Technology and Market Development for Used Oil Products in Western Australia

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Technology and Market Development for Used Oil Products in Western Australia

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Cardno BSD Pty Ltd

EXECUTIVE SUMMARY

The *National Product Stewardship for Oil Programme*, introduced in 2001 by the Commonwealth of Australia, is administered by the Department of Environment and Water Resources. The program has provided the basis for a used oil recovery regime in Western Australia. An issue that affects the viability of the scheme has been the limited markets for used oil products in the State.

Cardno BSD was appointed by the Department of Environment and Conservation (Western Australia) to carry out an investigation into technology and market development issues for used oil products. This study includes a detail analysis of the following:

- Existing situation in Western Australia including market characteristics, industry condition and influences affecting the market for used oil products; and
- Potential market size, trends, threats and opportunities for the state.

Collectable Oil

It is suggested that 94% of collectable used oil is being collected in Western Australia. This level of used oil collection is excellent when compared to the average for Australia and other countries. The accuracy of this figure could be in question as the waste oil may contain significant quantities of water and other contaminants. It also does not include the significant amount of used oil being stockpiled, reused or incorrectly disposed of by households that change their own vehicle oil.

Western Australia's Used Oil Industry

The Western Australian used oil industry provides a complete service starting from the supply of used oil storage tanks, through to the production of products ready for the appropriate market. The industry comprises of three companies operating within the State and a fourth company whom has recently decided not to establish a facility in Western Australia.

Wren Oil (based in Picton) services a variety of clients by providing a collection service for used oil materials. Wren Oil reprocesses the used oil into a variety of products by utilising the Thin-Film Evaporator process. These products include:

- Industrial Burning Oils
- Chainsaw bar oil lubricant
- Medium grade hydraulic oil
- Mould Oil
- Degreasers

Nationwide Oil has oil collection facilities located in Kalgoorlie, Kwinana and Newman. Nationwide also reprocesses used oil by utilising the dehydration process at their Kalgoorlie plant to produce a low-grade industrial burning oil product.

Tox-Free treats and manages a broad range of bulk liquid wastes. The company provides a collection service and treats the used oil to remove any excess water. The resulting used oil is collected by Nationwide Oil for further re-processing.

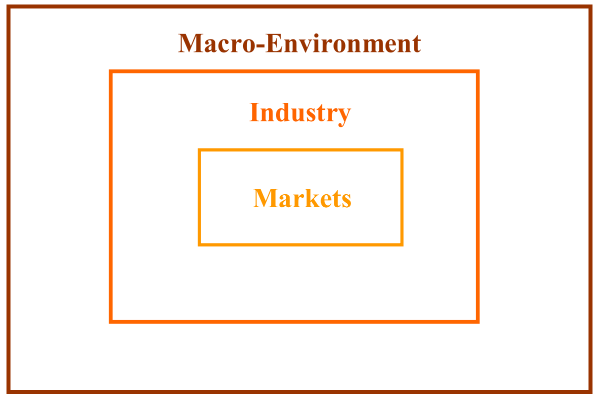
Aldwich Resources previously proposed a facility, which would utilise the thermal cracking process to produce diesel. However, the company had decided to stop the development of a Waste Oil to Diesel facility as they were unable to secure sufficient used oil quantities to operate the plant.

Analysis of Used Oil Industry

Three layers of Western Australia's used oil industry were analysed to gain an understanding of the environment and markets that the industry operates within.

The three layers of the used oil sector analysed included:

- The Macro-Environment
- The Industry
- The Markets



Macro Environment Analysis

The PESTEL framework (the assessment of Political, Economic, Socio-cultural, Technological, Environmental and Legal factors) was used to define and summarise the general environment that the used oil industry operates within and the associated issues. **Table E1** provides a summary of the Macro-environmental influences of the used oil industry in Western Australia.

Table E1: A Summary of Macro-environmental influences (PESTEL Framework)

POLITICAL • Stable political environment • Product Stewardship Arrangements for Waste Oil – Subsidies for different used oil based products • Levy on virgin oil • PSO Transitional grant scheme – provided collection facilities	**ECONOMIC** • Strong Western Australian economic activity • Low inflation • Low unemployment • High level of activity in resources sector • Increasing cost of transport fuel • Increasing cost of virgin oils
SOCIO-CULTURAL FACTORS • Increasing car ownership • DIY oil change and disposal by community • Small population base • Remote communities / used oil sources • Illegal disposal • Poor perception of recycled oils	**TECHNOLOGICAL** • Increasing service intervals for lubricating oils • Increasingly complex lubricating oils (e.g. synthetics) • Lack of lubricating oil refinery in Western Australia
ENVIRONMENTAL • High pollution potential from 'illegally dumped' used oil • Used oil classified as Hazardous Waste	**LEGAL** • Hazardous Waste (Regulations of Exports and Imports) Act 1989 (Cwlth) (the Act) restricts to exporting of 'waste' products • DEC Licence for treatment site • Controlled Waste Regulations for transport • Dangerous Goods Licence for Storage • ATO Excise regulations

Industry Analysis

The used oil industry in Western Australia comprises two main competitors: Nationwide Oil and Wren Oil. These companies dominate the industry and exhibit a high level of competition. These companies reprocess a similar volume of used oil, with neither company being the dominant player in the State. Both offer a similar collection service and provide burner fuel as their main used oil product.

Although collection volumes are increasing, there is only a small growth in the use of lubricating oils. Therefore there is little scope for either company to increase the volumes collected. Furthermore, a high amount of competition exists as the local market demand for burner fuels is decreasing within the state and there are number of barriers restricting access to interstate and international markets.

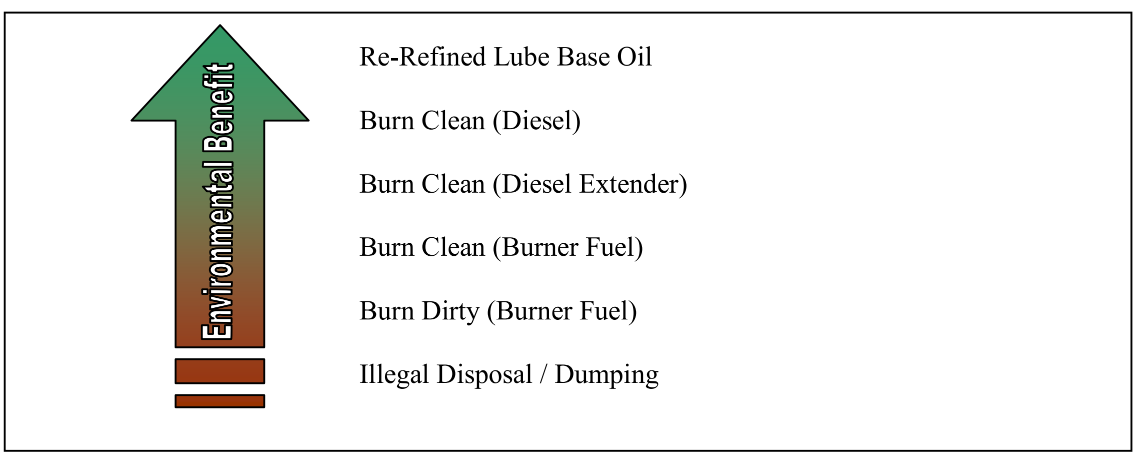
As a result there are significant barriers of entry for an additional company to enter the industry. For a company to be successful, it is likely that it would:

- Need to differentiate their collection service or collaborate with an existing operator to gain access to a supply of used oil, and
- Produce alternative products with had a market demand, rather than compete within the domestic burner fuel market.

The technology currently used by Wren Oil and Nationwide Oil is designed to either create an alternative burner fuel for industrial furnaces or smaller burning operations for heaters in the hydroponics industry. No used oil is refined to a grade that can be used as a diesel fuel, diesel extender and very little is refined to a grade that can be used as a lubrication fluid. There are possible technology gaps that could be utilised in Western Australia to create further markets and further increase oil recycling.

A number of Life Cycle Assessments (LCAs) have been reviewed as part of this study. The assessments compared the potential environmental benefits and impacts associated with used oil reprocessing technologies. **Figure E1** below shows an approximate hierarchy relating to each used oil treatment process and product.

Figure E1: Used Oil Technology Hierarchy



Market Analysis

The majority of used oil products produced in Western Australia are sold within the State's domestic market. The key 'large volume' consumers of used oil based products in Western Australia are power stations, cement kilns and other industries such as brickworks that require fuel oil. In 2002, the OSAC Working Groups: Collections and Markets, estimated this market to be 28ML (AATSE, 2004). However, they pointed out that due to market changes, both power stations and cement kilns could reduce their demand for burner oil. Based upon feedback from consumers, the demand for burner oil is decreasing in Western Australia. This is due to a number of reasons including environmental and community concerns, industry barriers and the switch to alternative fuels.

Quantification of the market for used oil based products in Western Australia has proved to be elusive, as this information is commercially sensitive for the two key oil processors in the State, especially with the competitive nature of the industry. A number of potential consumers were contacted for each industry group, however the information provided did not reflect the State market when compared to the general information the oil processors did provide. This does demonstrate that there are no 'easy' market opportunities for used oil products in Western Australia. The general feedback from the oil processors was that while there are outlets for the majority of their products, there is already surplus product that requires storage.

The current export market for used oil products is very small. The oil processors feedback stated that there have been enquiries from overseas for burner oil and lube base oil. As lube base oil is not produced in Western Australia this option is currently unviable.

The increased transport cost to reach overseas markets would impact upon profitability when compared to local markets, however as a surplus of burner oil is currently being produced this may be an option rather than disposal. The export of High Grade Industrial Burner Oil is controlled under the Hazardous Waste (Regulation of Exports and Imports) Act 1996 Amended (Cwlth) (the Act). There may be occasions, however, when it is not controlled under the Act. For instance, if it is blended with other fuels, such as decant oil (a by-product from oil refining), the Commonwealth government, after review of the blending process, may determine that it no longer meets the definition of a hazardous waste under the Act and that the resulting blend could be exported without a permit.

Potential for Lube to Lube Reprocessing

The establishment of a lube-to-lube re-refining facility in Western Australia would face a number of significant barriers due to the following reasons:

- Supply of used oil would need to be secured and this may only be obtained if the collection company paid a fee for the used oil. Alternatively, one of the existing used oil processors could develop their existing operation to produce re-refined lube base oil.
- The OCED Report (2005) states that the volume required (60,000 tonnes) for a commercially viable facility exceeds the annual volume of used oil collected in Western Australia. However, the facility operated by Southern Oil Refineries in NSW has a capacity of only 15 ML per annum.
- The capital cost to establish a re-refining facility is also a significant investment and presents a barrier to be overcome.

- There is currently no lubricant oil manufacturer refinery in Western Australia, and therefore any product would need to be exported to the Eastern States or overseas.

Ultimately, it is likely that the establishment of a lube-to-lube re-refinery in Western Australia would only be financially viable with significant government assistance relating to grants, subsidies or regulation to assist in the capital investment of the facility and / or market development for the products.

Recommendations

An analysis of the used oil industry and markets in Western Australia has resulted in a number of recommendations. These aim to eliminate barriers towards market development for use of used oil products in Western Australia. **Figure E2**, on the following page, summarises these recommendations and shows where they fit into the used oil supply chain in Western Australia.

Conclusions

The used oil industry in Western Australia provides an efficient, free collection service throughout the state. However there are a number of issues that are leading to a decline in the current markets for the used oil based products that have lead to approximately 22ML of product being stored in the State. The recommendations made by Cardno BSD in this report aim to address the key issues and therefore allow the used oil industry to have long term security with current markets while ensuring access to additional markets within Western Australia or overseas.

If the markets for the used oil products continue to decline and additional storage is unavailable, this is likely to impact upon the volume of used oil collected in the State and this may result in an increase in illegal disposal of used oil into the environment and the associated pollution impacts.

Figure E2 Summary of Recommendations

Recommendation 1. *The used oil industry and Department of Environment and Conservation, in consultation with the market stakeholders, should develop a specification standard for burner oil.*

Recommendation 5. *The viability of a re-refining facility in Western Australia, for the production of lube base oil for the domestic market is questionable and significant consultation is required between the DEC, used oil processors and the major lubricant oil manufacturers before a decision is made. The group / meetings should be facilitated by an independent third party.*

Recommendation 6*. Establish a working group to assess the viability of a re-refining facility in Western Australia, for the production of lube base oil for the domestic market.*

Recommendation 2 *Provided the costs were reasonable and this provided a long-term market for a significant quantity of burner fuel, a capital grant for investment into infrastructure should be considered, possibly funded through the PSO Transitional Assistance Grants.*

Recommendation 9. *The establishment of a burner oil specification (Recommendation 1) and the support of the WA Government to classify the burner oil that meets the standard, as a product.*

Recommendation 7. *The testing of larger batches of oil collected, which could be used for re-refining should be established. Economic incentives would be required to ensure the used oil is provide uncontaminated. This recommendation could also be used to ensure higher quality uncontaminated burner fuel could be produced.*

Recommendation 10. *To ensure a stable industry, any measures or policy implemented should be consistent with current policy direction.*

Recommendation 3. *A State based group should be established with representatives from the DEC, the used oil industry and major consumers to identify the specific issues preventing the use of used oil based products at facilities in Western Australia and develop actions that would enable these markets to be utilised.*

Recommendation 4. *A community consultation program should be completed to identify the concerns that the community has, and explore ways that the concerns could be addressed to ensure that the community and burner oil consumers were happy for burner oil to be used instead of virgin fuels.*

Recommendation 8. *Government could consider 'leading' the market by specifying use of re-refined lube oils in some government supply contracts.*

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1. INTRODUCTION

The recovery and reuse of used lubricating oil is a challenge that faces Western Australia. The Australian Government introduced the *Product Stewardship for Oil* program in 2001 to provide incentives to increase oil recycling in Australia. The program, administered by the Department of Environment and Water Resources encourages the environmental management and re-refining of used oil, and its re-use.

The national Product Stewardship for Oil Programme has provided the basis for a used oil recovery regime in Western Australia. An issue that affects the viability of the scheme has been the limited end uses for used oil products resulting from the collection. An assessment of the situation determined that an investigation to address technology and market development issues for used oil products were warranted and Cardno BSD were appointed by the Department of Environment and Conservation (Western Australia) to carry out this investigation.

Of the 37 million tonnes of lubricants sold globally in 2001, 40% - 50% was consumed or lost during use (OECD, 2005). Within Western Australia, 66 ML of lubricants were sold in 2005/06 and 37.2 ML[1] were collected during 2005/06 (ABARE, 2006). When used oil is not collected there is a risk of pollution from illegal disposal into sewers, storm water drains, soil or watercourses. Used oil can contaminate surface and groundwater, with associated impacts on aquatic plants and fish, wastewater treatment works and human health. In addition, when used oil is not collected, it can be considered a waste of resources since used oils can be used to produce many products that would otherwise be produced from virgin oil sources.

In Western Australia, the used oil is collected by a small number of operators and transported to central reprocessing facilities to produce a number of products that can be used as feedstock for a variety of uses, including:

- Fuel in horticultural space heaters;
- Fuel in industrial scale processes e.g. power stations, cement kilns, brick works; and
- Re-processing to produce various hydrocarbon based products e.g. chainsaw bar oil, mould oil.

The products produced from used oil depend upon policy incentives and market conditions. In Western Australia a large market for used oil based products has historically been to supply power stations and cement kilns with burner fuel, however the long-term security of these markets is in question due to competition from other fuels such as gas and coal. The loss of used oil markets, without the development of new outlets could have a significant effect vertically back through the used oil supply chain. This could result in reduced collections of used oil and the associated increase

[1] This is the total amount of controlled waste category 6.04 "waste mineral oils unfit for their originally intended purpose" that was collected and transported in W.A. during the 05/06 financial year. Please note that where the carrier is transporting under 200 litres or kilos in the entire load, the waste is not tracked.

in pollution risk. A key question is therefore, what alternative markets are available and what measures would be required to avoid the knock on effects of the declining existing markets?

2. METHODOLOGY

2.1 STAKEHOLDER CONSULTATION AND RESEARCH

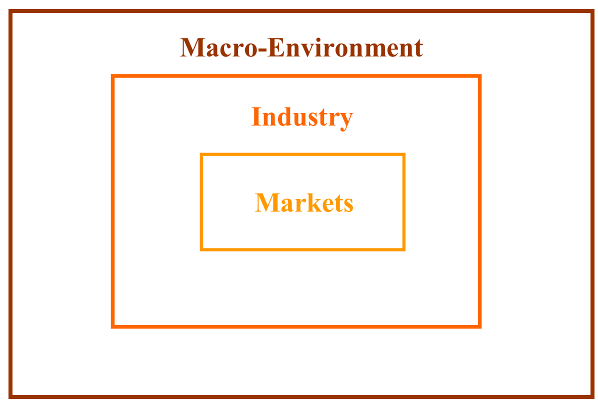
In order to provide a comprehensive assessment of the existing baseline situation for the used oil industry, the Cardno BSD project team completed a comprehensive review of all publicly available literature and information. Key used oil industry stakeholders (listed in **Appendix A**) together with non-industry stakeholders such as Federal, State, Regional and Local Governments, mining industry stakeholders and other groups were identified and contacted to gather feedback and information about the used oil industry and market development issues in Western Australia.

2.2 DETAILED ANALYSIS

Utilising the information gathered during the research and stakeholder consultation phase of the project, the Cardno BSD project team has completed the following analysis for the used oil sector.

The three layers of the used oil sector analysed included:

- The Macro-Environment
- The Industry
- The Markets



2.2.1 Macro-Environment

The analysis of the macro-environment concentrated on the general aspects of the impact on the used oil industry. The project team used a PESTEL framework (the assessment of Political, Economic, Socio-cultural, Technological, Environmental and Legal factors) to define and summarise the general environment that the used oil industry operates within and the associated issues.

2.2.2 Industry

The analysis of the used oil industry examined areas such as competition and linkages within the industry. These were analysed using Porter's five forces framework to determine the basis of competition in the industry. The Porter's five forces analysis uses concepts to derive five forces that determine the competitive intensity and therefore attractiveness of a market. They consist of those forces close to a company that affect its ability to serve its customers and make a profit. A change in any of the forces normally requires a company to re-assess the marketplace.

The use of the five forces framework was used in this study to outline competitive forces in the used oil industry and how they can be countered and overcome in the future. As part of this analysis the project team identified the industry segmentation by product, service, market and geography.

2.2.3 Markets

The analysis of the market characteristics defined the baseline position of the current market by value, product type, volume and end user. The quantity of used oil stocks in storage within Western Australia was estimated, distribution economics were analysed and transport synergies were identified. Current and future market trends were identified for the used oil products for both domestic and international markets.

After the baseline situation was determined, future trends for the use of used oil products were assessed for each product's existing market and potential niche and export markets. An analysis was completed to identify any constraints and potential opportunities for the reprocessing of used oil to lubricating oil (lube to lube), including the identifications of barriers and opportunities, together with cost estimates and potential industry partners. Specific regional variations were considered and the opportunities in the marketplace for the regional placement of infrastructure to capitalise on local markets.

2.2.4 Recommendations

The results from the analysis described above were used to develop a series of recommendations that aim to address the issues and barriers that were identified, while maximising the market development opportunities for used oil products for State, National and International markets.

