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SUMMARY

790,000 tonnes of lubricants with a value of £1.8 billion were sold in the UK during 1999. Within a few months of purchase approximately 50% had been used in a variety of products or otherwise lost in use. Of the remaining 395,000 tonnes, more than 80% was collected, mostly free of charge, added to a mixture of other oily wastes and after rudimentary treatment used as a support fuel.

Almost all of the recovered lubricant is treated to meet a specification as a recovered fuel oil (RFO) and is burnt in seven large coal or oil-fired power stations, 125 rotary heaters in road stone quarries, two or three cement and lime kilns, dozens of industrial furnaces, and an unknown number of smaller boilers and space heaters. The users of RFO pay up to 11p per litre, a price that has doubled in the past two years. Demand for RFO has increased over the past 18 months because of its relative price advantage over virgin fuel oil and gas oil, aided by poorly structured contracts for RFO that stipulate fixed prices at historically low levels. The additional demand has been met by importing as much 95,000 tonnes of waste oils from other European countries and elsewhere.

From 2006, the Waste Incineration Directive (W.I.D.) will prevent many of the current RFO users from burning it. The High Court judgment in March 2001 (CO/2635/2000) concerning the status of Cemfuel as a waste strongly indicates that the WID will alter the market for RFO as we suggest and it is possible that demand for RFO will begin to fall sooner than 2006. In these circumstances, it is highly likely that from 2006 and possibly sooner that the majority of the RFO will be directed to cement and lime kilns. The three major operators of these kilns claim that they will expect to be ***paid*** at least £20 per tonne (2p per litre) for accepting it. At this price, other competing technologies will be encouraged into the market, although all of them will be subject to the risk that the cement and lime kiln operators will alter their prices for a period of time specifically in order to undermine investment in competing uses. Cement and lime kilns are displacing fossil fuels by using RFO and could alter their projected pricing structures significantly if necessary. In Germany and France cement kilns pay up to 4p per litre for waste oils.

As prices for RFO fall following the introduction of the W.I.D. certain re-refining uses will increase. Specifically those that launder types of lubricant such as hydraulic oils and certain metal working fluids. These can be cleaned and returned to use relatively cheaply using simple technologies. It is possible that a major oil company will consider investing in plant to manufacture a 2005 specification (low-sulphur) diesel fuel extender. The market for this product is large and stable, and the gate fee is likely to be zero. European experience of this type of investment should be evident by 2006.

In contrast, re-refining technologies carry with them a high-risk profile for most investors in the UK; as a result the required rate of return is likely to be in the range of 15% to 20%. These risks are associated with the poor past performance of similar investments, the complexity and novelty of technologies on offer and in particular the market perceptions of re-refined base oils. We have estimated the capital costs for two types of 35,000 tonne re-refining plant between £8.45 million and £17.85 million. Assuming construction on an existing site and a 10% rate of return, a gate fee of nil is possible.

However, there is strong market resistance to re-refined base lube oils due to poor product quality in the past and restrictions on the type of base oils that can be used. Most lubricant blenders, buyers and manufacturers we spoke with had an anecdote to tell of smelly, discoloured and inconsistent re-refined base lube oils offered for sale over the past few years. Even small volumes of Russian-sourced virgin base lube oils have been difficult to sell into the current market at prices above £26p per litre and re-refined stocks are generally perceived to be significantly inferior to these virgin products. The cost of obtaining performance approval status for new lubricant products creates a strong barrier to entry for all non-standard base stocks,

and this effectively concentrates market power for the supply of base stocks in the hands of three large integrated oil companies.

Any new re-refining plant will require a severe hydrotreating system (or its equivalent) adding £5 to £6 million to the minimum capital requirement. Without the support of a major lubricant manufacturer, the limited demand for re-refined base lube oils from the independent sector will result in the building of plants below the optimum or minimum efficient scale, which we estimate to be at least 75,000 tonnes. Plants that seek to avoid the higher capital requirement of severe hydrotreating (or its equivalent) will produce a less highly specified product and could not expect to sell their output of base oils for more than 21p per litre and then only to a limited market. Potential investors are caught between the competitive risks of small-scale high cost plants and large scale plants the capacity of which exceeds demand. This difficult position could be changed if the investor had an interest in the re-refined output or if the investor had the assurance of contractual guarantees from certain large (non-independent) lubricant manufacturers.

