
Lubes						0.05		0.05
Fuel oil	10		10		10	1.4		31.4
Hydroponic	10	15				0.2		25.2
Sugar mill	2		10					12
Power stn	15	10	5		10			40
Pet food		4						4
Abattoirs	2			2	2			6
Canneries		3						3
Base oil	23							23
Diesel	7	10						17
Other		5		2				7
Total	**86**	**60**	**45**	**12**	**28**	**5.65**	**3**	**239.65**
Dble count								-20
Market								**219.65**

Comments on Markets by OSAC Working Groups:

1. Remote and regional areas have potentially the most uncollected oil.
2. Small to medium farms also have uncollected oil and stockpile backlog.
3. DIY market is a possible source of up to 30 ML of uncollected oil.
4. Communication strategy is important to initiatives to collect from uncollected areas.
5. Collection hubs can assist in consolidation of regional and remote collection.
6. Hubs may also assist in reducing the expense of collection.
7. Market changes: kilns could move from 35 to 45 ML and power stations 40 to 55 ML.
8. Markets for nickel and coal spray could disappear and hydroponics reduce by 5 ML.
9. Cement kilns anticipate they will need to be paid to accept waste oil in future.
10. Power stations, excluding WA, have greater capacity to use waste oil.
11. Opportunities exist to synergise collection with other waste streams, eg ChemCollect.
12. Look at motor vehicle wreckers to collect oil at vehicle end of life.

The MMA/BDA Report 'A Tradeable Certificate System for Used Oils'[2] reports:

1. Potential loss of waste oil market to gas: WA –2.5 ML early 2004 and -5 ML in 2005 Tamworth –8 to 10 ML in 2003-04; Townsville –15 to 20 ML in 2006.
2. BHP Port Kembla: threat to 12-15 ML waste oil as coal spray oil.
3. Hydroponics: possible loss of market due to tighter regulations –10 to15 ML

The Meinhardt Report 'Used Oil in Australia'[3] reports the following:

1. Total waste oil stockpile capacity is 23 ML in the NT and 26 in the rest of Australia.
2. Actual volume and period of build up of the oil stockpile are not known.
3. As a broad estimate, 20% of unaccounted oil is unrecoverable for a variety of reasons.
4. It was estimated some 10 ML of unaccounted oil comes from DIY activities.
5. Other sources of potentially recoverable oil include illegal dumping, oil retained in waste or scrap equipment, oil lost to the environment at collection points and various other sources.

Burnbank Consulting reports the following relating to 'Disappearing Markets'[4]:

1. The largest traditional markets for waste oil are as a treated or untreated burner fuel, and as a coal spray for coal beneficiation prior to coking.
2. Environmental concerns or product quality concerns have created an expectation that coal spray, and burner fuel uses in sugar mills, brickworks and meatworks will eventually cease. On AIP estimates of use, this would lead to in excess of 50 ML requiring another method of disposal or management.
3. Waste oil used as a bunker fuel ceased in 1993 after concerns by insurers regarding damage to diesel engines due to contaminants in waste oil.
4. Although some of the existing uses are expected to remain, such as use to fire cement and lime kilns, the prices paid and costs of transport will leave these as minor contributors to the waste oil management task.
5. As the natural gas pipeline infrastructure becomes more extensive, making natural gas accessible to large fuel users, the capacity of a relatively unclean fuel to compete will be further diminished.

Reported gains and losses in future markets from above sources:

1	Loss to gas:	–30.5 to –37.5 ML
2	Loss of coal spray:	–12 to –15 ML
3	Hydroponics loss;	–5 or –10 to –15 ML
4	Nickel loss;	–15 ML
5	Kilns gain:	+10 ML
6	Power stations gain;	+20 ML
7	Loss of diesel market	–10 to –15 ML
Net change:		**–42.5 to –68.5 ML**

Australian Oil Recyclers Association (AORA):

In a presentation to the Oil Stewardship Advisory Committee on 28 November 2003, AORA gave the following comments under the heading "Markets under Threat":

Threats to existing markets

- Promotion of clean and renewable fuels will have an impact on available markets as industry is encouraged to move away from fossil fuels.

- Changes to current excise arrangements on recycled fuel oil blends will make it difficult to compete with virgin fuels.
- Large gas reserves and increased gas infrastructure are also impacting on traditional fuel oil outlets.