3. THE USED OIL INDUSTRY

This Section gives background to the used oil 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:

- Re-refined lube base oil suitable for lubricant use;
- Reprocessed diesel fuel or diesel extender;
- Treated low grade (LG) industrial burning oil (fuel oil); and
- High grade (HG) industrial burning oil, competing with virgin fuel oil

3.1 OIL REFINERIES

The primary function of the refineries is to add value to crude oil by splitting it into a number of fractions. Heat is applied to the crude oil within a distillation column to separate its main component parts. The lightest fraction of petroleum gases is removed at the upper end of the distillation column and the heavy, sticky residue from the bottom end. In the main, distillation creates a surplus of fuel oil and insufficient motor fuels. The heavier residues from the distillation process are processed into lubricating oils, waxes and bitumen.

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 four major oil companies 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).
- Shell Australia Ltd: Refineries at Clyde (near Parramatta in Sydney) and Geelong (Victoria).

In 2004/05 Australian oil refineries processed 40,334 ML of crude oil. Total production of marketable oil products was 40,202 ML with product proportions shown in **Figure 3.1** (ABARE, 2006). Lubricating base oil makes up only 0.5% of the total output from Australian refineries (ABARE, 2006).

Lube oils are high boiling materials, however 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 or lubricating oil products are imported. During 2004/05, 327ML of lubricating oil products were imported to Australia (ABARE, 2006).

Therefore, the majority of lubricating oils available in Australia are either refined from imported crude oil or imported as pre-refined lubricating oil products. The total quantity of lubricating oil sold in

Australia during 2004/05 was 470ML[2] and the State-by-State sales figures are shown in **Figure 3.2**. The quantity of lubricating oil and grease products sold in Western Australia during 2005/06 was 66ML, or 15% of the total quantity sold in Australia (ABARE, 2006).

The Petroleum Division within the Department of Industry, Science and Resources publishes Australian Petroleum Statistics. Statistics are published monthly and report on product and state for production, refining, sales, trade and stocks of petroleum. **Table 3.1** outlines the sales of lubricants in WA by marketing area.

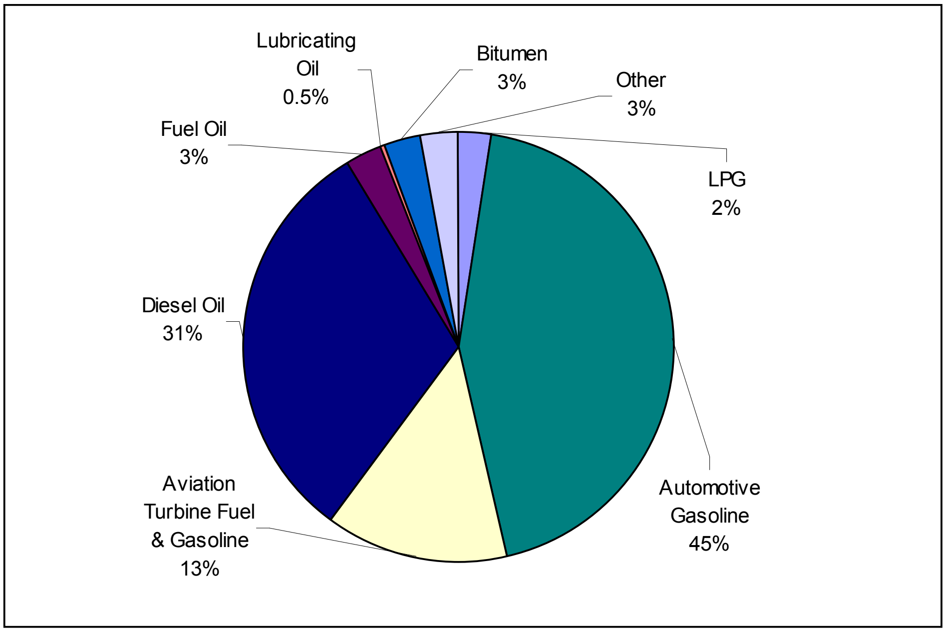
Table 3.1: Sales of Lubricants in Western Australia by Marketing Area

		Sales (KL)
Automotive Oils		
Engine Oils	Gasoline	7,444
	Diesel	19,181
	Total	26,625
Transmission Fluids		6,702
Gear Oils		3,373
Speciality Oils		709
Hydraulic Break Fluid		216
	TOTAL	37,625
Other Transport Oils		
Aviation Oils		180
Marine Oils	International	1,959
	Coastal	836
	Total	2,795
Railroad		1,623
	TOTAL	4,598
Industrial Oils		
Gear Oils		2,229
Hydraulics		8,099
Metal Working		480
Other		7,318
	TOTAL	18,126
Greases		3,027
Total Blended Oils		63,376
Other Lubricants		
Process Oils		600
Basestocks		3,821
	TOTAL	4,421
Total Lubricating Oils and Greases		**67,797**

Source: DITR, 2005

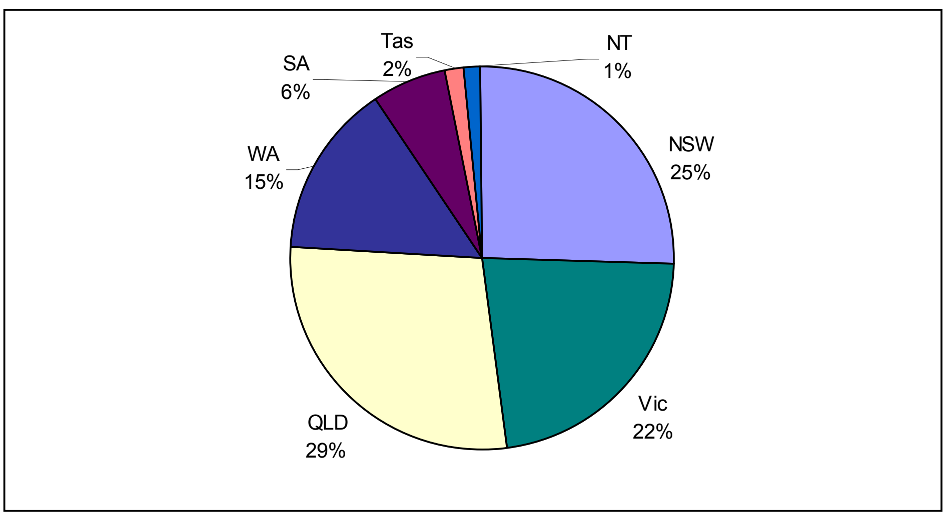
[2] The volume of lubricating oils reported as sold in Australia range from 450 – 581 ML depending upon the source of the information.

Figure 3.1: Products from Australian Oil Refineries, 2004/05.



Source: ABARE 2006

Figure 3.2: State Sales for Lubricating Oil and Grease Products, 2004/05.

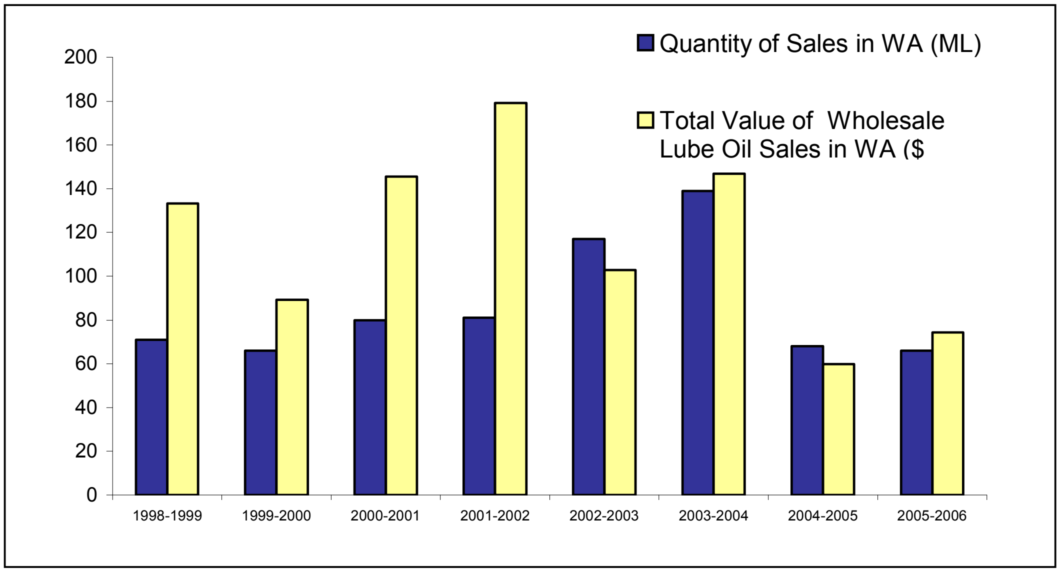


Source: ABARE 2006

The quantity of lubricating oil sold in Western Australia from 1998/99 to 2005/06 is shown in **Figure 3.3**. In order to estimate the value of the lubricating oil sold in Western Australia, the average price per litre of imported lubricating oil has been calculated for each year. This value per litre has been used to estimate the wholesale value of the lubricating oil sold in Western Australia**.**.

Based upon the value estimates, the approximate wholesale value of the lubricating oils sold in Western Australia during 2005/06 was $74,360,000.

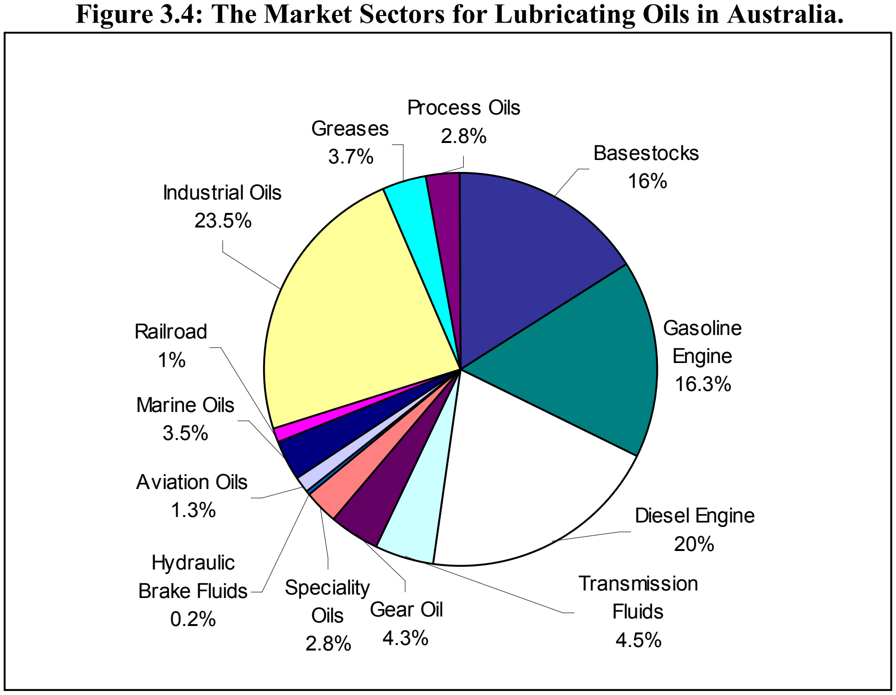
Figure 3.3: The Quantity and Estimated Wholesale Value of Lubricating Oils Sold in Western Australia.



Source: ABARE Australian Mineral Statistic Reports 1999 - 2006

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 3.4**.

Figure 3.4: The Market Sectors for Lubricating Oils in Australia.



Source: AATSE, 2004.

Large industrial, agricultural, mining and transport companies and the automotive industry purchase oil in bulk or in steel drums and are responsible for around 90% of lubricant sales (AASTE, 2004). 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 total around 60 ML per year in Australia (AASTE, 2004).

3.2 USED OIL REPROCESSORS – WESTERN AUSTRALIA

Used oil is generated from the use of lube oils. Different types of use generate different volumes of used oil. Some uses such as brake fluids and marine oils consume all of the oil while for other uses varying proportions of the oil are recovered. In the *Independent Review of the Transitional Assistance Element of the Product Stewardship for Oil Program (2004)* report the potential generation of used oil is calculated as around 52% of lube oil sales, however the report continues ‘A figure of 55% is anecdotally quoted as the best recovery that can be expected’. **Table 3.2** shows the percentage of used oil generated by each lubricating oil product sector.

Table 3.2: Lubricating Oil – Percent of collectable Used Oil Generated by Product Sector.

Lube Oil Type	Percent of collectable Used Oil Generated
Gasoline Engine	60%
Diesel Engine	60%
Transmission Fluids	80%
Gear Oils	80%
Specialty Oils	0%
Brake Fluids	0%
Aviation Oils	90%
Marine Oils	0%
Railroad Oils	40%
Industrial Gear Oils	75%
Industrial Hydraulics	50%
Metalworking Oils	20%
Other Industrial e.g. Transformers	61%
Greases	0%
Process Oils	0%
Basestocks	60%

Source: AATSE, 2004

3.2.1 ‘Collectable Oil’

‘Collectable Oil’ is defined as the potential quantity of used oil that is available for reprocessing after it is consumed and combusted through it use. Using the volumes of lubricating oil sales in Western Australia in 2005/06 of 66ML and the theoretically ‘best recovery rate’ of 60%[3], the estimated maximum quantity of ‘collectable’ used oil that could have been recovered in Western Australia is

[3] The percentage of ‘collectable’ oil varies with different organisations and bodies between 52%-60%. 60% was selected for this report as this is the figure used by the Oil Stewardship Advisory Council (OSAC).

estimated to be 39.6ML. The actual figure of used oil collected in Western Australia during 2005/06 was 37.181ML (DEC, 2006). This would suggest that 94% of 'collectable oils' are being collected in Western Australia, however the accuracy of this figure could be questioned as at the point of collection, waste oil may contain significant quantities of water (water is reported to be up to 10-12% of collected used oil (AATSE, 2004)) and other contaminants. Oily waters are a common type of industrial waste.

Another factor that questions the strength of the collected figure are the results of a survey commissioned by the Federal Government that found that one in three households have motorists who change their own vehicle oil, and nearly half of those people inappropriately dispose, store or reuse the oil (AATSE, 2004).

Having stated the concerns about this information, it should also be stated that this level of used oil collection is excellent when compared with the average for Australia, and other Countries and regions, as shown in **Table 3.3**.

Table 3.3: Used Oil Consumed, Collectable and Collected

	Unit	Consumption	'Collectable' Oil (based on 60%)	Oil Collected	% Total Oil Collected	% 'Collectable' Oil Collected
Western Australia[4]	ML	66.000	39.600	37.181	56%	94%
Australia[5]	ML	564.100	338.500	183.500	33%	54%
France	Tonnes	841,356	504,814	242,500	29%	48%
Germany	Tonnes	1,032,361	619,417	460,000	45%	74%
Sweden	Tonnes	142,814	85,688	61,786	43%	72%
U.K.	Tonnes	840,834	504,500	352,500	42%	70%
European Union	Tonnes	4,820,130	2,892,078	1,776,044	37%	61%

Source: All non-Australian data from OECD, 2006 based on 2002 data

[4] Source: ABARE, 2006

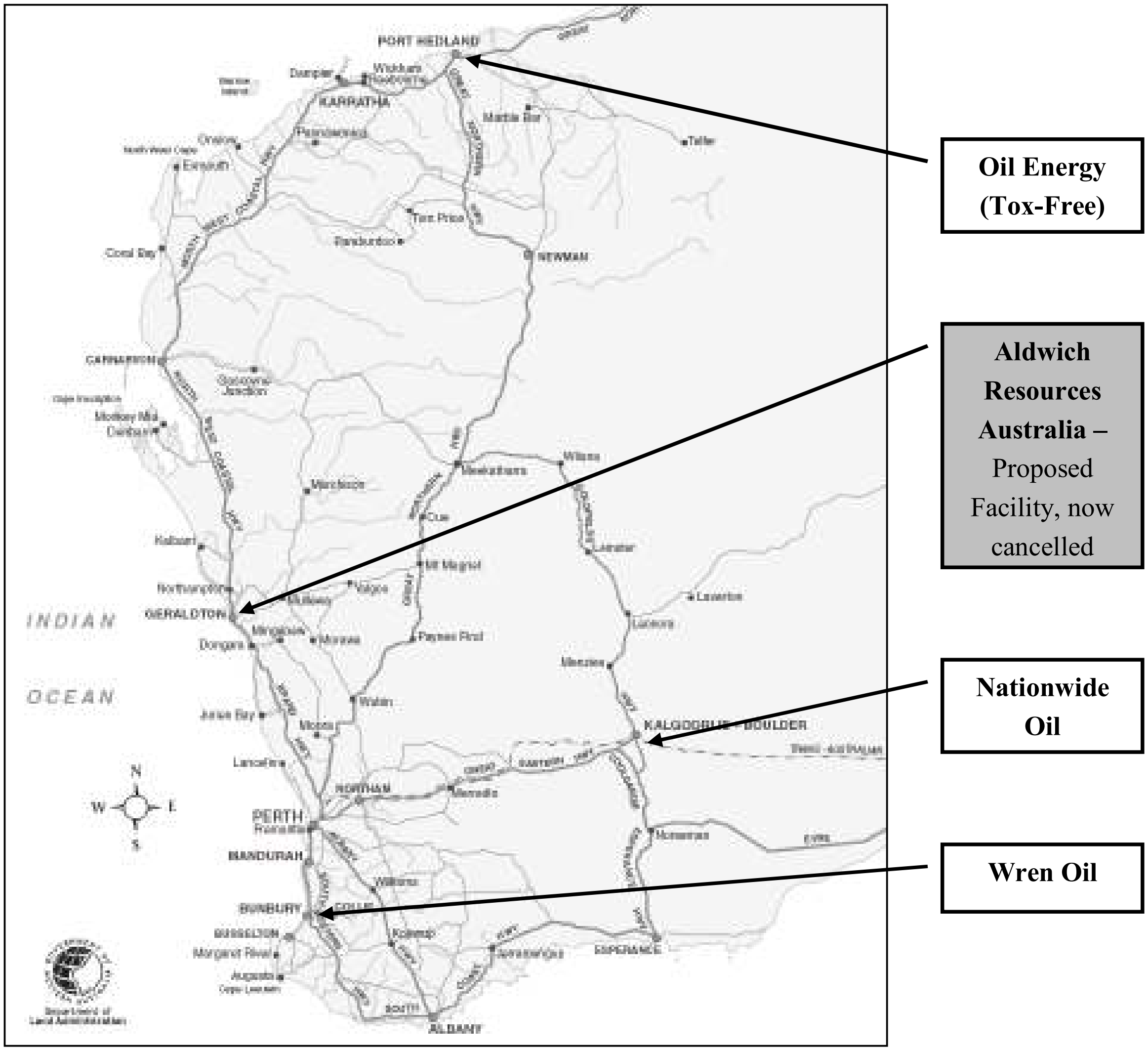
[5] 2002 data, source: Commonwealth Department of Industry, Tourism and Resources

The used oil industry in Western Australia comprises three companies operating within the State and a fourth company whom has recently decided not to establish a facility in Western Australia:

- Wren Oil (Picton)
- Nationwide Oil (Owned by the Transpacific Industries Group) (Kalgoorlie)
- Oil Energy Corporation (Owned by Tox-Free Ltd) (Port Headland and Kwinana)
- Aldwich Resources Australia were considering the development of an oil cracking plant for used oil that would be sited in Geraldton, WA.