Using waste oil as a feedstock for an existing refinery would overcome many of these financing risks although we understand that there are technical constraints on this option relating principally to a potentially higher rate of corrosion within the refinery.

Conclusions:

1. Removal of the excise duty derogation of 2.74p per litre on the use of waste oil as RFO would cause a reduction in the price paid for RFO and would not cause a significant change in the amount of waste oil collected and processed during 2001/2. Evidence to support this conclusion is that prices have increased by more than 4p per litre for the use of RFO during the past 18 months. However, after 2006, and possibly sooner, prices for RFO will fall as demand for it will be greatly reduced by the introduction of the Waste Incineration Directive. The issue of duty payments on RFO may become a focus of complaints, as it is likely that an uncertain amount of waste oil will be disposed of inappropriately as prices fall.
2. The introduction of special waste regulations to the movement of waste oils combined with a restructuring of the collection business is already leading to an increase in charges for waste oil collection regardless of any proposed duty or oil price changes.
3. By 2006, we would expect at least one major waste oil collection business to be integrated within a leading oil company, cement manufacturer or waste management business in preparation for the investment in alternative disposal routes implied by the Waste Incineration Directive. This ownership structure will determine the type of investment that occurs for waste oil processing, whether as support fuel for cement kilns or as a feedstock for a diesel fuel extender or re-refining to a base lube oil.
4. The technology least likely to benefit from new investment will be re-refining to manufacture base oil. Significant investment in this technology is only likely to occur if the Government intervenes to alter the risk profile of investment in re-refining projects.
5. The introduction of financial incentives for blenders and lubricant manufacturers to purchase specified re-refined base oils is highly unlikely to be effective in raising demand. Reducing prices through subsidy for inferior goods merely reinforces the signal that the good is inferior. Subsidies should be supplemented with measures to deal with the poor market perceptions of the re-refined product.
6. The supplementary measures might include one or more of the following: voluntary agreements with certain large lubricant producers to use a minimum quantity of re-refined base oils that meet agreed quality standards; producer responsibility measures aimed at specific lubricants; voluntary agreements with certain large industrial lubricant users that they will specify the use of high quality re-refined oils in new contracts; grants toward the cost of establishing a separate re-refined oil quality standard.
7. WRAP (Waste and Resources Action Programme) may wish to investigate the development of these market measures since they will require the cooperation of major oil companies to create the market conditions suitable for an independent investor to develop re-refining capacity.

INTRODUCTION

The waste oils sector in the UK is currently experiencing a period of uncertainty. Uncertainty about the environmental acceptability of the fuel product supplied to a variety of major fossil fuel users, uncertainty about the legislative framework in which they will operate in the future and uncertainty about the commercial consequences for many of the several dozen very small businesses that operate in the sector.

A key element of this uncertainty is the degree to which the EU Waste Incineration Directive will curtail demand for the replacement fuel that the industry supplies. If demand falls, there is concern that some waste oil will not be collected but will be disposed of inappropriately.

At the same time, the UK Government is being challenged to justify its policy position in relation to the EU Waste Oils Directive in which there is a general presumption in favour of re-refining waste oils as a base lubricant stock.

The DETR commissioned Oakdene Hollins to investigate the economics of the waste oils market in the UK and to draw conclusions from four main policy options. This study describes the commercial activities that transform crude oil into highly sophisticated lubricants and the market for their post-use collection and disposal. It investigates the economic consequences that would follow changes to prices caused by a range of legislative and fiscal changes. It reports on the market for re-refined base oils in the UK and the barriers to investment in new re-refining capacity.

Readers of the report may find it helpful to detach appendices 1 and 2 to follow the volume and price information given in the text.

The study was undertaken during January and February 2001. We are especially grateful to the many individuals and companies in the petroleum, lubricant, waste management, aggregate, power generation, metals and oil recovery industries that gave so generously of their time to assist in the preparation of the study and to the academic, Environment Agency, DTI and DETR staff who provided assistance. All errors and omissions remain the responsibility of the authors.

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Base Oil and Lubricant Manufacture

Twelve refineries in the UK process approximately 80 million tonnes of crude oil annually. Three of these, Coryton operated by BP Amoco, Fawley operated by Esso and Stanlow operated by Shell, manufacture base lubricant oils.

The UK economy consumed 66.1 million tonnes of petroleum products during 1999, 72% of which were for transport uses as motor spirit, aviation turbine fuel and diesel fuel.