Potential market closures

- Queensland Nickel – 24 ML per annum looking at gas in 2006.
- BHP/One Steel – 12 ML per annum threat of closure.
- Western Power Regional – 8 ML per annum remote power stations to gas 2005.
- Loongana Lime – 20 ML per annum under pressure to move to gas.
- David Mitchell Lime (Tamworth) – 8 ML per annum going to gas 2004/05.

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Appendix E: Recycling Processes

The attached document "VARIOUS RECYCLED PRODUCTS AS PRODUCED BY THE USED OIL RECYCLE INDUSTRY" has been prepared by Nationwide Oil P/L. It provides a useful summary of general information on processes, products and typical specifications as well as capital and operating costs.

The Academy wish to express their appreciation to Nationwide Chief Executive Officer, Harold Grundell, for permission to include this information in the report.

Nationwide Oil Pty Ltd
P.O. Box 1049 Toowong QLD 4066

VARIOUS RECYCLED PRODUCTS AS PRODUCED BY THE USED OIL RECYCLING INDUSTRY.

The following lists the recycled products as produced by the used oil recycling industry. The table will identify the product, process, typical specification and PSO subsidy received.

Whilst there is some conjecture as to which is the best process, depending on which recycler you talk to, at the end of the day the specification achieved by the process is the determining factor.

PRODUCT	*PROCESS*	*WASTES PRODUCED*	*TYPICAL END USERS*	*PSO CATEGORY*	*TYPICAL SPEC.*
Filtered & Dewatered	Used oil is simply collected, strained and free water drained off the bottom.	Oily water and solids collected in strainers (typically strained to 40 mesh)	Feedstock for other recyclers for further recycling, large industrial users, cement industry, smelters, small users such as hydroponics, brick kilns and light industry.	6	(a)
Filtered, Dewatered & Dehydrated	After above process used oil is then dehydrated by applying heat to achieve water contents of less than 1%. Product can be filtered to as low as 10 microns.	Oily water and solids collected in strainers, spent filter cartridges.	Typically sold to larger industrial users as an alternate fuel.	6	(b)

Demineralised	Used oil is collected and then tested for compatibility to demin. process. Oil is treated using acid and surfactant to remove metals, ash, water and solids.	Oily water and solids collected in strainers, spent filter cartridges, there is also some heavy metal sludge that is directed to secure landfill (approx. 1% of volume treated)	Typically sold to Power Stations & small industrial users with limitations on emissions.	4 & 5	(c)
Refined	Thin Film Evaporation, Propane Deasphalting & Vacuum distillation are processes used to produce Base Oils, Diesel and bituminous bottoms.	Oily water and solids collected in strainers, spent filter cartridges, heavy bituminous bottoms directed to cement kilns as an alternate fuel at a minimal return.	Typically sold to Power Stations, small industrial users with limitations on emissions.	3, 4 & 5	(d)
Thermal Cracking & Diesel Recovery	Oil is subjected to pyrolysis using high temperatures to manufacture diesel.	Oily water and solids collected in strainers, spent filter cartridges & inert char bottoms that have been used as road base.	Can be used as a diesel fuel and also as fuel oil. Recent changes to fuel specs. will limit its use for on-road transport.	3	(e)
Rejuvenated & filtered	Micro filtration to remove contaminants, oil is then analysed & additives are topped up to meet specification.	A small percentage of waste is generated and usually quit as used oil.	Hydraulic oils, turbine oils as used in large industrial plants & power stations. Some smaller applications such as chain bar lubricant	2	N/a

			and mould release oil.		
Re-refined lube to lube	Thin Film Evaporation, Propane Deasphalting & Vacuum distillation are processes used to produce Base Oils which are then further refined using either solvent washing or hydrogenation.	Oily water and solids collected in strainers, spent filter cartridges, heavy bituminous bottoms directed to cement kilns as an alternate fuel and minimal return.	Various users that look to place product in non-critical lubricant applications.	1	Product must conform to EA's acceptance criteria for Base Oil to be entitled to category 1 benefit.

Typical Specifications for Products

PARAMETER	PROCESS (see Table above)				
	(a)	(b)	(c)	(d)	(e)+
Water % w/w	10 to 15%	< 1%	< 1%	< 0.01%	< 0.01%
Viscosity cst @ 40°C	70 to 100	70 to 100	70 to 100	40 to 80	4 to 6
Density @ 15 °C Kg/L	0.89 to 0.95	0.89 to 0.95	< 0.9	0.87 to 0.88	0.85 to 0.86
Ash % w/w	1.5%	1%	0.3%	< 0.05%	< 0.05%
Sulphur % w/w	1.0%	1.0%	< 1.0%	0.9%	0.7%
Colour	Black	Black	Dark Red to Amber	Amber	Light Amber

+Refers to typical diesel products not necessarily from thermal cracking

COMMENTS:

The costs to produce products varies depending on the process employed by the recycler but there are increased costs incurred by recyclers to produce products of higher quality, both in relation to ongoing process costs and initial capital outlay.