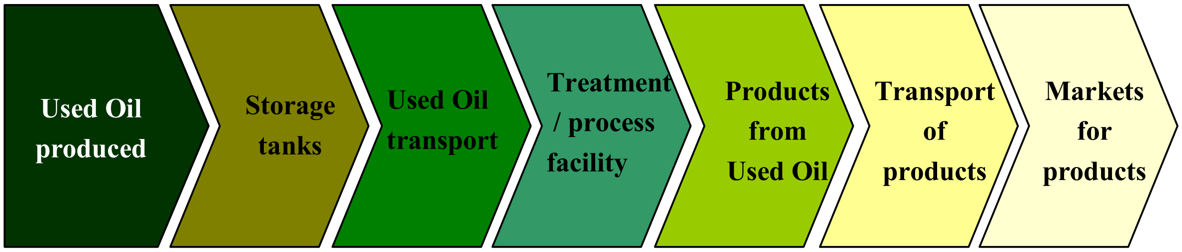
The locations of used oil collection and/or reprocessing companies are shown in **Figure 3.5**. These companies have all been contacted or visited as part of this project and a more detailed description of their services in included later in this Section.

Figure 3.5: Location of Used Oil Reprocessing Facilities in Western Australia



The used oil industry provides a complete service starting with the supply of used oil storage tanks, through to the production of products ready for the appropriate market. Some operators are expanding along the supply chain by exploring the development of technologies and markets with other companies to secure a demand for their products. Some operators are only active within a section of the supply chain, for example, Tox-Free only provide a collection and basic treatment process before Nationwide Oil collects the used oil for further processing into a marketable product. The used oil supply chain in shown in **Figure 3.6**.

Figure 3.6: The Used Oil Supply Chain



3.2.2 Wren Oil

Established in 1981, Wren Oil is based in Picton in the southwest of the State. Wren Oil services a wide variety of clients including car & truck mechanical workshops, service stations, earthmoving contractors, farms, local councils and mine sites. Wren Oil provide a collection service for the following materials:

- Used oil;
- Oil filters;
- Radiator coolants;
- Oily rags;
- Parts washers; and
- Oil interceptor waste

The process technology utilised by Wren Oil is Thin Film Evaporator re-refining. Products produced by Wren Oil using the TFE process include:

- Industrial Burner Oils;
- Chainsaw bar oil lubricant (own brand sold locally);
- Medium grade hydraulic oil (own brand sold locally);
- Mould oil - ideal for concrete pouring and prevents adhesion to the mould; and
- Degreasers

3.2.3 Nationwide Oil

Nationwide Oil is Australia's largest used oil collection and recycling company. As well as managing waste hydrocarbons and associated products, Nationwide Oil also produces industrial fuel oils and base lubricating oils; treats and disposes of industrial liquid wastes.

The Western Australian headquarters for Nationwide Oil is in Welshpool, however they have additional facilities in Kalgoorlie, Kwinana and Newman. Nationwide Oil service the mining, petroleum, manufacturing, power, automotive and food processing industries and include the collection and processing of materials such as:

- Used oil;
- Used oil filters;

- Oily rags;
- Oily waters;
- Coolants; and
- Grease traps and grease

Previously Nationwide Oil operated a batch process demineralisation plant in Perth, however this has been decommissioned and a continuous flow dehydration plant has been established at Kalgoorlie to produce furnace oil.

*3.2.4 **Oil Energy Corporation** (wholly owned subsidiary of Tox-Free Solutions Ltd)*

Tox-Free treats and manages a broad range of bulk liquid wastes including oily water and sludges, acids, alkalis, chromium wastes, heavy metal and organic wastes as well as other manufacturing process wastes. Unlike Wren Oil and Nationwide Oil, Tox-Free charge for any used oil collections that are requested. The used oil collected undergoes treatment to remove any water and the resulting used oil is collected by Nationwide for further processing.

Tox-Free have a thermal destruction (incineration) facility in Port Hedland. Any oil based wastes that are collected and taken to this facility are assessed for quality. Any used oils are collected by Nationwide for reprocessing, while lower quality oil based sludge's are combusted in the incinerator.

3.2.5 Aldwich Resources Australia

David Bowdan, of Aldwich Resources Australia (ARA), was contacted for this project. Mr Bowdan informed Cardno BSD that ARA wished to develop a Waste Oil to Diesel (WOTD) facility in Australia. The facility would process used oil using a thermal cracking process incorporating the ROBYS™ process to produce diesel. ARA had identified two potential sites for the facility; Gladstone, QLD and Geraldton, WA.

Great Northern Processing (USA), WATCO (Belgium) and Aldwich (Malaysia) already use this process. The main product would be diesel, however other by-products would include: gas, which is used as an energy source for the facility, Petrol and Kerosene (Naphtha) and Heavy fuel oil and 10-15% waste which is made up of water and coke.

NOTE: During the production of this report the authors received a letter from Mr Bowdan stating that Aldwich Resources had decided to stop the development of a Waste Oil to Diesel facility in Western Australia, as they were unable to secure sufficient volumes of used oil from Wren Oil or Nationwide Oil to operate the plant.

4. ANALYSIS OF USED OIL INDUSTRY

This Section of the report outlines an analysis of the environment and markets that the Western Australian used oil industry operates within. Three layers have been examined, firstly the macro-environment and the associated factors that influence the used oil industry, secondly the industry or sector for used oil in Western Australia, with particular focus on competition and barriers to entry for new entrants into the industry and finally the markets for used oil products are analysed, looking at segmentation, size and trends.

4.1 MACRO-ENVIRONMENT

This Section examines the macro-environmental influences that are affecting the used oil industry in Western Australia. **Table 4.1** summarises these influences into six main categories: political, economic, social, technological, environmental and legal. The key influences on the used oil industry are explained further in **Sections 4.1.1** to **4.1.6**.

Table 4.1: A Summary of Marco-environmental influences (PESTEL Framework)

POLITICAL • Stable political environment • Product Stewardship Arrangements for Waste Oil – Subsidies for different used oil based products • Levy on virgin oil • PSO Transitional grant scheme – provided collection facilities	**ECONOMIC** • Strong Western Australian economic activity • Low inflation • Low unemployment • High level of activity in resources sector • Increasing cost of transport fuel • Increasing cost of virgin oils
SOCIO-CULTURAL FACTORS • Increasing car ownership • DIY oil change and disposal by community • Small population base • Remote communities / used oil sources • Illegal disposal • Poor perception of recycled oils	**TECHNOLOGICAL** • Increasing service intervals for lubricating oils • Increasingly complex lubricating oils (e.g. synthetics) • Lack of lubricating oil refinery in Western Australia
ENVIRONMENTAL • High pollution potential from 'illegally dumped' used oil • Used oil classified as Hazardous Waste	**LEGAL** • Hazardous Waste (Regulation of Exports and Imports) Act 1996 Amended (Cwlth) restricts the exporting of 'waste' products • DEC Licence for treatment site • Controlled Waste Regulations for transport • Dangerous Goods Licence for Storage • ATO Excise regulations

4.1.1 Political

A key political influence on the used oil industry was the introduction of the Product Stewardship for Oil (PSO) legislative package that sought to achieve the objectives of the *Product Stewardship (Oil) Act 2000* to:

- Develop a product stewardship arrangement for waste oils;
- Ensure the environmentally sustainable management, re-refining and reuse of waste oil; and
- Support economic recycling options for waste oil

The PSO Program is underpinned by a regime of legislation and associated regulations. These include the:

- Product Stewardship (Oil) Act;
- Excise Tariff Amendment (Product Stewardship for Waste Oil) Act 2000;
- Customs Tariff Amendment (Product Stewardship for Waste Oil) Act 2000;
- Product Stewardship (Oil) (Consequential Amendments) Act 2000; and
- Product Grants and Benefits Administration Act

The core of the Program is the financial incentives introduced to promote product stewardship, including a product stewardship levy and benefits. The product stewardship levy on oils (currently fixed at 5.449 cents per litre) is applied to domestic and imported oils, and is paid by oil producers and importers. The product stewardship benefits are paid to recyclers of used oil as volume-based incentives to encourage oil recycling with improved environmental outcomes. In this way, the cost of encouraging recycling used oil is borne by producers and users of lubricating oils. Benefits are provided at different rates (**Table 4.2**), depending on the type of product produced.

Table 4.2: Product Stewardship (Oil) Act Benefit Categories

Item	Category	Benefit (cents per litre)
1	Re-refined base oil (for use as a lubricant or a hydraulic or transformer oil) that meets the specified criteria[6]	50#
2	Other re-refined based oils (e.g. chain bar oil, oils incorporated into manufactured products	10#
3	Diesel fuels that comply with the Fuel Standard (Automotive Diesel) Determination 2001, as in force from time to time	7
4	Diesel extenders: a: that are filtered, de-watered and de-mineralised b: that, if combined with diesel fuels, would produce a combined fuel that complied with the Determination mentioned in item 3	5
5	High grade industrial burning oils (filtered, dewatered and de-mineralised)	5
6	Low grade industrial burning oils (filtered and dewatered)	3
7	Industrial process oils and lubricants, including hydraulic and transformer oil (reprocessed or filtered, but not re-refined)	0
8	Gazetted oil consumed in Australia for a gazetted use	5.449
9	Recycled oil mentioned in item 5 or 6 that has been blended with a petroleum product that meets the criteria mentioned in Schedule 2[7]	9.557

Source: DEH, 2006a

[6]The regulations specify a health, safety and environment standard for re-refined lubricants that is comparable with the current required for similar 'virgin' products. The purpose of this standard is to protect users of re-refined products from exposure to carcinogenic components.

[7]Category 9 ceased as of 30 June 2006 - claims may still be submitted if the used oil was recycled and sold for use (or used by the claimant) prior to 30 June 2006.

Products in this category will be subject to the PSO levy.

Further information about the category definitions and additional benefits from the PSO Act are included in **Appendix C**.

Transitional financial assistance is provided to support the implementation of the product stewardship arrangements. The assistance is for strategic initiatives to stimulate the uptake of environmentally sustainable management and re-refining of used oil recycling and its reuse. The funding 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 program does encourage the development of markets for waste oil through benefits. Significant benefits ($34.5 million) have been provided to a range of schemes. By the end of 2003 approximately $6 million had gone toward collection infrastructure (AATSE 2004). However, the single largest grant ($1.3 million), excluding those made to State Governments, was disbursed for the capital costs of a re-refining plant (AATSE 2004). Other grants have gone toward "waste oil market development" projects.

4.1.2 Economic

The current strong economic activity in Western Australia has led to an increase in used oil volumes collected as reported by the States reprocessors. However, this is not reflected in the ABARE Australian Mineral Statistic Reports, which showed a decrease in lubricating oil sales in Western Australia for 2004/05 (see **Figure 3.3**). This suggests that the collection of used oils is becoming more efficient with less illegal disposal, rather than a general increase in used oil produced.

The increase cost of crude oil during the last few years also has an influence on the used oil industry. A negative factor is the increased fuel prices, which have a considerable impact on the collection costs of used oil from remote areas of Western Australia. However, a positive impact of the increased cost of crude oil is the knock on affect for the value of most oil-based products, including those manufactured from used oil. The price of lubricating oils is broadly correlated over time with crude oil prices, with a six-month delay (DETR, 2001).

4.1.3 Social

Of the social influences, key issues for Western Australia are the relatively small population base and distance from further markets to either provide used oil supplies or provide markets for the resulting products. The volumes of used oil generated in Western Australia are unlikely to increase beyond the influence of economic cycles, therefore the total volumes are relatively static and this factor may make some process technologies unviable in Western Australia due to insufficient volumes to achieve the required economies of scale.

A further key social influence is the poor perception of the quality of recycled lubricating oils. Buyers of base oils typically blend base oils with additive packages to achieve a consistent product that delivers specified performance attributes. These buyers are highly sensitive to the risk of using materials that may cause their own products to fail in use or for their own production process to be stopped as additive packages fall out of suspension. Moreover, lubricants offer performance-critical attributes for a value that is typically insignificant when compared to the equipment (motor vehicle or industrial equipment) it is protecting.

Downstream, buyers of lubricants are often reluctant to purchase re-refined oils based on the perceived risk of damaging their vehicle engine or industrial equipment. In reality, the quality of re-refined lubricants is equivalent and often better than the primary lubricants. This ethos undercuts the market and can persist for a considerable length of time, even if a strong technical case can be made for the equivalent quality attributes of re-refined oil, relative to lubricants manufactured from base oils derived from virgin crude.

Thus, re-refiners, who are almost always independent of oil refiners and lubricant manufacturers, sell their base oil and with it the negative connotations of waste. Risk aversion amongst buyers causes re-refined base oil to be directed into lower value markets. Typically, re-refined base oil attracts a price 20% to 25% below that which might have been expected for a product with similar viscosity and related features supplied by crude oil refiners (OECD, 2005). For instance, in Australia the base oil prices for a re-refined product are 10-12c per litre lower than for a virgin base oil of comparable specifications (AATSE, 2004).

The poor perception of the industry or 'risk aversion' practices exhibited by the base oil industry and lubricant buyers to re-refined oil have a large impact on the potential to market re-refined base oil. In an attempt to distance re-refined base oils from the association with poor quality, the Viscolube plant in Italy and the Puralube plant in Germany recently began shipping high quality oils manufactured from waste oil. The quality of the base oil is expected be superior to that produced in the majority of European refineries. It remains to be seen whether this strategy of exceeding expectations of technical standards amongst buyers is effective (OECD, 2005).

4.1.4 Technological

With the increasing complexity of lubricating oils, a wide variety of additives are added to base oils during the manufacture of lubricants. All of these additives provide benefits in terms of performance but can create difficulties for re-refiners. Technological externalities can reduce economic efficiency if the benefits (improved performance) are not as great as the costs (reduced recoverability). This can arise if incentives are not provided to ensure that the product designer does not take the downstream costs into account.

Some of the most problematic additives for re-refiners are chlorinated hydrocarbons and dithiocarbamates (containing lead and used as extreme pressure agents), polysulphides and several sulphur containing compounds that can cause emissions. Additives such as styrene butadiene (SBR) and styrene isoprene (SIP) are used in engine oils to provide shear stability appear in the waste from re-refining as asphalt or as a substitute for heavy fuel oils used in cement kilns (OECD, 2005).

If the costs associated with re-refining are not transmitted back up the product chain, it is possible that sub-optimal specifications for lubricating oil will be developed. As noted above, a technological externality results in sub-optimal design if the performance advantages associated with the additive are of smaller positive value than the negative values associated with reduced potential for re-refining. Indeed, it has been argued that minimum quality standards can be redrafted with a view toward increasing the potential for re-refining (AATSE, 2004).

4.1.5 Environmental

The most significant environmental impacts associated with lubricating oils almost certainly arise from illegal disposal. A survey commissioned by the Federal Government found that one in three households have motorists who change their own vehicle oil. It was found that nearly half of those people inappropriately dispose, store or reuse the oil. The amount of uncollected waste oil, in Australia, has been estimated to be in the region of 40-65 million litres (AATSE, 2004).

Thus, significant quantities of used lubricant are deliberately spilled on the ground or in surface waters. The extent of these illegal activities in Western Australia can be estimated by comparing the amount of waste oil collected with the amount that is potentially recoverable (**Table 4.3**). Approximately 2,400 ML of used oil was unaccounted for in 2005/06.

Table 4.3: Used oil consumed and collected in 2005/06

	ML
Oil Sold	66,000
Oil Recoverable (60%)[8]	39,600
Oil Collected	37,181
Oil Not Collected	**2,419**

[8] The percentage of 'collectable' oil varies with different organisations and bodies between 52%-60%. 60% was selected for this report as this is the figure used by the Oil Stewardship Advisory Council (OSAC).

The environmental impacts associated with illegal disposal are likely to be similar to those arising from the discharge of other oil products. These include:

- Pollute land, water and environment (one litre of oil can contaminate one million litres of oil);
- Harm to wildlife through depletion of the oxygen supply for fish and other aquatic life;
- Aesthetic and recreational impacts through contamination of surface waters;
- Loss of soil productivity and contamination of groundwater; and
- Human health impacts associated with the contaminants commonly found in waste oils

Therefore, if the objective is to minimise the risk of environmental damage, maximising the collection of the recoverable proportion of lubricants should be a priority. In the case of used oil, the threat presented to water resources by just a few litres demands attention.

4.1.6 Legal

There are a number of legal and regulatory measures that the used oil industry must comply with, however the Hazardous Waste (Regulations of Exports and Imports) Act 1996 Amended (Cwlth) (the Act) and its restrictions on the exportation of 'waste' products has a significant impact on Western Australian used oil processors. The main purpose of the Act is to regulate the export and import of hazardous waste to ensure that hazardous waste is disposed of safely so that human beings and the environment, both within and outside Australia, are protected from the harmful effects of the waste (DEH 2004)

The Act is also the response of the international community to the problems caused by the annual worldwide production of tonnes of wastes, known as the Basel Convention. This global environmental treaty regulates the trans-boundary movements of such wastes and obliges parties to the convention to manage and dispose of the wastes in an environmentally sound manner.

Currently, the Hazardous Waste (Regulations of Exports and Imports) Act 1996 Amended (Cwlth) (the Act) defines a number of the products manufactured from used oils as 'wastes'. This puts restrictions on the exportation of these ‘products’ outside Australia. Used oil is permitted to be exported overseas if it can be demonstrated that the final disposal operation is not landfill or incineration. Shipments of used oil that are destined for resource recovery or recycling including energy from waste (not direct incineration) are permitted provided certain conditions are met. Waste shipments can only take place between countries which are parties to the Basel Convention.

There is a demand for used oil products in Asia. The domestic market for the used oil products stockpiled in high quantites, such as burner fuel are declining within Western Australia, therefore if the markets in Asia could be accessed this would provide the demand required for the current over supply.

4.2 INDUSTRY ANALYSIS

This Section examines the used oil industry in Western Australia, with particular reference to switching costs and barriers, which restrict entry into the oils market. **Figure 4.1** summarises these influences and lists them in terms of potential entrant to the industry, the power of suppliers and buyers and the threat of product substitution.