REFINERY PROCESSING CAPACITY (1999)
Million Tonnes

Company Refinery site	**Distillation**	**Reforming**	**Cracking & Conversion**
BP Amoco Coryton Grangemouth	19.8	3.2	6.5
Conoco Killinghome	9.4	2.1	9.0
Elf Oil/Murco Milford Haven	5.3	0.8	1.7
Esso Fawley	15.6	2.8	4.6
Petroplus/Phillips North Tees	5.0	0	0
Shell Stanlow	11.5	1.4	3.8
Texaco Pembroke	10.1	1.5	6.1
TotalFina South Killinghome	9.5	1.4	4.1
Others Carless Solvents Ltd Eastham Refinery Ltd Nynas UK	2.3	0	0
TOTAL	**88.5**	**13.2**	**35.8**

Source: Adapted from Digest of UK Energy Statistics 2000 DTI table 3.B

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; the heavy sticky residue from the bottom end. In the main, distillation creates a surplus of fuel oil and insufficient motor fuels. Catalytic cracking, now common in UK refineries, converts some of the surplus fuel oil components into motor fuel products for which there is a higher demand.

The heavier residues from the distillation process are processed into lubricating oils, waxes and bitumen. Typically, depending on the type of crude oil being processed, approximately 1% of the crude oil input to UK refineries will be manufactured as base lubricant oils although for an individual refinery the percentage might be 3%.

The three refineries manufacturing lubricating base oils in the UK are estimated to have an annual production capacity of 1.09 million tonnes. Each of them may from time to time import partially processed lubricating oil from other refineries to supplement their own supplies.

LUBRICATING BASE OIL CAPACITY
Million Tonnes p.a.

Company Refinery site	**Distillation Capacity**	**Lubricating Base Oil Capacity**
BP Amoco Coryton	9.6	0.40
Esso Fawley	15.6	0.44
Shell Stanlow	11.5	0.25
Total UK	**88.5**	**1.09**

Source: Adapted from Europalub 1999 and Digest of UK Energy Statistics 2000 DTI table 3.B

Lubricating base oils are generally one of the more costly products for a refinery to manufacture because of the additional capital investment required, the higher level of energy inputs and the specialist equipment required to handle and store the output. These higher costs are reflected in the market price paid for base oils. As a general guide, the most common base oil sells for a price that is currently double the gate price of crude oil.

The American Petroleum Institute (API) classifies base lubricating oils into five main groups. Groups 1, 2, and 3 are the most common base oils, group 1 being simple solvent-refined base oil whereas groups 2 and 3 are manufactured using capital-intensive hydro cracking units that require significant quantities of hydrogen. A growing market is developing for group 4 and 5 base oils. These are synthetic oils and are manufactured by polymerising olefins from petrochemical sources. Although four or five times more expensive to produce than group 1 lubricating oils, their higher performance and longevity reduces the high cost of machine downtime when lubricants are changed. Synthetics are increasingly being used in high performance automotive engines. Estimates made by the British Lubricants Federation suggest that up to 8% of the automotive engine oil market in 2000 consisted of synthetic oils. Castrol expect the proportion to increase steadily to at least 13% by 2010.

The price of base lubricating oils is broadly correlated over time with crude oil prices , with a six month delay. However, the atmospheric residue that traditionally was traded between oil refineries as the feedstock for base lubricating oil stocks did vary in price regardless of the signals from the crude oil market. The only UK refinery that sells atmospheric residue now is the Petroplus Phillips plant on the Tees.

As a general guide, for the purposes of establishing the processes in which value is added and destroyed during the life of oil manufactured as lubricants, we have taken prices provided by ICIS-Lor Group, BLF (British Lubricant Federation) and others in early 2001. The crude oil price during this period was between $25 and $27 per barrel equivalent to $184 - $198 per tonne or 12p - 13p per litre.