Recyclers producing specification (a) type products would do so at minimal cost and there would be little in the way of initial capital expense.

Recyclers producing specification (b) type products would have increased capital costs ($200 to $400K) for the installation of boilers, filtration equipment and additional storage tanks. The processing costs (3 to 5 cents per litre) would also be higher than that of (a) due to running costs associated with boiler, filtration, pumping and associated equipment.

Recyclers producing specification (c) type products would have increased capital costs ($500K to $2M) for the installation of boilers, process vessels, filtration equipment and additional storage tanks. The processing costs (10 to 15 cents per litre) would also be higher than that of (a&b) products due to running costs

associated with this equipment and the purchase of acid, surfactant and neutralising agents, which are all employed in producing demineralised products.

Recyclers producing specification (d&e) type products would have increased capital costs ($2M to $15M) for the installation of refinery equipment including thin film evaporators, distillation columns, cooling towers, boilers, process vessels, filtration equipment and additional storage tanks etc.. The processing costs (up to 25 cents per litre) involved in producing these products are extremely high when compared to (a,b & c) type products given the equipment involved and the personnel required to operate it. Nationwide Oil has spent in excess of $12M on its refinery operation in Sydney as an example.

A cost that is common to all recyclers is that of collecting the used oil in the first place. The cost of collection can vary depending on location, equipment used and nature of the collection activity. From our experience the cost per litre to collect used oil ranges from 6 to 12 cents per litre with the average cost running at approximately 10 cents per litre. Some remote collections can be as high as 16 cents per litre when vehicles have to travel vast distances to service remote mining and rural communities.

Appendix F: Awarded Transitional Assistance Grants

Title: Achieving improved product stewardship for waste oils in rural and regional south Australia
Proponent: PPK Environment & Infrastructure
State: South Australia
Grant: $179,400

Project Description: The project identified the major sources of waste oil and the barriers to collection and reuse of waste oils in rural and regional South Australia. The project then developed region specific implementation plans.

Project Status: Project complete, report produced.

Title: Mobile recycling of transformer oil & dechlorination of transformer oil
Proponent: Castrol Australia Pty Ltd
State: Victoria
Grant: $157,270

Project Description: The objective of part one of this project is to prove the environmental performance of a mobile transformer oil recycling plant and experiment with different layouts to minimise exhaust emissions. This involves running controlled tests with oil of known PCB concentrations in the range 0-0.2ppm, 1.8-2.0ppm and 49-50ppm. The project will also investigate the effect of an incinerator and water scrubber on the gaseous emissions from the plant.

The second part of this project concerns the design and testing of a prototype mobile dechlorination plant capable of dechlorinating 10,000 litres of PCB contaminated transformer oil. A Waste Management Protocol concerning the environmentally responsible transfer of PCB contaminated oil from rural and regional Australia to the dechlorination plants in Brisbane and Melbourne will also be developed and promoted.

Project Status: A mobile transformer oil regeneration plant was tested and proven to be able to successfully regenerate transformer oil containing up to 50ppm PCB without exceeding air emission limits. A mobile dechlorination plant was designed, built and successfully trialled. A draft PCB Waste Management Protocol has been produced.

Title: Feasibility study for a 'dirty waste plastics recycling plant for discarded HDPE oil containers'
Proponent: Delynda Pty Ltd
State: Victoria
Grant: $62,590

Project Description: The proponent will undertake a feasibility study for a plastics recycling plant or plants to recycle HDPE oil containers. The project will include an extensive desk review of existing HDPE oil-container recycling technology in terms of operating costs, output material quality, material end use performance, production efficiency, environmental issues, capital efficiency and space requirements.

The final report will contain a summary of the current state of play in oil container recycling, here and overseas, consider supply chain issues such as technology, environmental costs and collection and transportation systems, and identify specific end use markets.

Project Status: Project complete, report produced.

Title: Upgrade of Southern Oil Refineries' Wagga Wagga re-refinery
Proponent: Southern Oil Refineries Pty Ltd
State: NSW
Grant: $1,330,650

Project Description: Southern Oil Refineries will upgrade its Wagga Wagga refinery to enable it to remove hazardous contaminants from used oil so it can be fully recycled. This project will be the first to produce re-refined engine lubricant to a quality that meets the Australian Government's tough new health, safety and environmental standards.