Figure 4.1: Industry Analysis and Source of Competition (Porter's Five Forces Framework)

Potential Entrants

- Approximately $6 - $8M to establish a lube-to-lube reprocessing facility (Nationwide Oil, per comm.)
- Alternatively $20M – $40M to establish lube to lube facility (UK DETR, 2001)
- High capital investment for any used oil reprocessing facility
- High capital investment to establish collection network and haulage fleet
- Economies of scale (step up costs for infrastructure)
- Relatively technical processes
- Controlled Waste regulations for transport of used oils
- Significant experience with existing used oil recyclers
- Specification testing costs for lubricating base oil products ($500,000)

Suppliers

- Many points of supply, e.g. Local Government, Agriculture, Resource Industry, Motor Industry. So no concentration of suppliers
- Used oil collected at zero cost
- Some collection tanks provided by used oil recyclers
- Some used oil suppliers will give oil to any collector that 'turns up'
- Some long term contracts or service agreements in place between collectors and suppliers
- No alternative sources of supply
- To collect used oil required extensive tanker fleets to provide the service

Competitive Rivalry

Buyers

- Concentration of buyers, e.g. steam and hot water generators, brickworks, hothouses, foundries, cement kilns, power stations.
- Pressure from alternative products, e.g. LPG displacing used oil in power stations.
- Barriers to accessing overseas markets
- State wide demand decreasing
- No lubricating oil refineries in Western Australia
- Eastern state markets supplied by local reprocessors
- Used Oil products perceived as 'waste', so feel that the product should be cheaper than 'non-waste' alternatives

Substitutes

- No threat from used oil imports (i.e. product for product substitution)
- Lubrication market dominated by virgin oil based products, and demand per vehicle is reducing with increased service periods and use of synthetic oils (i.e. substitution of need)
- Burner markets shifting to LPG as alternative to used oil based burner oils leading to a reduction in demand (i.e. product for product substitution)

4.2.1 Power of Suppliers and Buyers

These two forces can be considered together as they are linked. The used oil industry, like many 'waste' industries, cannot easily control the supply of raw materials, in this case used oil. The oil is always available as a 'waste' product and the two main Western Australian reprocessors provide a free collection service for used oil producers. The collection arrangements from the many different sources can be formal in terms of a contractual arrangement; some are linked to a reprocessor due to the provision of collection tanks, while other used oil producers will provide their oil to any collection vehicle that arrives.

The buyers of used oil derived products are limited, depending upon the product. Demand is highest for high and low grade burner fuel within Western Australia. Used oil based products are perceived as 'waste' so the buyer believes that the product should be cheaper than 'non-waste' alternatives.

4.2.2 Threat of Substitution

The used oil industry is experiencing a threat of substitution for the burner fuels, as natural gas and LPG are increasingly being utilised as an alternative product. This is directly impacting on the demand for a significant product line that is produced by the two main used oil reprocessors in the State. A less significant threat is from the increasing service intervals for motor engines, the implications of which could lead to a reduction in used oil that is available for collection. Environmentally, this is a good outcome, however for the used oil industry it could lead to a reduction in supply of raw material from a major sector.

4.2.3 Potential Entrants

Incumbents seek to protect their market position and since volume growth in the used oil industry is small, it is suppliers and buyers of the incumbents who must switch to the entrant. The capital cost for the collection and processing infrastructure to reprocess used oils is significant. If the entrant (e.g Aldwich Resources) wished to compete with the existing used oil reprocessor in Western Australia, there are significant barriers that would need to be overcome to secure both the large volumes of used oil required to make any reprocessing viable and the market for the resulting products e.g. burner fuel. An entrant would only be successful at the expense of the existing operators.

If an entrant wished to re-refine used oils to produce a base oil that can be used to produce lubricant, the minimum efficient scale of 60,000 tonnes would be required (OECD, 2005). This presents a major challenge in any market, particularly in Western Australia, as this equates to the approximate total potential generation of used oils. Once production starts, the existing market will need to accommodate the new source of supply. The existing vendors are typically large integrated oil companies who can respond to the new competition from re-refiners.

Faced by competition from virgin oil refiners, re-refiners are susceptible to a short-term change in pricing policy from such large-scale incumbents. A reduction in the price of base oil for 12 months may be sufficient to undermine the profitability of any new re-refining plant. This is of course, a risk that investors will consider and value in the cost of capital. (ACG, 2004).

Moreover, before the re-refinery is able to sell re-refined base oil to the engine oils market, a sector that forms approximately 50% of lubricant demand, the oil must meet international quality specifications (i.e. Society of Automotive Engineers or American Petroleum Institute specifications). Testing costs are typically $500,000 and since the scale of re-refining plants is less than 60,000 tonnes output annually, these costs can form a significant barrier to investment, and thus market entry.

The re-refiner must meet the testing costs without certainty of success in selling the output to a mature and risk-averse market. The product tests cannot be carried out until the re-refining plant has been made operational. Furthermore, as the tests require at least several months to complete, the base oil output will have to be sold to alternative markets. This can increase the opportunity cost of testing (OECD, 2005).

Frequent changes to engine oil standards also make it more difficult for re-refiners to enter this market. However, API (American Petroleum Institute) base oil inter-changeability guidelines permit up to 10% of base oil to be substituted without requiring a re-test. This offers re-refiners an opportunity to sell to independently owned blenders. In practice, this market is constrained by the risk that competitors will inform customers that waste oil sources are being used in certain branded lubricant products (OECD, 2005).

4.2.4 Competitive Rivalry

Considering the forces outlined in **Sections 4.2.1** to **4.2.3** above, the following key forces and issues shape the competitive rivalry of the used oil industry in Western Australia. Two companies, Nationwide Oil and Wren Oil, dominate the industry and exhibit high level of competition because:

- Within Western Australia these companies reprocess a similar volume of used oil and are in balance, with neither company being a dominant player within the State (However, Wren Oil is a State based company, while Nationwide Oil has a range of used oil facilities in the Eastern States and is part of the Transpacific Industries Group).

- Both of these companies offer a similar collection service and reprocess used oil to produce a range of products, but with burner fuel as the predominant product by volume. Neither of these companies re-refine used oil to produce base oil for lubricant manufacture on a large scale. Therefore both companies compete directly with each other, as there is little differentiation in service or products.

- The supply of raw material (used oil) is finite. Although collection volumes are increasing, there is only small growth in the use of lubricating oils, so there is little scope with either company to increase its volumes of throughput without it impacting upon its competitor.

- The local market demand for the products (burner fuel) is decreasing within Western Australia

When this high level of competition is combined with the high capital investment required to collect and process used oil in Western Australia, there are significant barriers of entry for an additional company to enter the industry. For a company to successfully enter this market it is likely that it would:

- Need to differentiate their collection service or collaborate with an existing operator to gain access to a supply of used oil, and
- Produce alternative products which had a market demand, rather than compete within the domestic burner fuel market.

4.3 USED OIL PROCESS TECHNOLOGIES

Processing (or reprocessing or reclaiming) used oils can utilise a number of technologies. The processing removes contaminants and separates the used oils into separate products. Most industrial oils contain up to approximately 2–5% of additives to enhance the performance of the lube oils. Mostly they involve antioxidants, wear protection additives, and de-foamants to extend the life of the oils and enhance performance. The process technology involves:

- Removal of water and heavy sediment by settling;
- Removal of particulates by filtration; and
- Separation of oil by refining

Some processes remove water light fuels and chlorinated solvents by distillation, centrifugation, or use chemical treatment to break emulsions or reduce content of ash and sulphur. Processed products can be marketed as burner fuel oils to asphalt plants, industrial boilers, utility boilers, steel mills, cement kilns, power stations, and commercial boilers (US Department of Energy, 2006).

A range of the process technologies, together with product specification and PSO subsidy received are shown in **Table 4.3**. The existing and potential used oil processors based in Western Australia are labelled with the process technology they utilise. A number of process technologies are available to manufacture products of different specification. Rather than one process being defined as the ‘best option’, it is the process cost and market demand for the product that defines the economic viability of the process and therefore the ‘best option’. The typical specifications for the products saved from each process identified in **Table 4.3** are presented in **Table 4.4**.

Table 4.3: Typical Used Oil Process Technologies, Products, Wastes and Markets

Product (Users)	Process	Wastes Produced	Typical Markets	PSO Category	Benefit	Specification Code
Filtered & Dewatered	Used oil is collected, strained and free water drained off the bottom.	Oily water and solids colleted in strainers (typically strained to 40 mesh)	Feedstock for other recyclers for further processing, large industrial users, cement industry, smelters, small applications such as hydroponics, brick kilns and light industry.	6	3c/L	(a)
Filtered, Dewatered and Dehydrated **(Nationwide Oil)**	Follows the processing described above, the used oil is then dehydrated by applying heat to achieve a water content <1%. The product can be filtered to a low as 10 microns	Oily water and solids are collected in strainers, spent filter cartridges.	Typically sold to larger industrial users as an alternative fuel.	6	3c/L	(b)
Demineralised	Used oil is collected and then tested for compatibility for demineralisation 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 (approximately 1% of volume treated)	Typically sold to Power Stations & small industrial users with limitations on emissions.	4 & 5	5c/L	(c)
Base Oil **(Wren Oil)**	Thin Film Evaporation, Propane De-asphalting and Vacuum Distillation are all processes used to produce base oils, diesel and bituminous bottoms.	Oil water and solids collected in strainers, spent filer cartridges and heavy bituminous bottoms (although these can be used in Cement Kilns as an alternative fuel)	Typically sold to Power Stations & small industrial users with limitations on emissions.	3[#], 4 & 5	7 & 5c/L	(d)
Thermal Cracking & Diesel Recovery **(Previously proposed by Aldwich Resources)**	Oil is subjected to pyrolysis using high temperatures to manufacture diesel.	Oil water and solids collected in strainers, spent filer cartridges and inert char bottoms (although these can be used road base)	Can be used as diesel fuel and also as a fuel oil.	3[#]	7c/L	(e)
Re-refined	Micro filtration to remove contaminants. The oil is then analysed and additive are topped up to meet specification	A small percentage of waste is generated and this is usually dealt with as used oil.	Hydraulic oils, turbine oils. Some small applications such as chain bar oil	2	10c/L	(n/a)
Re-refined lube to lube	Thin Film Evaporation, Vacuum Distillation and are all processes used to produce base oils which are further refined using either solvent washing or hydrogenation.	Oil water and solids collected in strainers, spent filer cartridges and heavy bituminous bottoms (although these can be used in Cement Kilns as an alternative fuel).	Various users that can market re-refined lubricant oils.	1 [9]	50c/L	

Source: AATSE, 2004. Based on information in the report provided by Nationwide Oil and BHP LCA Report (2000)

[9] Product must conform to Department of Environment and Water Resources acceptance criteria for Base Oil to be entitled to category 1 benefit payment

[#] For a product to fall in the Category 3 – the Diesel Fuels must comply with the Fuel Standard (Automotive Diesel) Determination 2001, as in force from time to time.

Table 4.4: Typical Specifications for Products

Parameter	Process (see Table 4.3 above)				
	(a)	(b)	(c)	(d)	(e)[6]
Water % w/w	10% - 15%	< 1%	< 1%	< 0.01%	< 0.01%
Viscosity cst @ 40°C	70 -100	70 -100	70 -100	40 - 80	4 - 6
Density @ 15°C Kg/L	0.89 – 0.95	0.89 – 0.95	< 0.9	0.87 – 0.88	0.85 – 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

Source: AATSE, 2004. Based on information in the report provided by Nationwide Oil

[10] Refers to typical diesel products not necessarily from thermal cracking

4.3.1 Technology Gaps

The technology currently used in Western Australia for the recycling of used oils is designed to either create an alternative burner fuel for small and large industrial furnaces or smaller burning operations such as the hydroponics industries. No oil is refined to a grade that can be used for PSO Category 3 diesel fuel or PSO Category 4 diesel extender (fuel with a similar composition to diesel to extend the life of virgin diesel). Small quantities of PSO Category 2 lubrication fluid (for chainsaws) are produced by Wren Oil.

Diesel producing technologies such as thermal cracking and wiped film evaporation are a possible avenue, however the proposed Aldwich Resources thermal cracking plant could not source enough used oil to make the plant viable due to Aldwich Resources being unable to come to an agreement with Wren Oil or Nationwide Oil to source their used oil. Lube to lube technology, the other possible technology gap, may also have the problem of not being able to source enough material. However, Wren Oil is looking to develop this technology in the future to increase and diversify its markets.

Research into new methods of re-refining 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 (ATTSE 2004)

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 to energy in bioreactors has also been claimed and represents a process, which is very attractive from an environmental aspect (AATSE, 2004).

4.3.2 Commercialisation opportunities in Western Australia

Commercialisation opportunities in regards to other products produced in the used oil re-refining process include the wastes produced in the process. Heavy bottoms, a bitumen like material, is one of the products from reprocessing units and has traditionally been expensive to store and dispose of. The Wren Oil TFE process produces heavy bottoms, and Wren Oil is now looking into possibly blending the material with modified or multi-grade bitumen. Some concerns need to be resolved including the possibility of fuming on application and leaching from the road asphalt.

4.4 USED OIL COLLECTION AND PROCESS COSTS

Table 4.5 is based upon a table from the *Independent Review of the Transitional Assistance Element of the Product Stewardship for Oil Program* Report (AATSE, 2004) and provides a summary of used oil products by benefit category with typical collection and processing costs and product selling values. The values have been modified to reflect 2006 costs and values.

Table 4.5: Used Oil Costs, Benefits and Sales Prices

Product	Collection Cost	Process Cost	Total Cost	Benefit Rate	Sales Price		
					Low	High	Typical value
	Cents per litre						
Lube Base Oil	22	43[11]	65	50	n.a	n.a	59[12]
Other Base Oil	16	27	43	10	n.a	n.a	n.a
Diesel Fuel	16	27	43	7	38	43	43
Diesel Extenders	16	27	43	5	n.a	n.a	n.a
High Grade Burning Oil [13]	16	27	43	5	30	43	38
High Grade Burning Oil [14]	16	16	32	5	30	43	38
Low Grade Oils	11	3	14	3	16	22	22
Other Oils [15]	11	0	11	0	11	22	16

Source: AATSE, 2004

NOTE: The values quoted in the AATSE report have been increased with inflation to reflect 2006 values, based upon 4 per cent increase per annum

[11]Costs associated with lube base oil production are detailed in **Section 7.1**

[12]Base oil prices for re-refined product can be as much as 11-14 cents per litre lower than for virgin base oils of similar specification.

[13] HG Burning Oil produced from Thin Film Evaporation (TFE) (e.g. Wren Oil) and Propane de-Asphalting (PDA)

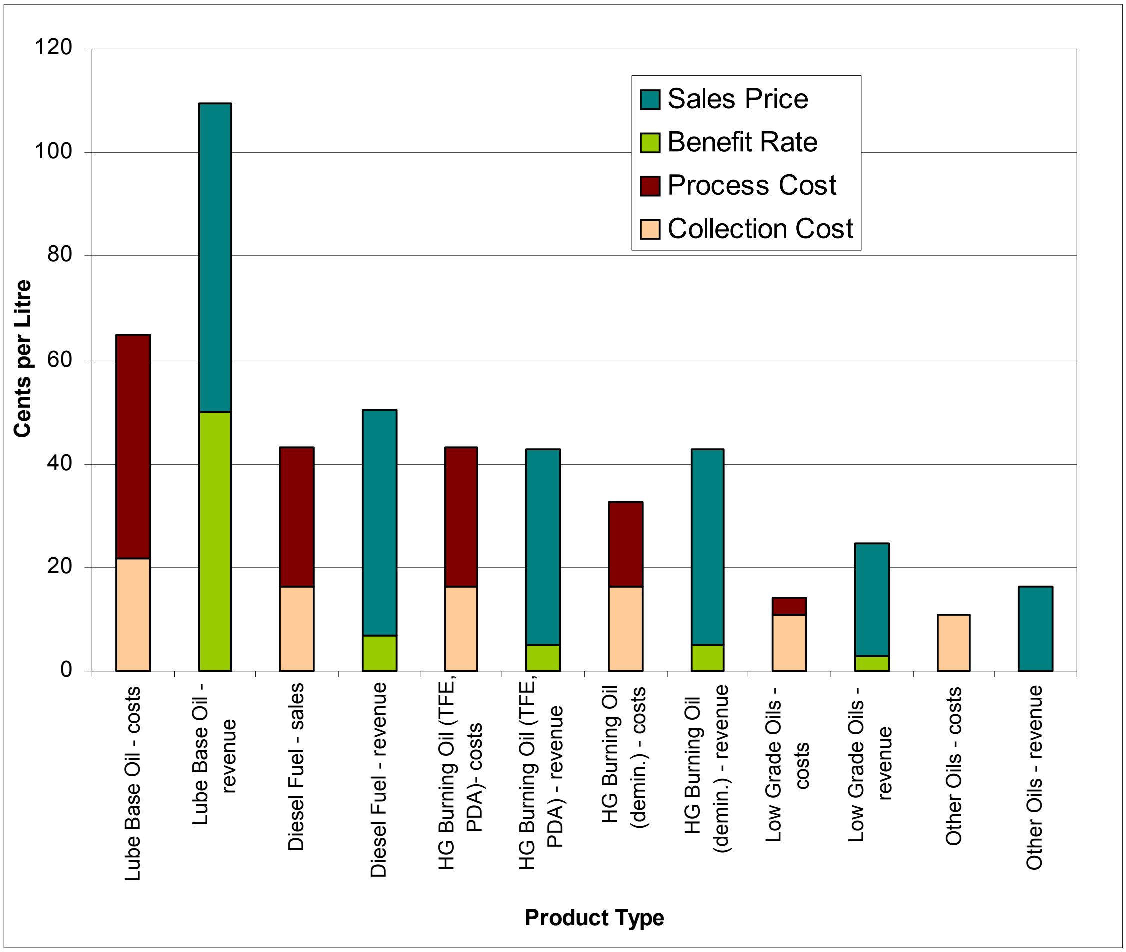
[14] HG Burning Oil produced from Demineralisation

[15] Low Grade Oil, including oil bottoms from TFE and PDA processes, when sold to cement kilns attracts prices below 11 cents per litre and in some cases a charge is made for disposal.

Based upon the consultation with stakeholders in the used oil industry in Western Australia, the transport costs for the collection of used oil range between 5c – 16c per litre with a typical cost of approximately 7c per litre.

While these are only broad ‘typical’ figures, they do provide an insight to where the cost pressures exist. As shown in **Figure 4.2** the difficult area for profitable operation is for High Grade burning oil products 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 (AATSE, 2004).

Figure 4.2: Used Oil Typical Costs and Revenues



NOTE: Care should be taken not to draw conclusions about the profitability of used oil processing types based upon this data. The sales and benefit revenue shown are for the highest value product produced by each process. Each process also produces a number of other lower value products and these would command a lower sales price and benefit payment, while still incurring the same collection and processing cost.

5. ENVIRONMENTAL IMPACT OF PRODUCTS AND MARKETS OPTIONS

This Section of the report aims to develop a hierarchy for the end markets for used oil based products, in terms of the environmental cost and benefit for each option. For example, does lube-to-lube recycling provide a better environmental option than the production and use of high-grade burner oil in cement kilns? In order to develop the hierarchy, a number of previous Life Cycle Assessments (LCA) reports have been reviewed and the results collated.

A LCA is a systematic technique for identifying and evaluating the potential environmental benefits and impacts (use of resources, human health, ecological consequences) associated with a product or function throughout its entire life from extraction of raw materials to its eventual disposal and assimilation into the environment. A LCA helps to place the assessment of the environmental costs and benefits of these various options (US Department of Energy, 2006).

Three reports have been reviewed; these include the U.S. Department of Energy Report (2006), the Independent Review of the Transitional Assistance Element of the Product Stewardship for Oil Program (2004) and the OECD – Improving Recycling Markets Report (2005). These reports include assessments from 10 previous LCA studies, four from Australia / New Zealand, five from Europe and one from the U.S.