INDICATIVE PRICES FOR BASE LUBRICATING OILS

Base Lubricant Stock	$ per Tonne FOB NW Europe	P per litre Equivalent	Comment
SN 150	370 - 385	25	"Neutral" stock
SN 500	370 - 385	25	
SN 380 - 400	380 - 400	26	
Group 3	850 - 900	57	PAO is a benchmark for pricing these products
Group 4	1300 -1400	90	
Group 5	1400 - 1600	100	

PAO (Poly alpha-olefins) FOB (Free On Board)

Although only 1% of refinery output is sold as lubricating base stock, there is a long-term problem of overcapacity in the market. Oversupply has led to price discounts of as much as 20% for exports to the Indian sub continent and South American markets. Another indicator of this supply overhang is that bright stock prices should typically be $30 to $50 above current levels to reflect the higher costs of production but it tends to be offered at similar prices to neutral stock to discourage discounting from the neutral stock price. These price signals indicate the extent to which there is a continuing surplus of lubricating base oils for sale in European markets, in particular of the common group 1 stock against which re-refined oils would compete.

Group 1 base stock remains the most commonly traded although the market is steadily moving toward the more expensive groups 2 and 3 that offer improved features similar to those offered by some synthetic oils. The US market has moved firmly toward group 2 where at least 50% of production is currently in group 2 product. It is likely that European refineries will follow this lead in response to demand from the automotive sector for a higher quality first-fill engine lubricant that permits an extended three-year warranty period.

Very little lubricating base oil is used as a final product. Almost all of it is used as a blending medium to which specialist additives are combined to manufacture an enormous range of lubricating products. It is this process and the branding and marketing effort associated with it that adds the greatest value in the journey between oil refinery and point of disposal several months later.

Lubricant Additive Packages

Although vegetable oils are used in very small quantities as the base stock for certain specialist lubricants, almost all base stocks are from mineral (petroleum) or synthetic origin. The viscosity, sulphur content, specific gravity, pour point and flash point of the base oil stocks determine the value of the base stock to the down stream companies that blend and manufacture lubricants.

For high viscosity base oils, pour points are typically not lower than -20^{o}C with a viscosity index in the range 90 to 100. Synthetic base oils on the other hand offer features such as pour points as low as -65^{o}C. These improved performance characteristics are counterbalanced by certain technical problems such as a tendency to shrink or expand seals and dissolve certain additives and a potential to oxidise.

The largest market for additives is in the transport sector where they are designed to protect moving metal surfaces and increasingly to extend the life of the lubricant and its range of functions. Waste oil contains significant quantities of additives. Without appropriate treatment they can cause, amongst other things, fouling and the production of malodorous gases within waste oil handling facilities. Strong odours from waste oil treatment are particularly associated with the many sulphur-based additives in lubricants, which can form highly malodorous compounds when in contact with heated water.

Major manufacturers of additives are Albright and Wilson at Oldbury, Infineum at Stanlow, Lubrizol at Bromborough Dock and Multisol at Irlam.

ADDITIVES USED IN LUBRICANTS

Additive	Compounds Used
Antiwear	Zinc dithiophosphates, acid phosphates, organic sulphur and chlorine compounds, sulphurised fats, sulfides and disulfides
Detergent	Metallo-organic compounds of sodium, calcium and magnesium phenolates, Phosphonates and sulphonates
Anticorrosion	Zinc dithiosphophates, metal phenolates, fatty acids and amines
Dispersant	Alkylsuccinimides, alkylsuccinic esters
Friction Modifier	Organic fatty acids, lard oil, phosphorus
Pour-Point Depressant	Alkylated naphthalene and phenolic polymers, polymethacrylates
Seal Swell Agent	Organic phosphates, aromatic hydrocarbons
Viscosity Modifier	Polymers of olefins, methacrylates, di-enes or alkylated styrenes
Antifoam	Silicone polymers, organic copolymers
Antioxidant	Zinc dithiophosphates, hindered phenols, aromatic amines, suphurised phenols
Metal deactivator	Organic complexes containing nitrogen and sulphur amines, sulphides and phosphites

Source: Derived from Lubrizol Corporation 2000

Blending and Lubricant Manufacturers

There are 3 major suppliers in the UK offering base stocks to companies that blend and mix additive packages for specific applications. As much as 75% of lubricant output is owned and managed by the major oil companies from base stocks supplied internally. The independent companies, the largest of which is Fuchs, control no more than 25% of the market but are themselves subject to two external controls on their apparent freedom to purchase base stocks of their choice. The first of these controls is the requirement to gain API/ACEA performance approval for new lubricant products. Typically the costs of doing so are in the range of £400,000 to £500,000. This tends to encourage research and innovation spending to be concentrated amongst the additive package specialists, the most important of which is Lubrizol. The complexity of keeping sophisticated additive packages in suspension requires the lubricant manufacturer to carefully specify the type of base oil. Manufacturers are typically constrained to buying a narrow range of base oils and where they have not devised their own additive packages they will buy in packages that have been tested and approved with specified base oils.