Project Status: Project complete, proponent is the first (and currently only) company in Australia to produce re-refined oil to PSO Category 1 standard.

Title: Domestic waste oil and container recycling - Tasmanian pilot project
Proponent: Gourmet Oil Pty Ltd (trading as Hagen Oil)
State: Tasmania
Grant: $110,000

Project Description: Construct and pilot a used oil containers processing plant that will produce recyclable plastic chips. The operator will put containers containing used oil in one end of the plant and shredded oil-free waste plastic and oil will be collected at the other end in separate streams.

Project Status: To be advised.

Title: Information dissemination through the Waste and Recycle 2001 Conference
Proponent: Western Australian Municipal Association
State: Western Australia
Grant: $6,645

Project Description: Sponsor the Waste and Recycle 2001 Conference.

Project Status: Complete. To complement sponsorship, the Department ran a booth and provided a speaker.

Title: Low cost oil-water separator
Proponent: University of NSW
State: NSW
Grant: $45,650

Project Description: In 1998, the UNSW Water Research Laboratory and Centre for Water and Waste Technology developed a new method for separating oil and water. It is known as an extended gravity oil water separator (EGOWS). It involves the gravitational separation of oil droplets from water in a batch mode where the input to the separator is a continuous flow. This is achieved by the use of a self-priming siphon located in a tank downstream of a skimmer wall. About 30 of these devices, ranging in size from 7,000 litres to 24,000 litres, have been installed in the power industry to separate transformer oil from rainwater runoff emanating from the concrete slabs on which the transformers are located.

This project will develop and test a small-scale low cost version of EGOWS, possibly using a standard 200-litre drum. The project also involves an education and awareness program targeted at rural and regional Australia.

Project Status: To be advised.

Title: Characterisation and assessment of waste oil utilisation as a fuel for heating in the hydroponics and greenhouse industries
Proponent: Warnken Industrial & Social Ecology
State: New South Wales
Grant: $31,900

Project Description: A combination of desktop and field research to investigate the current use of used oil as a heating fuel in the greenhouse and hydroponic industries and potential environmental and/or health issues.

Project Status: Project complete, report produced.

Title: Malaga Industrial Area Survey
Proponent: Bennett Brook Catchment Group
State: Western Australia
Grant: $9,075

Project Description: The proponent will survey 110 small to medium size automotive enterprises in the Bennett Brook Catchment Area (North East Perth) to determine how difficult it is for such businesses to responsibly dispose of their used oil.

Project Status: Survey complete and interim report provided. Awaiting final report.

Title: Waste oil collection and removal
Proponent: King Island Council
State: Tasmania
Grant: $24,260

Project Description: The King Island Council will collect, consolidate and transport to the mainland for processing approximately 52,000 litres of used oil currently stored in numerous locations across King Island.

Project Status: In progress.

Title: Local treatment of oily water
Proponent: Dubbo City Council
State: New South Wales
Grant: $6,250

Project Description: The project will enable the separation of oil from oil-contaminated water. The collected used oil can then be more economically transported to a metropolitan processing plant.

Project Status: Yet to commence.

Title: Improving waste oil outcomes in the auto dismantling and parts recycling industry
Proponent: Auto Parts Recycling Association of Australia
State: Victoria
Grant: $53,000

Project Description: The project will increase awareness of used oil management issues in the auto dismantling industry, which processes 500,000 end of life vehicles a year, and encourage appropriate responses at the individual business level.

Project Status: Project complete. An environmental best practice guide for auto recyclers and a directory of used oil collectors have been produced.

Title: Waste oil recovery system - Alice Springs region - Northern Territory
Proponent: Alice Springs Town Council
State: Northern Territory
Grant: $105,050

Project Description: This project has five components: conducting an oil audit, consolidating research into existing used oil, establishing a used oil recovery and consolidation facility in Alice Springs, conducting a pilot program to establish logistical requirements and finalising research on used oil recovery from remote communities.

Project Status: In progress. Report on oil audit due mid-2004.

Title: Pyrolysis pilot plant
Proponent: Loongana Lime
State:
Grant: $30,000

Project Description: Develop and trial a processing plant for grease generated at remote mine sites.

Project Status: Did not proceed. New company management declined grant.

Title: Multi-use waste oil collection facilities on Kangaroo Island.
Proponent: Kangaroo Island Council
State: South Australia
Grant: $34,100

Project Description: Collect and transport used oil to the mainland for processing.