The life cycle assessments (LCA) that have been reviewed mainly focus on the following scenarios:

- LCA of used oil compared to virgin product;
- LCA of combustion of burner oil compared to refining; and
- LCA of different oil refining technologies

Within each of these scenarios the studies focus on five main environmental problems, namely:

- Resource energy;
- Greenhouse gas (GHG) emissions ;
- Acidification;
- Wastewater; and
- Solid waste

However, some studies go into more detail and name, eutrophication, volatile organic compounds (VOCs) and eco-toxicity as important environmental problems.

The environmental impacts from used oil products depend upon the product produced and the application where the product is used. The products range from untreated used oil, to high-grade burner oil and re-refined lube base oil. While applications, especially for burner oil depend upon the level of emission controls that a consumer may have. Both of these aspects need to be considered when developing the environmental hierarchy.

5.1 APPRAISAL OF MARKET OPTIONS

The market options are compared in the sub-sections below.

5.1.1 Used Oil compared to Virgin Resources

The LCAs that compared the use of used oil instead of virgin resources concluded that all used oil products are of environmental benefit over the extraction of fossil (coal, oil and gas) or non-fossil (hydroelectric and nuclear) fuels (Taylor, Nelson Sofre Consulting, 2001). Essentially stating that the use of used oil based product is a better environmental options that any other virgin resource.

5.1.2 Burn Dirty (small scale burners) compared to Clean Burn

Oil re-refining (lube-to-lube) and combustion of treated used oils, is more environmentally beneficial than the combustion of un-treated used oils without pollution controls. There are high health and environmental implications for “burn dirty” operations as emissions from these units (e.g. space heaters) can create local high concentrations of heavy metal containing particulates due to limited dispersion characteristics (U.S. Department of Energy, 2006). Even if pollution controls could eliminate 99% of the emissions, they would still be higher than industrial “clean burn” consumers (Boughton, 2004).

5.1.3 Clean Burn compared to Re-refined Lube Base Oil

A number of studies have been undertaken which compare the environmental impacts of incineration and lube-to-lube re-refining to base oil. Whilst the environmental benefits of clean burn (i.e. high grade burner oil) and re-refined lubricant oil markets is clear over “dirty burn” markets, it is far more complicated when it comes to judging whether the production of high grader burner oil or re-refined lube base oil is more beneficial.

Studies by the French Environment and Energy Management Agency (ADEME, 2000) reported that the combustion of used oil was the best method of re-use in regards to the environment (without an improvement in re-refining technology), especially when coal was substituted for used oil. While studies from the Institute for Energy and Environmental Research (IFEU, 2005) indicated lube-to-lube re-refining and combustion markets both have environmental benefits, the level of benefit depended upon the type of fuel that was substituted. For the majority of impact categories, regeneration is shown to be more beneficial than direct burning. A study from Norway (1995) indicates that the lube-to-lube re-refining of oils, when fuel and electricity is used as a substitute, is the best environmental outcome.

5.2 APPRAISAL OF PROCESS TECHNOLOGIES

Research undertaken into used oil processing technologies by BHP Billiton (2000), exhaustively analysed 12 re-refining processes, broken into product, categories, and their environmental impacts in relation to resource efficiency, greenhouse gas emissions, acidification, wastewater and solid waste (**Figure 5.1**).

Figure 5.1: The Production of 1GJ (26L) of re-refined oil using a range of current technologies

Product	Process	Resource Energy (MJ)	GGE (kg CO2-e)	Nox (g)	Sox (g)	Waste Water (l/GJ)	Solid Waste (kg/GJ)
Burner Fuel	Unprocessed	5.2	0.4	4.2	0.4	0	0
	Dewatering	61.4	4.7	70	15.8	1.7	0.4
	Demineralisation	21.8	1.6	18	1.4	3	0.9
	Thermal Cracking	71.4	5.4	21	11.2	2.1	1.6
	Wet Film Evaporation	65	4.3	14	6	1.2	N/A
Diesel Extender	Thin Film Evaporation	140	10.8	145	27.4	1.8	0.4
	Interline PDA	143	9.1	26	10.4	3.8	1.7
Diesel	Thermal Cracking	101	7.6	29	16.1	2.1	1.6
	Wet Film Evaporation	65	4.3	14	6	1.2	N/A
Lube Oil	Dewatering	70	6.3	48	21.1	1.8	0.4
	Precipitation Process	101	7.7	96	26.1	3.2	N/A
	Wet Film Evaporation	151	10	26	10.8	0.9	N/A

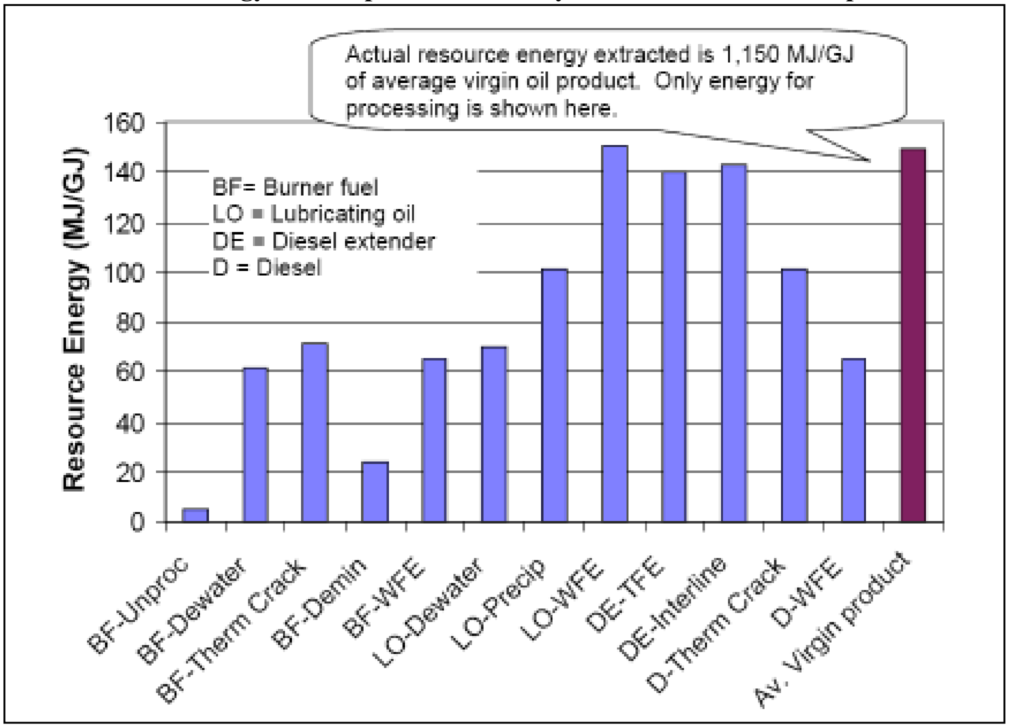
Source: BHP, 2000

This is the most relevant report in relation to Western Australia, as it is the only report that takes into account Australian conditions. The results presented by BHP should only be used as a guide and do not conclusively or accurately represent all processes currently used in Western Australia. One main drawback of the study was it did not take into account other environmental impacts such as heavy metals.

5.2.1 Resource Energy

Resource energy relates directly to the amount of virgin fuels that need to be consumed for the used oil processing to take place. It also relates to energy costs. All processes are more energy efficient than the production of virgin fuels when feedstock energy is considered. The demineralisation of used oil to produce burner fuel is the least energy intensive (21.80 MJ) whilst thin film evaporation when producing diesel extender is the most energy intensive (140 MJ). A graphical interpretation of resource efficiency is presented in **Figure 5.2**

Figure 5.2: Resource energy consumption for the recycled/re-refined used oil processes analysed



Source: BHP, 2000

5.2.2 Greenhouse Gas (GHG) Emissions

Greenhouse gases are contributing towards an increase in temperature around the globe and are recognised as having a large global environmental impact. GHG's are correlated with energy input as most energy production relies on fossil fuel consumption to allow the oil re-refining process to proceed, hence demineralisation (burner fuel) emits the lowest amount of GHG (~2kgCO_2/GJ), whilst thin film evaporation (diesel extender) is emits the largest amount of GHG (~11kgCO_2/GJ).

5.2.3 Acidification

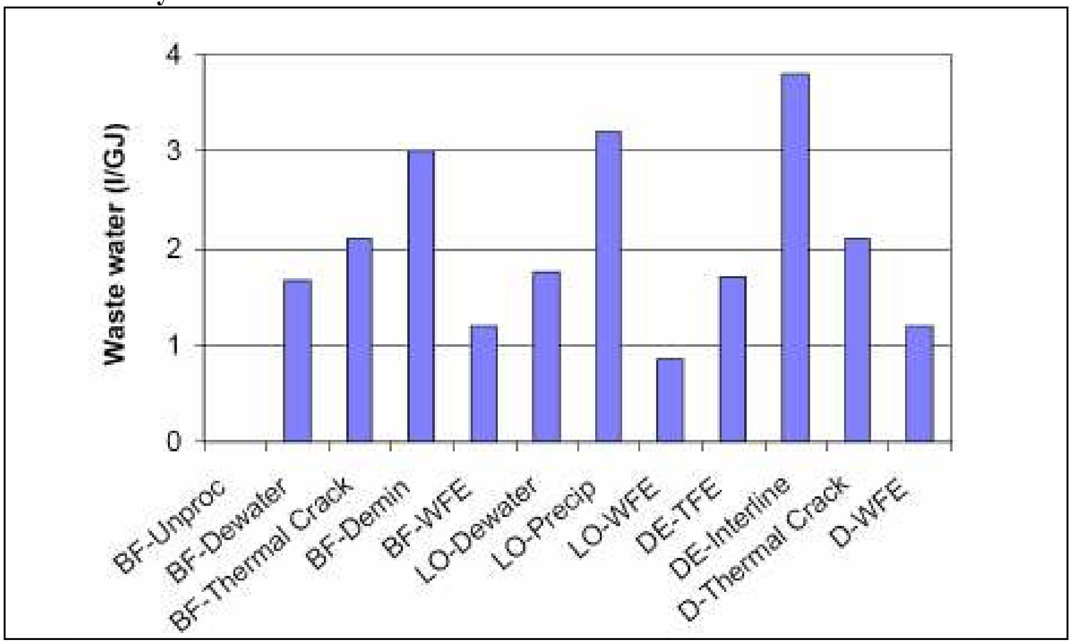
Acid Rain is caused by the release of NO_x and SO_x gases into the atmosphere and can cause severe damage to vegetation if pH levels in rainfall become too low. These molecules are released into the atmosphere in the re-refining process and are similar or much higher than emissions from the processing of virgin oil products. This is due to contaminants becoming established in the used oil after engine use. The TFE (diesel extender) process again has the highest concentration of NO_x, for all the sampled technologies (~0.14kg/GJ) whilst demineralisation (~0.02kg/GJ) and thermal cracking to produce diesel (~0.03kg/GJ) are the lowest of the technologies used in WA.

In relation to SO_x emissions, thin film evaporation produces the highest amount (0.027kg/GJ), whilst demineralisation produces the lowest (0.002kg/GJ). Thermal cracking to produce diesel extender (0.015kg/GJ) and dewatering producing burner fuel (0.015kg/GJ) create moderate emission levels.

5.2.4 Waste Water and Solid Waste

Whilst demineralisation is the best performing process used in West Australian process in regards to resource efficiency, greenhouse gas and acidification categories, it performs the worst for the wastewater (3l/GJ) and solid waste (0.9kg/GJ) categories. Thin film evaporation requires the least amount of water (1.8l/GJ) to generate diesel extender and produces the lowest amount of solid waste (0.4kg/GJ) out of the current processes used in Western Australia. A graphical interpretation of resource efficiency is presented in **Figure 5.3.**

Figure 5.3: Comparison of wastewater emissions for the recycled/re-refined used oil processes analysed



Source: BHP, 2000

5.3 USED OIL TECHNOLOGY HIERARCHY

All of the studies previously mentioned do not accurately represent the Western Australian used oil industry, these differences include:

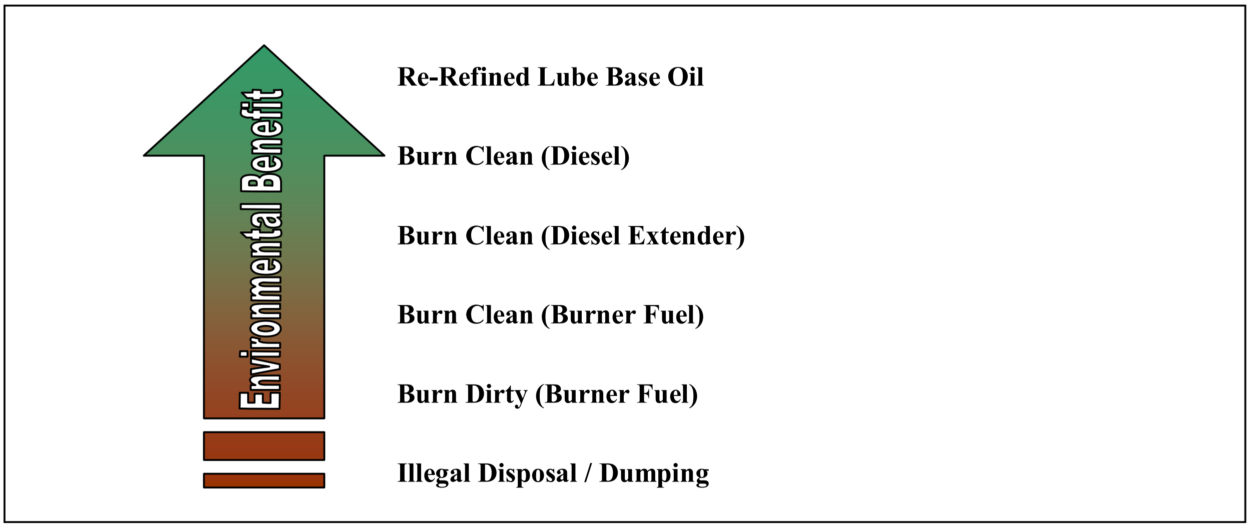
- The studies assess the combustion of the used oil without pre-treatment;
- The properties of coal used in Europe are different to those used in Western Australia; and
- No studies use natural gas as a substitute fuel

This makes it extremely difficult to determine whether combustion or lube-to-lube re-refining is the better option for the use of used oil in Western Australia. There is no consistency between studies, and data accuracy has been questioned in most cases.

All of the studies undertaken vary in their assessment of the environmental impact of each used oil product and / or process and are generally inconclusive. The environmental outcomes depend on the type of used oil processing utilised, the type of fuel being displaced and the scale and type of combustion plant being used by the consumer. This makes it difficult to find a conclusive product and / or process that provides the best environmental outcome.

Figure 5.4 below shows an approximate hierarchy relating to each used oil treatment process and product. Further investigation would be required to accurately quantify the environmental impact of the various processing technologies for used oil. However, the hierarchy below provides an approximate order for the processes.

Figure 5.4: Used Oil Technology Hierarchy



6. USED OIL MARKET ANALYSIS

During 2005/06, 66ML of lubricant oil and grease (ABARE, 2006) was sold in Western Australia. During the same year 37.2ML of used oil was collected (per comm. DEC, 2006) for processing. Once processed, the range of used oil based products are marketed to consumers. This section of the report summarises the current market situation of the Western Australian used oil processors and aims to identify any market trends and potential consumers for the used oil based products.

6.1 THE CURRENT SITUATION

Some of the used oil products produced in Western Australia are exported to other States for further treatment, and some products are exported overseas However, the majority are sold with in the State's domestic market.

6.1.1 Domestic Market

The key 'large volume' consumers of used oil based products in Western Australia are power stations, cement kilns and other industries such as brickworks that require fuel oil. In 2002, the OSAC Working Groups: Collections and Markets, estimated this market to be 28ML (AATSE, 2004). However, they pointed out that due to market changes, both power stations and cement kilns could reduce their demand for burner oil. Based upon the feedback from consumers for this report, the demand for burner oil is decreasing in Western Australia due to a number of concerns, barriers and alternative fuels. These are detailed in **Section 6.3** of the report.

Quantification of the market for used oil based products in Western Australia has proved to be elusive, as this information is commercially sensitive for the two key oil processors in the State, especially with the competitive nature of the industry. A number of potential consumers were contacted for each industry group, but the information provided did not reflect the State market when compared to the general information that the oil processors did provide. This does demonstrate that there are no 'easy' market opportunities for used oil products in Western Australia. The general feedback from the oil processors relating to domestic markets stated that while there are outlets for the majority of their products, there is already surplus product that requires storage.

6.1.2 Export Markets

The current export market for used oil products is very small. The oil processors feedback stated that there have been enquiries from overseas for burner oil and lube base oil. As lube base oil is not produced in Western Australia this option is currently unviable.

The increased transport cost to reach overseas markets would impact upon profitability when compared to local markets, but as a surplus of burner oil is currently being produced this may be an option rather than disposal. The key barrier to the export of burner oil is its classification as a hazardous waste, under the Hazardous Waste (Regulations of Exports and Imports) Act 1996

Amended (Cwlth) (the Act). The Hazardous Waste (Regulations of Exports and Imports) Act 1996 Amended (Cwlth) (the Act) prevents the exportation of waste between countries. Since 1996, considerable dialogue has already occurred relating to the exportation of used oil based burner oil and the barrier presented by the Act. Currently, the export of High Grade Industrial Burner Oil is restricted, however if it is blended with other fuels, such as decant oil (a by-product from oil refining), it no longer falls within the Hazardous Waste (Regulations of Exports and Imports) Act 1996 Amended (Cwlth) (the Act) and could be exported.