Some European operators of re-refining plant have expressed a concern that the increasingly integrated market structure for petroleum products makes the sale of re-refined product very difficult.

The value of the UK market is estimated to be approximately £1.8 billion annually.

The structure of the UK lubricant manufacturing market is more mature than in other European countries, notably Italy where the independent sector is considerably larger than in the UK. This has important implications for the viability of waste oil re-refining since the main market for the use of re-refined base oil is amongst smaller, independent blenders and manufacturers. Larger manufacturers with heavily branded products resist using re-refined base oils, either because of internal pressure to purchase virgin base stock from company refineries or because of various technical and marketing concerns. They are sensitive for

example to the way in which public attention is drawn to health issues. Waste oil has been described as potentially carcinogenic in a number of studies because of the presence of certain post combustion compounds. Brand managers are understandably highly sensitive to being associating their branded products with potentially carcinogenic substances. Our assumption that the independent sector is the natural market for re-refined oils could be avoided if waste oils were pretreated and fed back into a standard oil refinery since from that point onwards old oil would become indistinguishable from virgin oil. However, we are told that experience in Singapore has created health and safety concerns in the industry that will make an investment in this type of process unlikely.

The Institute of Petroleum publishes a quarterly update on deliveries of lubricant products in the UK market.

UK LUBRICANT CONSUMPTION
Tonnes

End Use	1998	1999	Jan - Sept 2000
Gasoline & Diesel Engines	244 189	249 488	178 167
Agricultural Engines	14 842	15 000	8 720
Other Engines	3 222	7 288	4 221
Marine Engines	39 488	37 728	25 582
Aviation & Turbine Oils	2 183	2 214	1 818
TOTAL ENGINE OILS	**303 924**	**311 718**	**218 508**
Hydraulic & Transmission	100 707	96 352	72 177
Other Gear Oil	57 645	53 815	41 601
TOTAL GEAR/TRANSMISSION OILS	**158 352**	**150 167**	**113 778**
Automotive Greases	4 959	4 786	3 173
Industrial Greases	6 402	6 981	5 244
Other Greases	52	48	52
TOTAL GREASES	**11 413**	**11 815**	**8 469**
Metalworking Oils - neat /soluble	33 019	28 736	21 109
Other	6 722	6 812	4 870
TOTAL METAL WORKING OILS	**39 741**	**35 548**	**25 979**
Turbine & Electrical Oils	26 904	27 070	19 121
General Machine Lubricants	19 630	15 219	13 190
Non-Lubricating Industrial Oils	11 674	11 792	10 454
Other Industrial Oils	12 234	10 939	6 579
TOTAL OTHER OILS	**70 442**	**65 020**	**49 344**
Process Oils	109 292	108 230	63 817
White Oils	18 977	21 678	13 184
TOTAL PROCESSING OILS	**128 269**	**129 908**	**77 001**
Deliveries to Blenders	100 597	86 151	113 298
TOTAL ALL LUBRICANTS	**812 738**	**790 327**	**606 376**

Source: Institute of Petroleum Jan 2001

According to data provided by Europalub, of the 790,327 tonnes of lubricant consumed in the UK in 1999, approximately 30,000 tonnes were imported. UK manufacturers exported approximately 350,000 tonnes of lubricant product.

The added value in these blending and manufacturing processes is the single most significant change in value before the lubricant is either used or collected as a waste product several months later.

ADDED VALUE IN LUBRICANT PRODUCTION, MARKETING AND DISTRIBUTION

Base Oil Pence per litre	Lubricant	Retail Pence per litre
25	10W/40 engine oil	350
50	0W/40 ACEA category E4.98 engine oil	800

Collectable Used Lubricants

Only a proportion of the 790,327 tonnes of lubricant used in the UK annually will be collectable following use. A British Lubricant Federation working group prepared a mass balance study in the early 1990s to estimate the amount consumed during use and a CONCAWE working group in 1996 (WQ/STF-26) made similar estimates for each main use of lubricant. These estimates, and others made for other economies, have tended to confirm that approximately 50% of lubricants are lost in use.