Project Status: In progress.

Appendix G: Life Cycle Assessments of the Environmental Benefits of Lube-to Lube Recycling vs. Energy Reclamation

Life Cycle Assessment (LCA) is an environmental decision-making tool for assessing the environmental impacts of a product over its entire life cycle, from extraction of raw material through to the consumption and final disposal of the product.[1]

The aim of this section of the investigation is to review Australian and International LCA information on waste oil reprocessing and use and to make comment on whether further Life Cycle Assessment is justified at this time.

1. Review of LCA Studies

1.1 BHP

A comprehensive study[2] was carried out (October 1999 to March 2000) under contract to The Department of the Environment and Heritage to determine the environmental and economic aspects of reprocessing used lubricating oils in Australia. LCA modelling conformed to ISO 14040 procedures. The main environmental Key Performance Indicators (KPI) used were:

- Greenhouse gas (GHG) emissions, as equivalent mass emission of CO_2 (CO_2-e)
- Resource energy consumption/depletion (of fossil fuels - coal, oil, NG)
- NOx
- SOx
- Waste water
- Solid waste

Transportation and overall economics compared to virgin oils were also considered. Other possible emissions to land, air and water, particularly heavy metals and trace elements, were not considered because of difficulty in obtaining reliable data.

Seven Case Studies were undertaken:

- Re-refining technologies: settling, dewatering, demineralisation, thin-film evaporation (TFE), wiped-film evaporation (WFE), Interline propane deasphalting (PDA), thermal cracking, and chemically enhanced precipitation (CEP).
- Virgin oil production (for comparison)
- Waste oil use in cement kilns
- Recycled oil (demineralised) in nickel ore drying.
- Recycled oil (demineralised) in explosives (ANFO)
- Recycled oil (demineralised) in blast furnaces.
- Re-refined oil (diesel) in transport.

Key LCA findings were:

- re-refining generally results in better environmental outcomes for resource energy and GHG emissions over virgin product.
- significant resource energy savings are realised when waste oil replaces another energy resource.
- GHG emissions reductions are achieved when re-refined waste oil is used in place of virgin oil (due to lower processing emissions) and coal (due to avoided combustion).
- NOx and SOx emissions depend on the type of fuel and combustion system used.

- solid waste emissions are higher from waste oil reprocessing than for virgin oil production.
- The environmental impacts from transportation of waste oil are minor.

At the time the study was carried out there was limited published information available for benchmarking. Also, plant data for reprocessing routes were difficult to obtain (for proprietary and other reasons) and often difficult to interpret. Hence, only limited examination of the environmental effects was performed, but the authors expressed the view that full impact assessment was "not essential for ranking the environmental credentials of a given energy-technology combination, nor to identifying major areas for improvement."

The authors recommended that additional studies be carried out to determine benchmark practices for all treatment options, including more accurate flows and compositions of emissions and wastes, and also the risks posed by potential dioxin and heavy metal emissions for recycled oil use in a range of combustion equipment, particularly for major users.

1.2 European Commission (EC)

A report entitled "Critical Review of Existing Studies and LCA on the Regeneration and Incineration of Waste Oils" was published in December 2001[3]. (Note: "regeneration" is used in place of re-refining in this report). Critical assessment was made of four major European LCA studies (including eight individual comparative studies) comparing regeneration (vacuum distillation plus clay; vacuum distillation plus chemical treatment; hydrogen pre-treatment plus vacuum distillation) and incineration (in a cement kiln and an asphalt plant).

Environmental impact factors considered in the study were:

- Consumption of fossil energy resources
- Contribution to global climate change
- Contribution to regional acidifying potential
- Emission of volatile organic compounds (VOC).

Twelve environmental impact criteria were used in the evaluation.

It was concluded that:

- Considering only the recovery treatment, regeneration impacts are generally lower than for incineration.
- An old regeneration process can be improved with new technology.
- Recovery is preferable to replacement; all recovery options are favourable in terms of environmental impacts.
- Incineration in cement kilns (fossil fuel replacement) is more favourable than in asphalt kilns (gas oil replacement).
- Modern regeneration may be more favourable than incineration in an asphalt kiln compared to incineration in a cement kiln. Regeneration has environmental advantages and drawbacks depending on the impact considered. Regeneration would present advantages for all environmental impacts in all scenarios if the waste oil replaces non- fossil fuels (e.g. hydro, nuclear and maybe other wastes). Regeneration would have advantages and drawbacks compared to thermal cracking, and would be preferable to gasification for all impacts except solid waste and water input.
- Collection/transport impact is not significant.