6.2 AUSTRALIAN MARKET TRENDS FOR USED OIL

The major markets for used oil in Australia include:

- Re-refined lube based oil;
- Diesel fuels;
- High Grade (HG) Industrial Burning Oils; and
- Low Grade (LG) Industrial Burning Oils

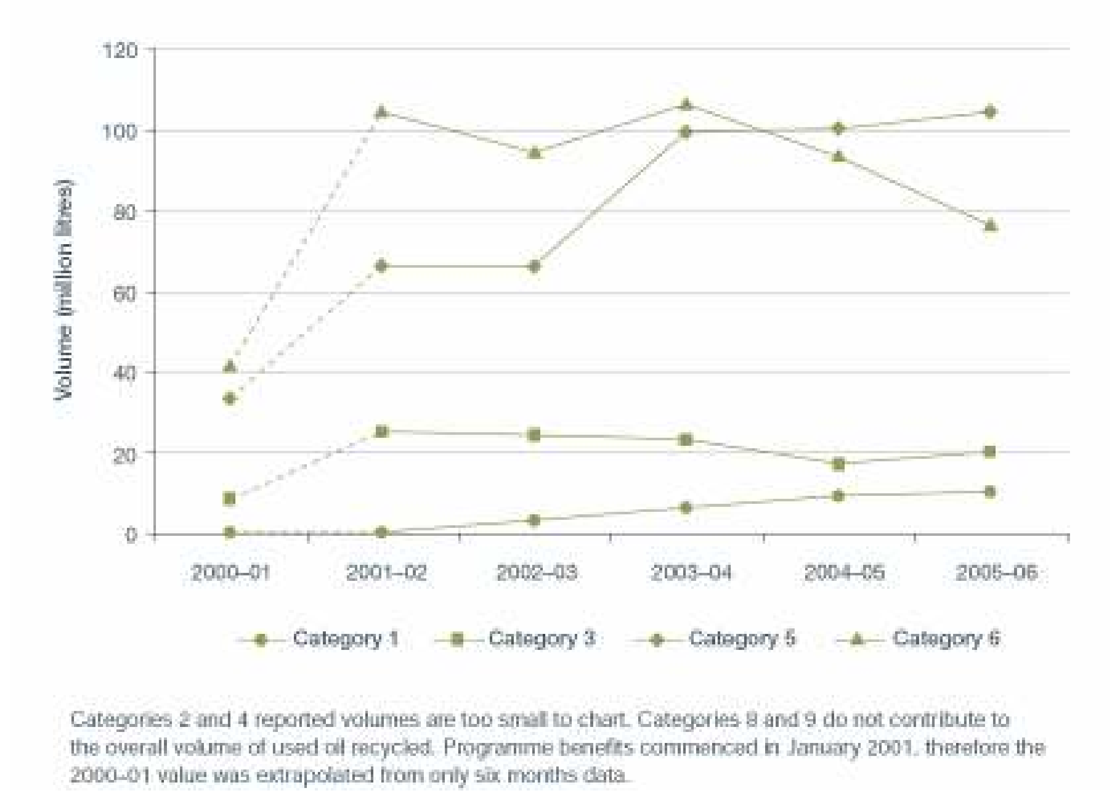
Figure 6.1 shows the annual volume (ML) of above-mentioned products since the Product Stewardship for Oil Program begun in 2001. The re-refined Lube Based Oils market (category 1) has had a very slow start and a slow increase over time. The Southern Oil Refinery (SOR) located at Wagga Wagga (New South Wales) is the first and currently the only company in Australia to produce fully re-refined base oil. SOR manufactures two grades of Category 1 lube base oil for a wide range of hydraulic and lubrication oil-blending applications including light and heavy base oil. Volumes claimed under category 1 are expected to continue to increase over the next few years (DEH, 2006b).

Nationwide Oil in New South Wales and Environmental Oil in Victoria are currently the only companies that sell diesel fuel for transport and stationary diesel engines. Other producers sell the product as a fuel oil, which can be mixed with High Grade (HG) Industrial Burning Oils or directly used for general burning applications. **Figure 6.1** shows that the trend for the diesel market is constant, but somewhat decreasing.

The sales of High Grade Industrial Burning Oils (category 5) have increased steadily since the commencement of the program. Low Grade Industrial Burning Oil (category 6) sales are decreasing slightly, however this suggested a potential shift from category 6 to category 5.

Other used oil products include other base oils (e.g. chain saw bar oil) and diesel extenders (categories 2 and 4 respectively). However, the reported volumes are too small to chart in **Figure 6.1.** Additional markets in Australia include oil bottoms for asphalt manufacturing and untreated used oil for heating in horticultural premises. These markets are given further attention in the following section.

Figure 6.1: Annual volume of recycled oil in each category since the Product Stewardship for Oil Program began



Source: DEH, 2006b

6.3 WESTERN AUSTRALIAN MARKET TRENDS FOR USED OIL

The Australian Tax Office (ATO) and Department of Environment of Heritage (DEH) were contacted for data outlining the annual volumes of recycled oil for each PSO category within Western Australia. Recent and current data for Western Australia, divided into category types could be used to chart the market trends within the state. However, both the ATO and DEH reported that recent information was only available at a national level.

To gain an understanding of the current and potential used oil markets in Western Australia, a number of stakeholders were contacted. Stakeholders included current and potential users of used oil products (cement works, brickworks, lime manufacturers and power stations). Each stakeholder was asked a series of questions surrounding the use of used oil products and was asked to supply current and potential quantities of used oil that are/can be utilised by the company. Some companies who do not currently utilise used oil found it hard to estimate potential quantities they could use in the future.

6.3.1 Re-Refined Lube Base Oil

Re-refined base lube oil (lube-to-lube oil) can be used as a lubricant, hydraulic or transformer oil. A number of refining processes can be used to remove contaminants and additives from waste oil to produce the 'lube-to-lube' oil and include:

- Wiped Film Evaporation;
- Thin Film Evaporation;
- Propane De-asphalting;
- Vacuum Distillation;
- Chemically Enhance Precipitation; and
- Hydrotreatment

The recycler who undertakes the final reprocessing stage and sells the lube base oil receives a Category 1 recycling benefit payment of 50c per litre. The benefit payment for this process has attracted the attention of existing recyclers.

The closure of the lube-quality base oil manufacturing refinery (crude-to-lube) at BP Kwinana offers replacement opportunities in Western Australia. However, a number of barriers exist, which limit the establishment of a lube-to-lube manufacturing facility in the State. The cost of testing lube oil is high while specifications from engine manufacturers are strict. In addition, it has been stated that a 60,000tpa facility is required to achieve economies of scale. Due to this reason, a facility may not be commercially viable in Western Australia because of the limited quantity of used oil collected within the state. However, the SOR refinery has a 15ML capacity and if this proves viable, a similar sized facility may be viable in Western Australia.

The market for re-refined base oil is developing only with secondary lube oil producers, as the current policy of major oil companies is to only use virgin base oil. Many oil companies apply a formal quality standard accredited by the American Petroleum Institute (API). This is based on an extensive testing program and is specific to the source of the base oil used, with certain oils being formally accredited for lube oil production (AATSE, 2004).

Re-refined lube based oil can be exported overseas as a product and it not restricted by the Hazardous Waste (Regulations of Exports and Imports) Act 1996 Amended (Cwlth) (the Act). An export market therefore exists in South East Asia, which could possibly absorb the recycled lube based oil not sold in Australia. This international market had not been quantified as the market is expected to have unlimited potential.

6.3.2 *Other Re-Refined Base Oils*

Other re-refined base oils are those which do not meet the Category 1 requirements and cannot be used as lubricants in engines. They are typically used as chain saw bar oil or in the manufacture of other products such as plastics, but they are not sufficiently ‘cleaned’ to meet the non-carcinogenic requirements of a high quality motor lubricant (DEH, 2006a). Other re-refined base oils are produced using the thin or wipe-film evaporation, or propane de-asphalting. Wren Oil produces chainsaw bar oil lubricant meeting Category 2 requirements; however this is only produced in low quantities when compared to lower grade burner fuel.

The recycler who undertakes the final reprocessing stage and sells the re-refined base oil receives a Category 2 recycling benefit payment of 10c per litre. Quantities of ‘other re-fined base oils’ produced in Western Australia are low and this is expected to stay unchanged in the future.

6.3.3 *Diesel Fuels*

Diesel fuel can be prepared using the Thermal Cracking process, which subjects the oil to pyrolysis under high temperatures. The recycler who undertakes this final reprocessing stage receives a Category 3 recycling benefit payment of 7c per litre.

Aldwich Resources had expressed an interest in establishing a Waste Oil to Diesel Plant (WOTD) in Geraldton, Western Australia. The plant would have dehydrated the waste oil to remove excess water while thermal cracking would have converted the oil into diesel. The previously proposed facility aimed to achieve the sulphur level specification of 50ppm set by the National Fuel Standard (Diesel) (Office of Legislative Drafting and Publishing, 2006). The proposed plant was not considered viable, as Aldwich Resources were unable to secure the quantities of collected oil required for the process (around 40ML). Aldwich Resources were unable to come to an agreement with Wren Oil or Nationwide Oil to source their used oil.

Recycled diesel fuel would compete successfully with virgin diesel fuel if it met Federal Government specifications. Typically the sulphur levels of re-refined diesel are 1,000 – 9,000ppm, which do not comply with the National Fuel Standard (AATSE, 2004). Therefore recycled diesel fuel could only be used in stationary engines, off-road vehicles, earthmoving equipment in remote areas and marine engines (ISO 8217:1996), to which there are less stringent standards when compared to automotive specifications (AATSE, 2004). For example, sulphur levels in marine fuel oil and marine diesel do not need to meet automotive diesel specifications. Sulphur levels in these types of fuels can be in excess of 10,000ppm. Unrefined used oils used as a marine fuel has been restricted in recent years through international standards due to fears of metals and contaminants in the used oil increasing engine wear, however a refined used oil marine diesel or marine fuel (with contaminants removed) may provide a possible market avenue for used oil.

Diesel fuel can be exported overseas as a product. Therefore an export market exists in South East Asia, which could possibly absorb the diesel fuel not sold in Australia. This international market has not been quantified as the market is expected have unlimited potential.

6.3.4 Diesel Extender

Waste oils can be filtered, dewatered and demineralised to produce diesel extenders, which are of a similar chemical composition to virgin diesel fuel. Diesel extenders can be blended with diesel up to about 40% depending on its quality (CSIRO, 2000). The recycler who undertakes this final reprocessing stage receives a Category 4 recycling benefit payment of 5c per litre.

Diesel extenders can be exported overseas as a product. Therefore an export market exists in South East Asia, which could possibly absorb the diesel extenders not sold in Australia. This international market had not been quantified as the market is expected have unlimited potential. Diesel extenders are subject to fuel quality requirements which will have implications if diesel extender made from used oil were to be used in automotive applications.

6.3.5 High Grade (HG) Industrial Burning Oils

High Grade (HG) Industrial Burning Oils are produced by filtering, dewatering, and demineralising collected used oil. The method leading to HG Industrial Burning Oils are significantly more expensive than simply filtering and dewatering to produce LG Burning Oils. The recycling process produces a high specification product compared to Low Grade (LG) Industrial Burning Oils and consequently there are lower levels of contaminants associated with the product. Many recyclers believe that the extra work involved and energy expended in producing HG oils is not compensated by the benefit paid (5cpl for HG and 3cpl for LG oils) (AASTE, 2004).

HG Industrial Burning Oils can be used by power stations for its flame control properties. The oil can be sprayed on to coal at start up and when adding significant new volumes of coal (DETR, 2001). Unless oil was added, heat output would fall as the coal is added, making the power generation less reliable (DETR, 2001). HG Industrial Burning Oil used as a start up fuel, competes with virgin diesel fuel and gas. HG Industrial Burning Oil also competes with 'demineralised' used oil, which involves the removal of metals and other inorganics. There is, for example, potential for the Worsley Alumina Power Station to use HG Industrial Burning Oils as a start up fuel. It is estimated that Worsley could utilise 4ML of the product annually (F Wren 2006, pers. comm., 30th October).

There are limited markets for HG Industrial Burning Oil in Western Australia as many power stations are now utilising gas. HG Industrial Burning Oil was previously sold to remote power stations located at Esperance, Broome and Derby, which have recently converted to gas.

HG Industrial Burner Oil can also be used to supply energy. Liddell Power Station in New South Wales currently burns significant quantities of low quality used oil for power generation. Kwinana Power Station can burn three fuels: coal, gas and oil for energy. Kwinana Power Station has the ability to use 40ML of used oil for power generation (F Wren 2006, pers. comm., 30th October). 2-5ML and 3ML can be used at Collie and Muja Power Stations respectively (F Wren 2006, pers. comm., 30th October). However, the used oil should be to an agreed specification to minimise the environmental impact.

6.3.6 Low Grade (LG) Industrial Burning Oils

Low Grade (LG) Industrial Burning Oils are produced by using the filtering and dewatering processes. Because of their minimal recycling, they are more likely to contain undesirable contaminants but can be burnt in appropriate applications. LG Industrial Burning Oil can be used as a fuel in brickwork, cement and lime kilns. Other intensive industries with burner and furnace operations, such a nickel smelters, are other potential markets for this used oil product.

The use of LG Industrial Burning Oil in cement kilns offer an environmentally sustainable method for burning low quality recycled used oil (AATSE, 2004). The temperatures within cement kilns are extremely high and can therefore fully combust organic material in the fuel. Any waste residue from the process can be used as cement clinker.

LG Industrial Burning Oil is relatively competitive with gas and oil as it can be offered at a low price. LG Burning Oil is sold by oil recyclers in Western Australia and by some kilns in the State. However, the majority of kilns utilise gas as a preferred combustion fuel. Currently the quantity of oil used by kilns and other burning applications in Western Australia is at around 14ML.

A number of stakeholders commented that they do not use LG Industrial Burning Oil because of the concerns within the community regarding emissions, even though the product can be an economic and environmental alternative to gas and coal. The potential quantity of LG Industrial Burning Oil that can be utilised as a fuel for kilns and other burning applications in Western Australia was difficult to quantify, however the potential quantity is expected to be above 50ML.

6.3.7 Industrial Process Oils and Lubricants (including hydraulic and transformer oils)

Products including hydraulic and transformer oil do not receive any product stewardship benefit as these product are typically filtered and not re-refined. It is therefore expected that the market size for this category is not increasing over time.

One waste oil collector in Western Australia however re-refines collected industrial process oil and lubricants into hydraulic oil, gear oil and degreasers.

6.3.8 Oil Bottoms for Asphalt Manufacturing

Some of the recycling processes as previously described produce heavy bottoms, which are similar to bitumen like material. There are environmental concerns if ‘heavy bottoms’ are burnt at a low temperature, however at high temperatures, such as cement and lime kilns, there are little to no environmental concerns (with appropriate air pollution filters in place).

Several claims have been made that this material can enhance the performance of road asphalt when blended into modified and multi-grade bitumen. In June 2006 a grant was awarded to Wren Oil for a project titled Used Oil Distillation Residue for Use in Road Bitumen. The project objective was to enable used oil distillation residue (i.e. oil bottoms) to be processed so that it can be used in road bitumen. To date a pilot plant has successfully produced road bitumen and the environmental approvals are being prepared to enable the establishment of a commercial plant in North Fremantle.

Provided a commercial plant can be established in Western Australia, this facility would utilise all the oil bottoms currently generated by Wren Oil, with potential to increase production to utilise additional quantities of oil bottoms that may generated in the State.

6.3.9 Untreated Used Oil

Untreated used oil can be used in space heaters for use in horticultural premises. **Figure 6.2** shows a hydroponic heating system used in hydroponic tomato greenhouses. The heating requirements for greenhouses and hothouse are a significant cost consideration for companies in the hydroponics industry, and in some cases the cost associated with this determines the profitability of the operation (Warnken, 2003). Other heating sources can include diesel, coal, solar, briquettes and wood. Reasons for choosing gas as a fuel source range for good control of heating to the avoidance of messy cleanup. Natural gas is preferred over LPG due to superior heating quality and cheaper cost.

More companies are moving towards natural gas and away from LPG due to these reasons. However, a number of hydroponic utilise waste oil as a heating medium as they are located away from natural gas pipelines. The investment in natural gas pipeline extensions can be too expensive and many gas boilers can easily be converted into used oil boilers.

There is an environmental risk when using used oil in small furnaces as they do not require formal EPA approval (AASTE, 2004). If they are used incorrectly, it 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 (AATSE, 2004).

The untreated used oil does not undergo significant treatment to qualify for benefit payment under the national Product Stewardship for Oil Programme. It is recommended that this industry should be better understood before it is identified as a potential market for used oil in Western Australia.

Figure 6.2: Hydroponic heating system used in hydroponic tomato greenhouses.

Source: Warnken, 2003

6.3.10 Used Oil in explosives

Used oil can be used as an ingredient in explosives. Used oil in explosives can be eligible for a Category 8 benefit as it is considered gazetted oil (incorporated into a product or process). The current benefit rate for Category 8 is 5.449 cents per litre.

Pilbara Iron is currently investigating the use of used oil in its explosives at its Marandoo Operation. This has involved the recommissioning of its used oil facilities. Trials have been undertaken, however it was concluded that the oil was too thick for pumping purposes. Further trials will be carried out on an ongoing basis (Pilbara Iron 2006).

6.4 COST/PRICE OF USED OIL PRODUCTS VS ALTERNATIVE FUELS

Figure 6.3 on the next page outlines the benefit rate, cost to process (including collection cost) and sale price of used oil products in Australia. These cost/prices were obtained from a combination of communications with stakeholders during the consultation process and the *Independent Review of the Transitional Assistance Element of the Product Stewardship for Oil (PSO) Program Report* (AATSE, 2004). The sale prices of these products are compared to the sale price of competing alternative fuels, which were obtained, from a variety of sources as specified on the following page.

Figure 6.3: Comparison of Cost/price of used oil products vs. alternative fuels

Product / end use	Description of product and process	Benefit Rate (c/L)	Used Oil Product Costs (c/L)		Cost of Alternative Fuels (c/L)			
			Process Cost inc Collection Cost	Sale price of product	Base Oil	Diesel	Pipeline Natural Gas	LPG
Re-refined Lube Base Oil	Thin Film Evaporation, Propane De-aphalting and Vacuum Distillation	50	65	N/A	110			
Other Base Oil (chainsaw bar oil)		10	43	138	110			
Diesel Fuel	Thermal Cracking, Thin Film Evaporation, Propane De-asphalting and Vacuum Distillation	7	43	43		58		
High Grade Burning Oil	Demineralisation	5	43	38		58	25	35
Low Grade Burning Oils	Thin Film Evaporation	3	32	38			25	35
Low Grade Burning Oils	Filtered, Dewatered and Dehydrated	3	14	22			25	35
Other Oils (hydraulic and transformer oils)	Rejuvenated and Filtered	0	11	16	110			
Untreated Used Oil		0	11	37			25	35

Assumptions
These cost do not include distribution or marketing costs
Excludes government excise and GST

References	
Used Oil Product Costs	
Used Oil Product prices have been obtained from W.A used oil recyclers, consumers and (AATSE, 2004) (reflecting 2006 values, based upon 4 per cent increase per annum)	
Re-refined Lube Base Oil sale price was N/A. This product is not manufacturered in Western Australia and a price was not obtainable from Southern Oil Refinery in NSW	
Cost of Alternative Fuels	
Base Oil	ICIS pricing available online. Base Oils (Asia Pacific) 6th June 2006, available online: http://www.icispricing.com/il_shared/Samples/SubPage257.asp
	Prices are converted from USD/metric tonne into c/litre assuming $1.35 AUD = $1 USD and 1 metric tonne base oil =1,124 litres
Diesel	Department of Consumer and Employment Protection available online: www.fuelwatch.wa.gov.au
Pipeline Natural Gas	Cost obtained during stakeholder consultation process. 25c/litre is a typical value.
	Values usually depend on individual companies as contracts are negotiated
LPG	Department of Consumer and Employment Protection available online: www.fuelwatch.wa.gov.au

6.5 REGIONAL INFRASTRUCTURE AND TRANSPORT ISSUES

6.5.1 Regional Variation and Opportunities for Regional Placement of Infrastructure

At present, there are regional variations in regards to infrastructure throughout Western Australia. This is evident from **Figure 3.5** (shown on page 10) with infrastructure being spaced large distances from each other. Nationwide Oil utilises the close proximity to the BHP Billiton Nickel Smelter in Kalgoorlie, Tox Free to the Pilbara mining sector in Port Hedland and Wren Oil in Picton, close to the Perth metropolitan area.

Aldwich Resources Waste Oil to Diesel (WOTD) facility proposed to site their facility in Geraldton. This would have allowed the plant to be in close proximity to both the Pilbara Mining Sector and the Perth Metropolitan Area. As this project has now been closed, it leaves a possible area for future used oil infrastructure development.