In some cases, no lubricant is recoverable. Where the lubricant is used in two stroke engines or as a process oil for example the product is either used as a fuel or so widely distributed that it could not be economically recovered. Many metal working oils are lost in use and are mostly dissolved then discharged to sewer. Many types of grease will be used and not collected other than in the form of oily rags.

Of the oil industry estimates of the recoverable or collectable percentage of lubricant sales, the least credible is that only 65% of oil sold as automotive engine oils can be recovered. This is the same percentage as that applied to agricultural engines. Over time we would expect the proportion to rise. If, for example, the percentage were 80% the additional oil from this source alone would increase by a further 37,423 tonnes.

Equally, it is possible that there are significant underestimates of the amount of oil used in various industrial processes and that consequently the amount of oil collectable oil is less than forecast.

In the absence of alternative data, we have accepted that approximately 390,000 tonnes of the lubricant used in the UK could be collected. However, this does not make any easier the task of measuring the amount of lubricating oil collected. At the point of collection, the condition of the used lubricant is often heavily contaminated with water, other fuel oils and various other wastes such that identifying the lubricating oil is difficult.

UK LUBRICANT COLLECTABLE WASTE OIL ESTIMATES
Tonnes

End Use	Sales 1999	%age recoverable[1]	Potentially Collectable
Gasoline & Diesel Engines	249 488	65	162 167
Agricultural Engines	15 000	65	9 750
Other Engines	7 288	0	0
Marine Engines	37 728	25	9 432
Aviation & Turbine Oils	2 214	50	1 107
TOTAL ENGINE OILS	**311 718**		**182 456**
Hydraulic & Transmission	96 352	80	77 082
Other Gear Oil	53 815	80	43 052
TOTAL GEAR/TRANSMISSION OILS	**150 167**		**120 134**
Automotive Greases	4 786	10	479
Industrial Greases	6 981	10	698
Other Greases	48	0	0
TOTAL GREASES	**11 815**		**1 177**
Metalworking Oils - neat /soluble	28 736	20	5 747
Other	6 812	20	1 362
TOTAL METAL WORKING OILS	**35 548**		**7 110**
Turbine & Electrical Oils	27 070	95	25 717
General Machine Lubricants	15 219	50	7 610
Non-Lubricating Industrial Oils	11 792	10	1 179
Other Industrial Oils	10 939	20	2 188
TOTAL OTHER OILS	**65 020**		**36 693**
Process Oils	108 230	0	0
White Oils	21 678	0	0
TOTAL PROCESSING OILS	**129 908**		**0**
Deliveries to Blenders	86 151	50	43 075
TOTAL ALL LUBRICANTS	**790 327**	**(49.4)**	**390 646**

1. Estimates based on CONCAWE WQ/STF-26 study

Intensity Of Use

Industrial Products

The use of additives and more sophisticated base oils has intensified the use of lubricant products. Although annual sales of 450,000 tonnes have remained broadly constant or have declined over the past 5 years, the price of lubricant products has increased to reflect their greater sophistication. Some industrial lubricant products, particularly cutting fluids, hydraulic oils, gear oils and quenching oils are laundered on site or at merchant facilities so that contaminants such as water and various solids are removed before additive packages are replaced and the lubricant is returned to use.

Only when the lubricant is no longer fit for the "laundry" or reconditioning process is it sent for disposal. In the past, companies such as Midland Oil Refinery laundered a range of industrial lubricants on behalf of major lubricant vendors. However, many of the larger vendors no longer offer this service as part of their total fluid care services to industry. The commercial drivers for this change in strategy are; used oil can be disposed free of charge; maintaining lubricant quality at remote industrial sites is over-reliant on a few highly skilled individuals; the requirement for specialised equipment on site; virgin lubricant can be cheaply

transported in bulk. The larger lubricant vendors are risk averse. Fearing incidents in which poor lubricant quality following a laundry process leads to a downtime claim and damaged machinery, they have generally left the "laundry" market, allowing smaller competitors to offer the service.

Companies active in this market are; Smallman Lubricants Ltd in the West Midlands, which was recently purchased by D.A. Stuart, Fuchs Lubricants, Houghton Vaughan of Birmingham and Oil Inventions Ltd. In the past, British Rail laundered significant quantities of lubricants for internal use but this no longer occurs. The volumes of lubricant subjected to a laundry process are not thought to be more than 45,000 tonnes annually and this is in decline.