Qualifications were:

- Noise, odour, nature conservation, land use, toxic emissions and the displacement of fossil fuels by waste oil were not considered.
- Although few studies have been reported on the potential health effects of re-refined base oils, it would appear that these are not acutely toxic nor are they skin and eye irritants.
- Non-traditional fuels were not considered.
- Possible evolution of new technologies should be considered.

1.3 OECD

The Working Group on Waste Prevention and Recycling presented a report[4] entitled "Improving Markets for Used Lubricating Oils" in October 2003. This report included reference to the aforementioned EC report findings and made the following relevant comments:

- "The studies provide evidence to justify support for either re-refining or direct burning in cement kilns."

- "The studies indicate that the comparative environmental benefits are finely balanced between the two main methods of post-collection management: incineration in cement kilns and re-refining."

It was noted that "several environmental impacts were excluded from some or all of the LCA studies. Specifically: noise, odour, biodiversity, land use, toxic emissions and the displacement of non-fossil fuels by used oils."

1.4 Warnken

A report entitled "Characterisation and Assessment of Waste Oil Utilisation as a Fuel for Heating in the Hydroponics and Greenhouse Industries" prepared for the Department of the Environment and Heritage, August 2003, refers to a "preliminary" qualitative LCA for combustion of waste oil as a fuel[5]. The conclusion reached was that "waste oils which have not been reprocessed, or waste oils of which the quality is unknown, should not be used in the direct heating of greenhouses whose products are consumed by humans or animals. No quantitative KPI information was determined, although the information needed to do this was specified.

1.5 PA Consulting Group, NZ

A report entitled "Options for Used Oil Recovery in New Zealand" was prepared for the NZ Ministry of the Environment on options for the effective recovery and disposal of used oil in New Zealand[6]. Interestingly, no mention was made of Life Cycle Assessment in the report, which was directed mainly towards improving collection.

1.6 CSIRO

A report on life-cycle emissions analysis of alternative fuels by Beer et al[7] includes the finding that while the use of waste oil blended into diesel offers a "slight reduction" in greenhouse gases, it also leads to increased air pollution. The authors suggest that the most favourable use of waste oil is as recycled lube oil.

2 Discussion

The BHP report presents a comprehensive Life Cycle Assessment for Australian waste oil recovery operations and utilisation. KPIs determined by LCA methodology are summarised in Table 7.1 for the processes used by six Australian reprocessing companies[2]. Also shown for comparison are KPIs for standard lube oil production.

Table G.1: Summarised Environmental KPIs for Australian Waste Oil Reprocessing Operations and Virgin Lube Oil Production

			Environmental KPIs					
Company	**Process**	**Product**	**Resource energy MJ**	**GHG kg CO2-e**	**NO_x kg**	**SO_x kg**	**Waste water L**	**Solid waste kg**
Nationwide	Interline	DE	143	9	0.03	0.01	4	1.7
	Demineralisation	BF	22	2	0.02	0.001	3	0.9
Environmental Oil	Thermal Cracking	D, BF	101	8	0.03	0.02	2	1.6*
Wren Oil	TFE	DE	140	11	0.15	0.03	2	0.4
AWOR	TFE	DE	140	11	0.15	0.03	2	0.4
SOR	WFE	RRLO	151	10	0.03	0.01	1	n/a
Evergreen	CEP	RRLO	101	8	0.10	0.03	3	n/a
Various LORs	Standard	VLO	1,150	10	0.02	0.04	n/a	0.1

Note: BHP, 2000. Basis (Functional Unit) used is 1 GJ of product). (DE = Diesel Extender; BF = Burner Fuel; D = Diesel; RRLO = Re-refined Lube Oil; VLO = Virgin Lube Oil).
*Environmental Oil advises that this figure is much larger than they currently produce. In general, it appears that this figure is too large as only the small amount of metal salts resulting from metal-containing additives remain after thermal cracking.

Resource energy requirements vary according to the energy intensity of the processing operation, ranging from 22 MJ/GJ for demineralisation to 140-150 MJ/GJ for the more advanced processes using various forms of distillation. Less intensive processing is required for production of boiler fuel. Upgrading to diesel fuel specification has similar resource energy requirements to producing lube oil. By comparison, virgin lube oil production requires similar resource energy input for processing (150MJ/GJ), but this is additional to the basic 1,000 MJ/GJ penalty for extraction of a natural resource that does not apply to waste oil. From a resource energy standpoint, any of the reprocessing options is preferable to extraction of virgin lube oil feedstock.