6.5.2 Used Oil Stocks

Meinhardt, in their report to Environment Australia in 2002, reported that the largest stockpiles of used oil were in the Northern Territory and Western Australia. Currently in Western Australia, large volumes of used oil are still being stockpiled . In particular re-refined burner fuel is being stockpiled in tanks, as this is the main used oil product produced in Western Australia. Wren Oil has approximately 22ML stockpiled at present at storage facilities in Kwinana (pers. comm. Fred Wren 2006).

6.5.3 Transport Economics

Transportation can involve moving the used oil in for processing and out to the market. Approximately 50% of expenses can be on collection transport costs but this is dependant on location. In addition to the general pick up service run regularly along a set route, the oil collection companies can do ‘milk runs’ to mines, towns and farms, which may require an increased expenditure on transport costs vs. the amount of oil collected. To offset these costs the collection companies may deliver processed oil, preventing double handling.

Based on our consultation with industry stakeholders, the costs of collection companies are in the order of approximately 5-16c per litre based on statewide services. This figure can be split between incoming and outgoing transport costs listed below.

- Controlled Waste Tracking Fees
- Depreciation – trucks
- Drivers wages
- Fuel & Oil
- Hire purchase charges
- Insurance - Workers Compensation
- Insurance - Trucks
- Hire/rent of Plant & Equipment
- Trucks Registration Fees
- Trucks Repairs
- Travelling Expenses

To transport re-processed used oil interstate it would cost approximately 30-35c per litre (D Leaney 2006, pers. comm., 28th August).

6.5.4 Potential Synergies with other Transport Operations

A synergy is a mutually advantageous conjunction where the whole is greater than the sum of the parts. Other transportation companies including SITA, Veolia and Cleanaway deal with controlled wastes, however they do not readily deal with used oil. Contamination of tanks may be an issue for other transport companies to become involved in the collection of oil. Nationwide Oil and Wren Oil have become the established used oil collection companies in Western Australia and will continue to be so in the future.

7. POTENTIAL FOR LUBE TO LUBE REPROCESSING

The process of producing base oil products from used oil is referred to as lube-to-lube re-refining, recognising that lubricating oil does not wear out but becomes dirty and contaminated and can be completely restored to its original condition. The re-refining of used oil to remove contaminants and additives to manufacture base lubricating oil has been done for many decades using a variety of techniques. There are hundreds of small scale plants in operation through out the world, most using the reliable, low cost but now out-dated acid / clay process.

Southern Oil Refineries operate Australia's only used oil refinery facility at Wagga Wagga, NSW. The Southern Oil refinery has a capacity to re-refine 15ML of used oil and produces a range of base oil products, which are all manufactured from previously used lube oils as opposed to being produced from crude oil. The refinery also produces a range of fuel oils as by-products.

BP Kwinana – Background

The lubricant refining facility was in operation from 1968 to 2004, although a significant part of the facility was de-commissioned in 2003. The plant was designed to produce base oil from crude oil, rather than used oils, and the base oil product was on-sold to lubricant oil manufacturers who blended additives, etc to produce their product.

The plant started to become uneconomic with the development of modern more efficient facilities in Asia. BP assessed the option to re-refine base oil from used oil, especially in light of the PSO benefit of $0.50 per litre that could have been gained, however it was concluded that it would be uneconomic. The plant has been shutdown since 2004 and would require considerable investment to re-start the operation. The infrastructure is still in place, but BP is considering demolishing the plant in the next few years.

Source: R Lukatelich 2006, per comm. 1st November

There has been a series of recent closures of virgin oil based lubricant refining facilities, including the BP Kwinana plant in mid 2002. Indeed the only remaining facility in Australia is operated by Caltex, which has around 50 per cent of the base oil market (SOR, 2006).

The *Independent Review of the Transitional Assistance Element of the Product Stewardship for Oil Program* Report (AATSE, 2004) states "*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*".

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 to only use virgin base oil, therefore focusing the market development for re-refined lubricant oil on secondary lubricant oil producers (AATSE, 2004).

The AATSE report continues to say, "*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 recycling and replace imports of virgin base oil.*"

The environmental implications of lube-to-lube re-refining have been reviewed in **Section 5** and while the present life cycle analysis (LCA) studies are not conclusive about the best management option for used oil between re-refining or incineration in industrial furnaces (provided with the appropriate pollution control device), it can surely be claimed that the production of lubricants from the re-refining process is more environmentally friendly than direct burning in individual small space heaters or in unregulated industrial furnaces using old technologies. It may also be more environmentally friendly than the production of lubricating oil from virgin oil, but the LCA reports reviewed in **Section 5** do not assess this comparison.

The Sections below summarise the operational economics and market barriers that relate to lube-to-lube re-refining.

7.1 ECONOMICS

Lube-to-lube re-refining to remove the contaminants and restore the oil to its original condition is a very detailed process with a technical complexity similar to operating a lube oil manufacturing plant in a crude oil refinery. There are significant costs associated with the infrastructure and operation of a re-refining facility. A number of costs have been sourced, however they cover a wide range of values partial due to the range of technologies available.

Upgrading facilities to produced to lube base oil can be done by a variety of processes (see **Appendix D** for further details about the processes):

- Solvent Extraction – as used by Southern Oil refineries
- Hydrotreating – reportedly the best to compete with virgin base oils

A report produced for the UK's Department of Environment Transport and Regions (DETR) in 2001 estimated the capital cost for a new 35,000 tonne per annum (approximately equivalent to 38.8 ML[16])

[16] Based on a density at 20°C of 0.9kg/litre for lubricant oil.

re-refining facility, based on hydrotreating technology, to be in the range of \$37M[17] –\$43M[18] The operating costs for this facility type depend upon the management of the process, and producing a higher quality product will lead to higher operating costs as the consumption of hydrogen increases. The operating costs quoted in the DETR report range from \$7.7M –\$8.4M. Allowing for depreciation and return on investment the processing cost per litre would be in the range of \$0.54 –\$0.68, excluding income from the sale of product. Again this is based on 2001 costs. If this was linked to inflation at 4 per cent per annum, the cost in 2006 values would be \$0.66 –\$0.82 per litre of input.

The *Independent Review of the Transitional Assistance Element of the Product Stewardship for Oil Program* Report (AATSE, 2004) provided costing for a facility that would produce high quality burner fuel or diesel. The report states a capital investment in the order of \$2.75M - \$17.5M with an operational cost of \$0.40 - \$0.47 per litre of input. It has been assumed that these are 2004 values, therefore if this was linked to inflation at 4 per cent per annum, the cost in 2006 values would be approximately \$0.43 –\$0.51 per litre of input. This type of facility would require additional investment in technologies such as solvent extraction or hydrotreatment to enable complete lube-to-lube re-refining and the production a high quality base oil, therefore increasing the cost of production.

The oil industry considers that severe hydrotreatment is needed to produce lube base oil of the required quality. The Viscolube plant in Milan, which opened in September 2003, is quoted as an example of this technology (AATSE, 2004).

Further costs relate to the testing requirements for high quality base lube oil. Before the re-refinery is able to sell re-refined base oil to the engine oils market, a sector that forms approximately 50% of lubricant demand, the oil must meet international quality specifications (i.e. Society of Automotive Engineers or American Petroleum Institute specifications) (OECD, 2005).

Testing costs are typically AUD\$630,000 (OECD, 2005) and since the scale of a re-refining plant in Western Australia would be less than 60,000 tonnes output annually (60,000 is stated as the minimum efficient scale of a re-refining plants in the OCED report), these costs can form a significant barrier to investment, and thus market entry. The re-refiner must therefore meet the testing costs without certainty of success in selling the output to a mature and risk-averse market.

As outlined in Section 4.2.3, the product tests cannot be carried out until the re-refining plant has been made operational. Furthermore, as the tests require at least several months to complete, the initial lube base oil output will have to be sold to alternative markets. This can increase the opportunity cost of testing. Frequent changes to engine oil standards also make it more difficult for re-refiners to enter this market (OECD, 2005).

[17] A conversion rate of \$2.40 to the Pound Stirling has been assumed.
[18] These costs have not been increased for inflation. Based on 4% cumulative inflation since 2001 the range would be around AUD\$45M - AUD\$52M for 2006 values.

7.2 MARKET ISSUES

There are a number of barriers and hurdles relating to the marketing of re-refined base oil that are summarised below.

7.2.1 Market Competition

The used oil recycling industry was analysed in **Section 4** and found to be highly competitive. The lubricant oil industry is no different as a few multinational integrated oil companies who seek to protect their market position dominate the market and since volume growth in the lubricant market is small, it is customers of the existing producers who must switch to the new entrant. Once production of re-refined base oil starts, the existing market will need to accommodate the new source of supply, which can only result in a reduced market share for the existing lubricant oil refiners.

Faced by competition from virgin oil refiners, used oil re-refiners are susceptible to a short-term change in pricing policy from existing large-scale oil refiners. A reduction in the price of base oil for 12 months may be sufficient to undermine the profitability of any new re-refining plant (OECD, 2005).

7.2.2 Contamination

Facilities that re-refine used oil to produce lube base oil are more sensitive to contaminants in the used oil pool than all other final used oil based products. While tankers tend to have separate compartments to allow for segregation of used oils of different qualities, collectors of used oil can never be certain that the oil is free of liquid contaminants to which re-refining is sensitive. Unless a comprehensive mobile testing program is in place, the cost of concealment is negligible and the cost of detection substantial since most used oil collected is immediately mixed with other oil in a road tanker, and the risk of those responsible for contamination being identified is small (ACG, 2004).

The impact of this asymmetry is revealed through the costs of testing undertaken in Italy before used oil is accepted into the re-refining process. Tests are carried out before used oil is placed in the 26 regional storage tanks and again on acceptance at the re-refining plant. The Italian waste oil consortium has estimated these costs to be €45 - €60 (AUD$70.00 - $94.00) per tonne (6c – 8.5c per litre) of collected used oil (OECD, 2005).

In the absence of effective control of used oil quality at the collection stage a producer of used oil has an incentive to place contaminated oil on the market. For instance, excessive water content will lower the value of the used oil and if sellers believe that this will not be detected, this can result in significant market inefficiency. This problem is particularly important if the used oil is contaminated with excessive levels of metals, PCB's or halogens (OECD, 2005).
The diffuse nature of used oil generation and thus the mixing of a variety of sources in collection strategies in order to reduce overall collection costs makes detection difficult. As such, the cost of discovery falls on re-refiners who are forced to direct a greater proportion of their oil feedstock to alternative, lower value burner fuel markets (OECD, 2005).

7.2.3 Risk aversion to using re-refined base oils

Buyers of lube base oils (lubricant oil manufacturers) typically blend their base oils with additive packages to achieve a consistent product that delivers specified performance attributes. These buyers are highly sensitive to the risk of using materials that may cause their own products to fail in use or for their own production process to be stopped as additive packages fall out of suspension.

Lubricants offer performance-critical attributes for a value that is typically insignificant when compared to the equipment motor vehicle or industrial equipment it is protecting. Consequently, a significant degree of "disappointment aversion" best describes the conservative approach of buyers in the market for lube base oil (OECD, 2005).

Downstream, buyers of lubricants are reluctant to risk damaging their vehicle engine or industrial equipment by purchasing re-refined oils, despite the quality of re-refined lubricants being equivalent and even possibly better than primary lubricants. This perception was confirmed during consultation with representatives from the Western Australian motor industry, who stated that they would not use re-refined lubricant oils for their vehicle services.

This risk-aversion can persist for a considerable length of time, even if a strong technical case can be made for the equivalent quality attributes of re-refined oil, relative to lubricants manufactured from base oils derived from virgin crude.

Thus, re-refiners, who are almost always independent of oil refiners and lubricant manufacturers, sell their lube base oil and with it the negative association of ‘waste’. Risk aversion amongst buyers causes re-refined lube base oil to be directed into lower value markets. Typically, re-refined lube base oil attracts a price 20% to 25% below that which might have been expected for a product with similar viscosity and related features supplied by crude oil refiners (OECD, 2005).

In Australia the lube base oil prices for the re-refined product from Southern Oil Refineries are 10- 12 c per litre lower than for a virgin base oil of comparable specifications, and is being sold to smaller companies for lube oil production, as major producers do not accept it. This is said to be for quality reasons and customer perception. (AATSE 2004).

7.2.4 Technological externalities

As stated above, a wide variety of additives are added to lube base oil to produce lubricating oil. All of these additives provide benefits in terms of performance but can create difficulties for re-refiners. Technological externalities can reduce economic efficiency if the benefits (improved performance) are not as great as the costs (reduced recoverability). This can arise if incentives are not provided to ensure that the product designer does not take the downstream costs into account (OECD, 2005).

Some of the most problematic additives for re-refiners are chlorinated hydrocarbons and dithiocarbamates (containing lead) used as extreme pressure agents, polysulphides and several sulphur containing compounds that can cause emissions. Additives such as styrene butadiene (SBR) and styrene isoprene (SIP) used in engine oils to provide shear stability appear in the by-products from re-refining as asphalt or as a substitute for heavy fuel oils used in cement kilns (OECD, 2005).

If the costs associated with re-refining are not transmitted back up the product supply chain, it is possible that sub-optimal specifications for lubricating oil will be developed. As noted above, a technological externality results in sub-optimal design if the performance advantages associated with the additive are of smaller positive value than the negative values associated with reduced potential for re-refining. Indeed, it has been argued that minimum quality standards can be redrafted with a view toward increasing the potential for re-refining (AATSE 2004).

7.3 SUMMARY

The establishment of a lube-to-lube re-refining facility in Western Australia would face a number of significant barriers. Initially a supply of used oil would need to be secured and, considering the high level of competition between the existing oil collectors, this supply may only be obtained if the collection company paid a fee for the used oil. Alternatively, one of the existing used oil processors could develop their existing operation to produce re-refined lube base oil. Wren Oil have expressed that they would be interested in providing a lube-to-lube service.

The volume of used oil required to operate a lube-to-lube facility economically has been quantified as 60,000 tonnes per annum (OECD, 2005). This volume exceeds the annual volume of used oil collected in Western Australia. However, the facility operated by Southern Oil Refineries in NSW has a capacity of only 15 ML per annum. If this facility proves to be financially viable it would suggest that a similar sized facility maybe viable in Western Australia. Provided the supply of sufficient volumes of used oil could be secured, the capital cost to establish a re-refining facility is also a significant investment and presents a barrier to be overcome.

Assuming a facility could be established in Western Australia to produce a re-refined base oil suitable for lubricant oil manufacture, the issue of marketing the product would need to be addressed. There is currently no lubricant oil refinery in Western Australia, and therefore any product would need to be exported to the Eastern States where the only lubricant refinery in Australia is located, or to overseas facilities. Alternatively the re-refining facility could extend down the supply chain and aim to manufacture and market its own lubricant products in Western Australia, but this presents different market barriers and issues that would need to be addressed.

Re-refined lube base oil produced in Western Australia could be exported, and the used oil industry has received enquiries from Asia about supplying lube base oil. However, there are issues relating to the method of shipping the product relating to the unloading facilities overseas. The lube base oil may need to be shipped in sea containers, rather than in bulk, and this could impact on the economic viability of this option.

Ultimately, it is likely that the establishment of a lube-to-lube re-refinery in Western Australia would only be financially viable with significant government assistance relating to grants, subsidies or regulation to assist in the capital investment of the facility and / or market development for the products.

8. SUMMARY AND RECOMMENDATIONS

This Section of the report summarises the issues relating to the used oil industry and suggests recommendations that could be introduced to eliminate barriers to the market development or use of used oil products.

The report has reviewed and analysed the used oil industry and markets in Western Australia. Achieving the division between re-refining, different forms of energy recovery, and other waste management options is clearly a delicate balancing act, especially as it is a constantly changing environment, with the demand for lubricating oil (although linked to economic activity) essentially stagnant and constant advances in the technologies for production, re-refining, and even detection of impurities.

The Product Stewardship for Oil Programme was introduce in 2001 by the Australian Government to provide incentives to increase used oil recycling. The arrangements comprise a levy-based system. The Programme, administered by the Department of Environment and Water Resources, aims to encourage the environmentally sustainable management and re-refining of used oil and its re-use. These arrangements provide incentives to increase used oil recycling in the Australia Community.

8.1 COLLECTIONS OF USED OIL

It is clear that the dumping of used oil into the natural environment results in significant environmental damages. As such, it is important to maximise collection rates, ensuring, to the greatest extent possible, that used oils do not end up being discharged into the natural environment.

It is not a straightforward task for the Department of Environment and Conservation to discourage illegal dumping. Used oils are generated diffusely and it can be relatively easy to dump them clandestinely. The administrative costs associated with monitoring and enforcement to prevent illegal disposal of used oils can be costly. In the face of high administrative costs, it is preferable to complement the ‘stick’ of regulatory control (i.e. fines) with a ‘carrot’ of appropriate incentives (i.e. free collection).

Wren Oil and Nationwide Oil, whom both provide free collections of used oil throughout the State and process it to produce a range of products, dominate the industry. The collection rate for collectable oil in Western Australia is 93%, which is very high when compared to the Australian average of 53% (OSAC Collections Working Group, 2003). This reflects the highly competitive industry in the State and demonstrates that the funding for collection facilities has achieved the objective to maximise used oil collections and avoid illegal disposals. Therefore the current measures in place that focus on maximising used oil collection, together with the competitive industry in Western Australia, are sufficient to ensure high used oil collection rates

Unfortunately the free collection service can provide perverse incentives with respect to the quality of oils collected. If there were differentiating return incentives according to used oil quality, this would help control the contamination of used oils and assist in the production of higher end-use products. This would, however, be dependent upon accurate and timely testing procedures. This issue is further explored under the re-refining market in **Section 8.2.4**.

8.2 USED OIL PROCESSES AND MARKETS

The key issues and barriers regarding the sustainability of the used oil industry in Western Australia relate to securing long-term markets for the products that are or could be produced from used oil. Existing markets for used oil products, such as power generation for electricity and industry, are in decline due to alternative fuel sources such as natural gas replacing the used oil products. One result of the lack of markets for some of the used oil based products is the 22 ML of product currently stored in the State.

The storage of the product is an unsustainable solution and when the storage facilities are full the processing of used oil will have to be reduced or cease at some facilities. This will have implications up the supply chain as collections of used oil are reduced and a likely outcome may be an increase in illegal disposal and the associated pollution and environmental damage.

It could be argued that if there is a declining demand for a product then too much product or indeed the wrong product is being produced. The used oil market has a number of issues that distort this statement's rationale.

Firstly, with the processing of used oil, a range of products are produced, including some 'by-products' that require markets for end use, or alternatively disposal. The cost to disposal of used oil by-products would impact on the financial viability of the industry and have knock on effects with the collection and illegal disposal of used oil as summarised above if the collections decreased.

Secondly, as with many 'waste related' industries, the rule of supply and demand cannot be controlled because there is always raw material (i.e. used oil) being produced and collected. This must be processed and sold. The output of a facility cannot be reduced to reflect the market demand.

However, this does highlight the strong link between the products produced and the market demand for different used oil products. As the process technology used dictates the range of products produced, the issue of processes, products and markets are directly linked. With this is mind the solutions could lie with:

- Changing the range of used oil products produced (therefore changing the processes used to treat the used oil),
- The securing of markets for the existing range of used oil products produced, or
- A combination of these.