Automotive Products

Approximately 42% of the waste oil collected is from the automotive sector; almost all of it is used engine oil. Changes in the specification of engine oils to achieve higher performance standards in use may have implications for the way in which waste oil can be reprocessed.

Two main systems of specification are used to identify the parameters within which the lubricant should perform; the API (American Petroleum Institute) and ACEA (Association des Constructeurs Europeen d'Automobile). Both have published a plethora of new standards in response to the demands of new engine technologies. Although the majority of engine oil sold continues to be traditional multigrade, there is a strong trend toward synthetic or semi synthetic first-fill oils at the car factory. The high performance oils allow extended service intervals and contribute toward an extended warranty period. Volkswagen are expected to offer commercial diesel engines with 100,000 km oil change intervals and other manufacturers will offer similar products.

The pressure from OEMs (Original Equipment Manufacturers) for extended warranty periods on commercial and passenger vehicles increases the demand for sophisticated additive packages. In the highest performance motor oils, such as the BMW long life oil, as much as 20% by weight of the product consists of an additive package of which approximately 50% is the carrying base oil.

The increasing use of additives in the engine oil offers enhanced economic and environmental benefits while in use but present additional difficulties for processors wishing to re-refine the lubricants after use. Although re-refined base oil will be improved by greater use of synthetic oils from mineral oil sources, a particularly difficult issue for some re-refining processes is the increasing use of esters in synthetic motor oil.

For those re-refining technologies that use sodium hydroxide, there is a risk that the ester will react with it to create soap that will appear in the final base oil unless subjected to a further washing process.

Whilst some high specification automotive lubricating oils are being used more intensively than in the past and consequently they are more contaminated after use, other industrial oils that were previously "laundered" and reused are now being disposed of sooner. Any economic instruments introduced to change incentives in the lubricant market and the associated waste oil market could take account of these trends by encouraging a more intensive first use.

COLLECTED WASTE OILS

The 790,327 tonnes of lubricant that were sold with a value of £1.8 billion are generally collected or lost in use within several months of purchase and have a residual value at the point of collection of between + £20 per tonne and - £30 per tonne depending upon the degree of contamination with water and other materials.

We estimate that 165,000 tonnes of used automotive lubricants are collected annually of a total of 380,000 tonnes and that at collection they have a value in the range £nil to £10 per tonne. Many industrial oils have a

lower value because of their higher levels of contamination. Typically, once mixed and sent for disposal these wastes contain as much as 90% water and have a negative value of £25 to £30 per tonne. We estimate from industry interviews that 75% of the constituent oil is recovered from this mixed waste and sold at a value of £64 per tonne (25p per gallon equivalent to 5.5 p per litre).

The Environment Agency, together with SEPA and Environment Agency Wales carried out a comprehensive study of industrial and commercial waste arisings and published their finding in January 2001.

OIL AND OIL/WATER MIXTURES SENT FOR DISPOSAL AS SPECIAL WASTE
Tonnes

REGION	Consigned As Special Waste	Treated / Disposed
Wales	111 376	105 883
NW England	95 118	107 264
East Midlands	60 668	76 045
West Midlands	132 827	172 662
SW England	113 260	93 434
SE England	183 024	156 989
London	67 491	12 689
Eastern England	82 371	107 843
Yorkshire & Humber	92 421	132 363
NE England	88 960	70 268
Scotland (estimated)	95 000	95 000
N Ireland (estimated)	30 000	30 000
TOTAL	**1 152 516**	**1 160 440**

Sources: Environment Agency 2001 R& D Publication 111, estimates by Oakdene Hollins

We have estimated that 391,000 tonnes of lubricating oils could be collected after use and that 380,000 tonnes are collected. Although this suggests that the UK has a 97% collection rate for waste oils, we believe that both estimates but in particular the collected tonnage estimate require further refinement. The amount of waste oil collected includes a higher proportion of contaminants, including water, than the collectable tonnage included at the point of sale. It also includes relatively small amounts of oily wastes that were not sold as lubricants.