Greenhouse gas emissions (equivalent CO_2) are roughly proportional to the resource energy requirements for processing.

NOx and SOx emissions are low when compared with GHG emissions. These need to be kept in perspective: the absolute quantities are small by virtue of the small amounts of waste oil processed when compared with other energy processing operations, such as power generation. Also, the generation rates are at least one order of magnitude lower when compared to coal-fired power generation on an equivalent energy basis.

Waste-water and solid-waste generation are inevitable in such processes and need to be dealt with responsibly. It is not possible to comment further on this without actual plant figures.

A common use of waste oil is in cement clinker production, in place of fossil fuels. The BHP report indicates that a resource energy saving of 84% can be achieved when waste oil is used as a 100% replacement of coal. GHG emissions are slightly reduced, but NOx and SOx emissions are essentially unchanged. Any fractional use of waste oil in such processing is thus environmentally advantageous.

As pointed out in the EC report, there is no scientific basis for reducing LCA results to a single overall number. Also, emission of toxic substances and other emissions in small quantities and low concentrations are often not monitored continuously and they are not sufficiently covered by LCAs. Additional measures are needed to ensure that unwanted impacts are not caused as result of reprocessing operations.

Hence, insofar as environmental impacts are concerned, the evidence provided by the BHP and EC reports supports the general conclusions that recovery/re-use is preferable to replacement and that re-refining has marginal advantage over combustion applications. What route is employed in practice will depend on economic considerations, including subsidies.

References

1. ISO 14040: defines LCA as "a systematic set of procedures for compiling and examining the inputs and outputs of materials and energy and the associated environmental impacts directly attributable to the functioning of a product or service system throughout its life cycle".
2. *The Environmental and Economic Aspects of used Lubrication Oil in Australia (based on LCA).* BHP Report for Environment Australia, 2000.
3. European Commission Report *Critical Review of Existing Studies and Life Cycle Analysis on the Regeneration and Incineration of Waste Oils*, conducted by Taylor Nelson Sofres Consulting, December 2001.
4. *Workshop on the Economics of Waste: Improving Markets for Used Lubricating Oils*, OECD Working Group on Waste Prevention and Recycling, Paris, 14-15 October 2003, 25 pages.
5. *Characterisation and Assessment of Waste Oil Utilisation as a Fuel for Heating in the Hydroponics and Greenhouse Industries*, prepared by Warnken Industrial and Social Ecology Pty Ltd for Environment Australia, August 2003.
6. *Options for Used Oil Recovery in New Zealand*, prepared by PA Consulting Group for Ministry of the Environment, 31 August 2001.
7. Beer, T. Grant, T., Brown, R. Edwards, J. Nelson, P. Watson, H. and Williams, D. *Life-cycle Emissions Analysis of Alternative Fuels for Heavy Vehicles – Stage 1.* CSIRO Atmospheric Research Report C/0411/1.1/F2 to the Australian Greenhouse Office, March 2000.

Appendix H: Visits and Discussions

A. Visits to Reprocessing Plants:

1. Nationwide Oil P/L - Wetherall Park NSW - Propane de-asphalting plant.
2. Southern Oil Refineries P/L - Wagga Wagga NSW - Thin Film Evaporator & Solvent Extraction.
3. Australian Waste Oil Refineries - Maitland NSW - Thin Film Evaporator.
4. Nationwide Oil P/L- Dandenong VIC - Demineralisation.
5. Environmental Oil Ltd - North Laverton VIC – Cracking
6. Wren Oil – Bunbury WA – Thin Film Evaporator.