8.2.1 Small Regulated Burners

The small burner market is dominated by the greenhouse and hydroponics industry. Generally used oil is used in small-scale burners with no emission controls. Although this option is preferential to illegal disposal and does prevent the use of virgin heating oil, thereby reducing fossil fuel consumption, there would be little environmental advantage in directing resources to developing this market for used oil.

8.2.2 Asphalt Production

Oil bottoms are produced in Western Australia as a by-product of used oil reprocessing and make up 10-20% of the products generated by Wren Oil. A potential market for this material is in asphalt production. It was noted in the *Independent Review of the Transitional Assistance Element of the Product Stewardship for Oil Program* Report (AATSE, 2004) that "…*this material (oil bottoms) 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.*"

8.2.3 Power Generation

The market demand for used oil based burner a fuel in industrial power generation is declining in Western Australia, mainly due to the threat of gas as an alternative fuel and concerns about emissions. During the stakeholder consultation completed for this report the feedback provided by existing and potential users of burner fuel expressed concerns about product quality and the implication this has on facility emissions, environmental impacts and heightened community concerns.

Recommendation 1.
The Used Oil Industry and Department of Environment and Conservation, in consultation with the market stakeholders, should develop a specification standard for burner oil. This would ensure that the end users of the burner product would be confident that using burner oil would not increase their risks of an emissions failure or damage to infrastructure.

The feedback relating to the economics of using burner oil varies, with some stakeholders indicating that the product was significantly cheaper than alternative fuel sources, while others suggested that the burner oil should be provided at no cost to make it more attractive.

A number of the stakeholders indicated that an investment was required to use burner oil at their facilities. This related to pre-heating requirements, pipelines or simply time for discussions.

Recommendation 2.
If the only barrier preventing the use of burner oil at some facilities was due to the investment required, this should be quantified and analysed. Provided the costs were reasonable and this provided a long-term market for a significant quantity of burner fuel, a capital grant should be considered, possibly funded through the PSO Transitional Assistance Grants.

During the stakeholder consultation with the used oil processors and the potential consumers of burner fuel, it appears that there are a number of issues that could be resolved to enable additional volumes of burner oil to be used (displacing diesel or other virgin oil fuel sources). However, the feedback received suggests that the discussions have been unstructured and changes in personnel have cancelled any progress made. There is potential for additional volumes of burner fuel to be used, or diesel extender and this would enable a reduction in the use of virgin fuel sources and help to ensure the used oil supply chain does not 'block up' and inhibit used oil collections.

Recommendation 3.
A State based group should be established with representatives from the Department of Environment and Conservation, the used oil industry (e.g. Wren Oil and Nationwide Oil), major consumers (e.g. Electricity Power Generators, Oil Companies, Industrial Users). The group's aim would be to identify the specific issues preventing the use of used oil based products at facilities in Western Australia and develop actions that would enable these markets to be utilised.

Some of the concerns of the consumers were, understandably, driven by the local community's feelings about the use of the burner oil and perceived health and environmental impacts associated with the use of a 'waste' fuel rather than natural gas or diesel. The consumers have a high regard for the local community and do not wish to jeopardise their relationships by using a fuel that has associated negative perceptions.

Recommendation 4.
In order to mitigate this barrier to the use of burner oil it is recommended that a community consultation program be completed. This would involve liaison with local groups and individuals to identify the concerns that the community has, and explore ways that the concerns could be addressed to ensure that the community and burner oil consumers were happy for burner oil to be used instead of virgin fuels.

This recommendation would only be of value when community perception is the main barrier for the use of burner oil at a consumer's facility.

8.2.4 Re-refining

For markets to operate efficiently, market participants must have access to reliable information. There is, therefore, a strong case to be made for an active Government role in informing. In addition, it may be possible to support the demand for re-refined lubricants by:

- Informing customers on the quality of re-refined lubricants
- Developing identical standards for virgin and re-refined lubricants
- Using Government procurement as a demonstration tool.

However, it must be recognised that Government measures designed to change 'preferences' in markets where is significant risk aversion are likely to be more successful if they focus on the quality characteristics of the product themselves, rather than any associated environmental benefits.

Unfortunately, free used oil collection can have a negative effect on the potential to re-refine used oil. Since it can be costly to run parallel collection schemes due to significant density economies (particularly in remote regions), there is a tendency for used oils to be mixed at the point of collection. In some cases used oil with high water content may be collected. In other cases, there is a danger that the used oil may contain hazardous substances. All of these restrict the potential for downstream re-refining.

This possibility is exacerbated by the fact that it can be easy to conceal (and difficult to detect) used oil of low quality at the collection stage. Indeed, producers of used oil may dump low quality used oil into the collection system.

Ultimately in order to develop the re-refined lube base oil market in Western Australia, it would be necessary to engage the major lubricant oil manufacturers in dialogue to agree terms under which re-refined lube base oil can be used. This should be on performance merit and it will also be essential to address the issue of customer perception that re-refined lube oil means poor quality.

Recommendation 5.
The viability of a re-refining facility in Western Australia, for the production of lube base oil for the domestic market is questionable and significant consultation is required between the Department of Environment and Conservation, used oil processors and the major lubricant oil manufacturers before a decision is made. The group / meetings should be facilitated by an independent third party.

If the production of re-refined base oil was to be started in Western Australia there are a number of recommendations that could be followed.

Recommendation 6.
The establishment of a re-refining facility or the upgrading of existing used oil processing facilities requires a large capital investment, with no guaranteed market for the end product, therefore a high investment risk. In order to reduce this investment risk a Government grant would be required.

Recommendation 7.
In order to minimise the risk of contamination in the used oil collected (that would impact on the processing and quality of the final product), a testing process should be established that could be completed at the point of collection. The testing of larger batches (on collection) that could be used for re-refining should be completed, economic incentives would be required to ensure the used oil is provide uncontaminated, e.g. the used oil producer is paid 2-3c per litre for uncontaminated used oil. This recommendation could also be used to ensure higher quality uncontaminated burner fuel could be produced.

The remaining smaller or missed used oil collections could still be provided at no cost to ensure the high rate of collection was maintained, and these batches could be used to produce products for markets with lower quality requirements.

Recommendation 8.
Government could also consider 'leading' the market by specifying use of re-refined lube oils in some government supply contracts, based upon some basic assumptions this could provide a market for 50,000 litres of re-refined base oil[8]. The AATSE (2004) report stated, "Informal discussions with oil companies suggest that they would work to comply with such a requirement".

8.2.5 Export / Overseas Markets

The industry stakeholders contacted for this report stated that there have been enquiries from overseas for burner oil and lube base oil. Obviously as lube base oil is not produced in Western Australia this option is currently unviable, however the export of burner oil could open up markets for some the excess product that is produced in the State.

The increased transport cost to reach overseas markets would impact upon profitability when compared to local markets, but as a surplus of burner oil is currently being produced this option should be explored. The key barrier to the export of burner oil is its classification as a hazardous waste, under the Hazardous Waste (Regulations of Exports and Imports) Act 1989 (Cwlth) (the Act). The Act controls the exportation of waste between countries. Since 1996 considerable dialogue has already occurred relating to the exportation of used oil based burner oil and the barrier presented by the Hazardous Waste (Regulations of Exports and Imports) Act 1989 (Cwlth) (the Act).

Recommendation 9.
The establishment of a burner oil specification (see Recommendation 1) and the support of the Western Australian Government to classify the burner oil, that meets the standard, as a product may provide the basis for the Hazardous Waste Technical Group to allow exports to overseas consumers who will pay for the product.

8.3 ADDITIONAL RECOMMENDATIONS

If it were possible for used oil processors to easily switch between different options, the market could absorb changes in relative costs and policy incentives relatively easily. However, as has been noted the capital costs for re-refining or indeed any used oil processing can be very significant, not only because of the capital cost but also due to other factors associated with market entry such as sourcing used oil and testing costs.

[12] Assumptions: State Government fleet of 5000 vehicles, average oil capacity 5L, requiring two oil changes per year

As such it is extremely important that the Federal and State policy makers provide long-term consistent policy that will provide stability to the industry and therefore incentives to investors.

More generally, there is a clear need to ensure that the policy measures which are designed to increase the supply side (i.e. collection infrastructure grants) are co-ordinated with measures to increase the demand side (i.e. procurement policy and market development). In the event that inconsistent signals are given, there is likely to be significant disequilibria in the market and thus great uncertainty. In the long run this will discourage investment.

Recommendation 10.

Any measures or policy implemented should be consistent with current policy direction, provide a reasonable 'lead in' time for the industry to adapt and remain consistent for the long term. This will encourage a stable industry and therefore investment.

All of the recommendations made above (***Recommendation 1*** to ***Recommendation 10***) are focused on the used oil industry and consumers of their products. The solution to provide secure long-term markets for the used oil could be focused further back in the lubricant oil supply chain, (i.e. lubricant oil manufactures or consumers). Although the industry is involved in the Product Stewardship of Oil Program and the levy payment linked to the sales of lubricant oil, it may be required to introduce an Extended Producer Responsibility (EPR) scheme for the lubricant oil industry. It is felt that this is not required at this stage as there are potential markets for used oil products that should be explored prior to the introduction of an EPR scheme. However, if these markets cannot be developed the lubricant oil industry may be required to take further responsibility for their products once they are used.

A similar principal could be focused on major consumers of lubricant oil. The current situation allows consumers to utilise the lubricant (although they will have paid the PSO levy) and then have the used oil collected and processed at no cost. Considering the hazardous nature of used oil and its comparison with the treatment cost for other wastes, this is a significant benefit for the consumers. Once the used oil has been reprocessed, the 'reluctant' potential consumers of these products are often the same organisations or industries that produced the used oil initially. These significant users of lubricant oil could be encouraged to assist in the market development of the used oil products and work with the used oil industry to remove these barriers (***Recommendation 3***). If voluntary participation could not be achieved, enforcing mandatory involvement could be considered.

8.4 CONCLUSION

The used oil industry in Western Australia provides an efficient, free collection service throughout the state. However there are a number of issues that are leading to a decline in the current markets for the used oil based products that have lead to approximately 22ML of product being stored in the State. The recommendations made by Cardno BSD in this report aim to address the key issues and therefore allow the used oil industry to have long term security with current markets while ensuring access to additional markets within Western Australia or overseas.

If the markets for the used oil products continue to decline and additional storage is unavailable, this is likely to impact upon the volume of used oil collected in the State and this may result in an increase in illegal disposal of used oil into the environment and the associated pollution impacts.

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APPENDIX A

ORGANISATIONS CONTACTED

The following organisations and government department were contacted as a part of the project's stakeholder consultation:

Organisation	**Contact Name**
Aldwich Resources Australia	David Bowden
Austral Brick	Dean Wilkinson
Australian Local Government Association (ALGA)	Angela Shepard
BGC Asphalt	Craig Hollingsworth
BGC Cement	Garry Mullens
Boral Asphalt	Julian Walters
BP (Kwinana)	Rod Lukatelich
Cockburn Cement	John Davids
Cockburn Cement	Enrico Chedid
Department of Environment and Heritage	David Collett
Greenhouse Association	Paul Humble
Kalamunda Toyota	Richard Sim
Loogana Lime	
Midland Brick	Kim Kramer
Nationwide Oil	David Leaney
Nickel West (BHP Billiton)	Sam Penglis
Tox Free	
Verve Energy	Bruce Douglas
Western Australian Local Government Association	Rebecca Brown
Westralia Carnations	Fer Winter
Wren Oil	Fred Wren

APPENDIX B

WEBSITE LINKS AND SUGGESTED READING

AATSE, 2004 Independent Review of the Transitional Assistance Element of the Product Stewardship for Oil (PSO) Program. Australian Academy of Technological Sciences and Engineering.

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APPENDIX C

PRODUCT STEWARDSHIP BENEFITS

Additional Benefits

In the 2006-07 Federal Budget, the Government announced an additional $30.1 million for used oil recycling. This Budget measure will ensure that the oil recycling industry will have time to adapt to the changes arising from the Federal Government's Fuel Excise Reform by adding an additional benefit for three years to the current product stewardship benefit arrangements.

The additional benefit is separate from the table of benefit categories and set out in regulation 4A of the Regulations. All Category 5 and 6 claimants will be eligible to claim the additional benefit. The additional benefit is the only benefit payment that may be claimed if another category of benefit payment (categories 5 or 6 only) has been claimed for on the same recycled used oil.

Eligible recyclers will receive:

- 7.557 cents per litre from 1 July 2006 to 30 June 2007
- 5 cents per litre from 1 July 2007 to 30 June 2008, and
- 2.5 cents per litre from 1 July 2008 to 30 June 2009

The additional benefit will cease after 30 June 2009.

The basis for the different PSO benefit rates

The regulations set out seven main types of used oil products that may receive benefits. The categories are designed to cover known current and likely future uses of used oil. The benefits paid for each recycled product have been determined by identifying the level of incentive required for each form of recycling to increase the volume of oil recycled. Other factors considered in determining the benefit rates include environmental and economic considerations and the likely available revenue.

Payment for the first category (lube-to-lube) is significantly higher than for others in order to encourage full re-refining of used oil and thereby more sustainable management of the resource. The higher benefit reflects the very substantial industrial and marketing investment that is needed to make lube-to-lube viable and the environmental and sustainability benefits that accrue.

It should be noted that re-refined used oil products in Categories 1 and 2 will be liable for the oil stewardship levy as they enter the market again.

The benefit table (**Table 4.2** Product Stewardship (Oil) Act Benefit Categories) is arranged in a descending hierarchy. This hierarchy broadly reflects the recycling effort and investment required to make products of better quality and with improved environmental outcomes. In determining appropriate benefit categories the key principle is that benefits should only be paid where they might serve as an incentive for increased recycling activity - that is, not be simply rewarding existing good practice.

Category 1

Category 1 is the highest level of processing. It provides the maximum reward for the highest quality product - that is, a non-carcinogenic re-refined base-oil used as engine lubricant, transformer or hydraulic oil. It must comply with health, safety and environment standards comparable to those for similar 'virgin' products.

Category 2

Category 2 is for oils re-refined from used oil that are not suitable for use as lubricants in engines. They are usually produced by thin- or wiped-film evaporation, or propane de-asphalting. They are typically used in applications such as chain saw bar oil or in the manufacture of other products such as plastics, but they are not sufficiently 'clean' to meet the non-carcinogenic requirements of a high quality motor lubricant.

Categories 3 and 4

Categories 3 and 4 are diesel fuels and diesel extenders (respectively) made from used oil. From 1 January 2006, the sulfur content in automotive diesel is capped at 50ppm. The full specifications for diesel can be found in the Fuel Standard (Automotive Diesel) Determination 2001. Supply of fuel that does not comply with appropriate standards can attract substantial penalties under the *Fuel Quality Standards Act 2000*. Categories 3 and 4 are expected to be declining sectors of the used oil recycling industry over time.

Category 5

Products in Category 5 (high grade industrial burning oils) are filtered, dewatered, and demineralised. The higher benefit paid (compared to Category 6 products) reflects the higher level of recycling performed and the consequent lower level of contaminants associated with the product.

Category 6

Products in Category 6 are typically low-grade fuel oils that have been filtered and de-watered. Because of their minimal recycling they are more likely to contain undesirable contaminants but can be burnt in appropriate (ie EPA-approved) applications such as (some) cement kilns and nickel smelters. When used in high temperature furnaces, toxic materials in the oil are destroyed and the emissions from the smokestack are able to comply with State and Territory regulations. Such high temperature furnaces are valuable sinks for used oil, and additionally provide cheap thermal value to industrial processes. This is particularly important in remote areas (eg WA Goldfields, Tasmania) where more sophisticated recycling operations may not be readily accessible.

Currently an estimated 95% of the recycled oil products made in Australia fall into either categories 5 or 6. These categories are under increasing pressure from cleaner, 'turn the tap' fuels such as gas, plus higher emission standards increasingly required by State and Territory EPAs. Community pressure on emissions and odours is also a factor in some cases.

Category 7

Products in Category 7 will not receive any benefit as this type of recycling is already occurring as part of existing sound business practices and is unlikely to increase if a benefit is paid, ie there is no substantial policy outcome to be obtained. Recyclers who carry out this type of recycling typically filter the oil, often on-site. The oil is not what most would class as waste, and is not re-refined before being topped up and returned to the equipment. The process is analogous in many ways to an oil filter on an engine. Paying benefits on this type of recycling is not likely to increase the amount of used oil being brought to account, even acknowledging that this service has sustainability benefits. Additionally, if a benefit was paid on this product, the recycled product, when returned or sold back to the user, would be liable for the oil levy.

Category 8

While the PSO levy is paid on all new petroleum-based oils and their synthetic equivalents, there are some uses of these oils that do not create a recyclable used oil stream and are a low risk to the environment. These specific uses of oil were never intended to be caught by the Product Stewardship for Oil program. An example of this is naphthenic process oil incorporated into inks for printing newspapers. Category 8 benefits are paid to producers of eligible uses of specific oils. These were declared by the Minister for the Environment and Heritage. The list can be found on the excise page. The benefit rate is equivalent to the PSO levy.

Category 9

Products in Category 9 are a type of fuel oil that has been, at least, filtered and dewatered. It is typically used as a start-up fuel in power stations. Category 9 pays a benefit for recycled used oil that has been added to a blended diesel/used oil petroleum product, the criteria for which has been specified in the Regulations. The level of benefit payment reflects an excise exemption that oil recyclers received prior to 1 February 2004. This was[1] the only category of benefit payment that may be claimed if another category of benefit payment (categories 5 or 6 only) has been claimed for on the same recycled used oil.

Category 9 ceased as of 30 June 2006 - claims may still be submitted if the used oil was recycled and sold for use (or used by the claimant) prior to 30 June 2006.

APPENDIX D

CURRENT AND FUTURE TECHNOLOGIES

Current and Future Technologies (Source: AATSE 2004 PSO Independent Review)

1.1 Recycling Plant

Reprocessing plants located in NSW, Victoria and Western Australia are summarised below

Table 1: Australian Reprocessing Plants State Company Technology Capacity ML Products

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)

PDA is a process 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)

TFE is a form of high vacuum distillation 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 hydro-finishing, is required to produce PSO Benefit Category 1 lubricant quality base oil.

Thermal cracking

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. 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. Producers of diesel fuel seem confident that there are markets suitable for their product quality.

Demineralisation

Demineralisation plants were once used by Nationwide in Queensland, Western Australia and Victoria with a combined current capacity of around 50 ML per year. The Western Australian plant in Welshpool has since been decommissioned. As it is a batch process, flexibility is available by extending operating hours to increase capacity. Demineralisation1 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.

1.2 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. 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.

1.3 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. 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:

- Solvent extraction – as used at Southern Oil Refinery (NSW);
- Hydrotreating – reportedly the best to compete with virgin base oil;
- Sophisticated membrane systems – new technology.

Solvent extraction

Solvent extraction 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

Hydrotreating is a hydro-finishing 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; It is generally acknowledged that government support is necessary to achieve commercially viable production of re-refined base oil.

In a very interesting future development, Shell 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 gas oil – 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.