B. Other meetings/discussions:

1. Mike Williamson - OSAC Chair.
2. AIP - Ewen Macpherson.
3. SAMI P/L - Bitumen Manufacturer - Camellia NSW
4. Mark Glover - Southern Oil Refineries P/L, Eco Waste P/L, Renewed P/L, Oil Drop P/L.
5. Queensland EPA - Gary O'Connor (OSAC member) - phone
6. Wright Corporate Strategy - Paul Howlett (OSAC member).
7. EPA Victoria –Waste Management - Peter Jackson - phone.
8. City of Boroondara – Vic Waste Management - Sam Giovanni - phone.
9. Resource NSW – Rod Clare.
10. Queensland EPA – Gary O'Connor – phone.
11. Victorian EPA – Lynn Denison – phone.
12. ATO – Kerrie Hepworth – phone.
13. Valvoline (Australia) P/L – Peter Fitzgerald.
14. Shell Engineering P/L – Turlough Guerin
15. NSW EPA – Waste Management Section – Tanya Ritchie and Greg Cooper.
16. Hagen Oil – Doug Hagen – phone.
17. Fuchs Lubricants (Australasia) P/L – Richard LaGanza
18. Western Australian Local Government Association – Bernard Ryan, Danielle Witham.
19. WA Department of the Environment – Environmental Management Division - Lillias Bovell, Manager Controlled Waste Section.
20. Shell Australia – Peter Jaeschke – Head of Lubricants.
21. BP Australia – Rob Kalder-Bull, Product Stewardship Manager, Australasian Lubricants Performance Unit.
22. EcoRecycle Victoria.
23. Dr M. Perry, US Department of Energy
24. Macquarie Generation – John Marcheff, Manager Liddell Power Station.
25. Cement Industry Federation – Ros de Garis - phone.

Appendix I: The Oil Stewardship Advisory Council

The Oil Stewardship Advisory Council (OSAC)[1] provides advice to the Minister for the Environment and Heritage on the product stewardship mechanisms and their operation, the oil recycling and oil production industries and markets.

Part 3 of the *Product Stewardship (Oil) Act 2000* establishes OSAC. Members are drawn from a range of backgrounds so that the oil producing and recycling industries, state and local government, consumers and other non-government interests are appropriately represented and can contribute to formulating advice on the PSO. The Environment and Heritage portfolio and the Commissioner of Taxation represent the Commonwealth.

The members and chair of OSAC were originally appointed on 15 February 2001 – the Chair for a period of 2 years, and members for 12 months. Several members retired during the course of the year 2002-03 due to their appointments lapsing, and were either replaced or the membership position lapsed due to the position no longer being required. These members were Mr David Braham, Mr Doug Hagen and Mr Andrew Poole. The membership of the Council as of 30 June 2003 is as follows:

Member	Representing
Mr Mike Williamson (Chair)	Independent Chair
Mr Peter Holt	Commissioner of Taxation
Mr Peter Burnett	Environment and Heritage portfolio
Mr Ewen McPherson	Australian Institute of Petroleum
Mr Bob Pullinger	Australian Oil Recyclers Association (AORA)
Mr Gary O'Connor	Environment Protection and Heritage Council
Mr Mark Borlace	Royal Automobile Association of South Australia
Mr Paul Howlett	Waste Management Association of Australia
Ms Catherine Halliday	Additional member (community representative)
Mr Harold Grundell	Additional member (oil recycler)
Mr Martin Kirwan	Additional member (oil recycler)
Mr Fred Wren	Additional member (oil recycler)

The Council held three meetings in 2001-02. The first was in Sydney on 12 September 2001, the second in Melbourne on 5 December 2001 and the third in Shepparton on 11 June 2002. Three council meetings were held in 2002-03: in Sydney on 15 October 2002, in Canberra on 11 February 2003 and 26 June 2003.

1. Annual Reports 2001-02; 2002-03: Operation of the Product Stewardship Arrangements for Waste Oil (PSO) and the Product Stewardship (Oil) Act 2000. *Department of the Environment and Heritage.*

List of Acronyms

AORA	Australian Oil Recyclers Association
AIP	Australian Institute of Petroleum
API	American Petroleum Institute
ATO	Australian Taxation Office
BHP	Broken Hill Pty Ltd
BP	BP Australia Pty Ltd
CO_2-e	carbon dioxide equivalent
cpl	cents per litre
DITR	Department of Industry, Tourism and Resources
DIY	do it yourself
EC	European Community
EPA	Environmental Protection Authority
GHG	Greenhouse Gas
HG	High Grade industrial burning oils
LCA	Life Cycle Analysis
LG	Low Grade industrial burning oils
ML	Megalitre, Million Litre, 10^6 litre
MSDS	Material Safety Data Sheets
NG	natural gas
NOHSC	National Occupational and Health Safety Committee
OSAC	Oil Stewardship Advisory Council
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorobiphenyl
ppm	parts per million
PSO	Product Stewardship for Oil
TA	Transitional Assistance

List of Written Submissions Following Public Consultation

Liz Richmond, Project Officer, EcoRecycle Victoria

Chris Newcombe, Proprietor, Northern Lubequip

Barry Dobson, Director, Environmental Oil Limited

Ewen MacPherson, Deputy Director, Australian Institute of Petroleum