OIL AND OIL/WATER MIXTURES - METHOD OF DISPOSAL
Tonnes

Region	Incineration	Landfill	Reuse	Transfer	Treatment	Other	Total
Wales	393	48 277	13 069	4 164	39 965	16	**105 883**
NW England	2 085	12 063	24 904	26 649	40 295	1 268	**107 264**
East Midlands	81	36 463	8 489	3 817	27 107	88	**76 045**
West Midlands	33	13 844	20 983	20 130	116 454	1 219	**172 662**
SW England	0	5 831	6 674	23 759	56 420	752	**93 434**
SE England	59	59 663	130	6 011	85 750	5 376	**156 989**
London	9	1	7	1 777	10 799	97	**12 689**
East England	0	36 286	21 984	15 061	34 415	97	**107 843**
Yorkshire & Humber	163	23 268	26 319	10 728	71 816	68	**132 363**
NE England	0	6 935	17	9 325	54 009	0	**70 286**
Scotland							**95 000**
N. Ireland							**30 000**
TOTAL	2 823	242 631	122 576	121 421	537 030	8 981	**1 160 440**

Sources: Environment Agency 2001 R& D Publication 111, estimates Oakdene Hollins.

The information collected by the Environment Agencies is the most comprehensive ever provided in the UK. However, the data does not enable the estimation of the amount of lubricating oils collected from users since they are typically mixed with so many other liquids and solids. The data is further complicated by the introduction of five additional sources of oily wastes, not generated from lubricant sales; production wastes from North Sea oil platforms (drilling muds etc) oily wastes from shipping discharging at UK ports (bilges etc) diesel/petrol mixtures mostly from garages where drivers have mistakenly filled fuel tanks with the wrong type of fuel, occasional production wastes from oil refineries (and base oil blenders and lubricant manufacturers) and imported waste oils. In Northern Ireland the estimates are inflated by diesel fuel seized by customs (diesel is smuggled from Ireland where it is cheaper) and by waste oils collected in Ireland but treated and sold as RFO by two companies (Capital Oils and Thompson Oils) based in Northern Ireland.

The Environment Agency for England and Wales carried out a further analysis of the movement of oil wastes. They identified 306,738 tonnes of oil wastes of which 45,954 were in short term transfer at the time of the survey. 22,913 tonnes were halogenated and mostly treated, reused or recycled. Of the 283,825 tonnes of non-halogenated oils, 22,569 tonnes (8%) were consigned to landfill disposal. Assuming that some part of the halogenated oils might be diluted within the larger body of non-halogenated oils during that average two month stock holding period for treatment and transport, the data suggests that approximately 275,000 tonnes of waste oils and oily wastes are consigned for treatment, reuse and recycling.

ENGLAND AND WALES - DISPOSAL ROUTES FOR OILS AND OILY WASTES 1998

Waste Type	Disposal Route	Tonnes
Oils - Halogenated	Incineration	165
	Landfill	410
	Recycling/Reuse	7 621
	Short Term Transfer	3 610
	Treatment	9 720
	Other	33
	Sub Total	***21 559***
Oils (Non-Halogenated)	Incineration	176
	Landfill	9 073
	Recycling/Reuse	53 818
	Short Term Transfer	35 553
	Treatment	110 249
	Other	464
	Sub Total	***209 333***
Oily Wastes (Halogenated)	Incineration	516
	Landfill	159
	Recycling/Reuse	48
	Short Term Transfer	148
	Treatment	477
	Other	6
	Sub Total	***1 354***
Oily Wastes (Non Halogenated)	Incineration	132
	Landfill	13 496
	Recycling/Reuse	10 323
	Short Term Transfer	6 637
	Treatment	39 497
	Other	4 403
	Sub Total	***74 488***
TOTALS England & Wales	Incineration	989
	Landfill	23 138
	Recycling/Reuse	71 810
	Short Term Transfer	45 948
	Treatment	159 943
	Other	4 906
	Total	**306 734**

Source: Derived from Environment Agency Bristol 2001 unpublished

This data is perhaps best regarded as the minimum recognised quantity of collected used oils. However, although it is the best we have it is likely to understate the actual amount of waste oils that are being collected, treated and reused. Our interviews with waste management and oil reclaiming businesses indicate that Section 62 notifications are unreliable, that treatment and transfer facilities do not make full returns to the Agency and that some facilities operated by large national companies in the waste management sector have never made a return.

Interviews were held with a number of waste management industry representatives with experience of the waste oils market in the UK to evaluate the extent and type of contamination that is customary.

Most industrial customers make no effort to segregate types of lubricant and it is not unusual for the mixed waste to contain less than 10% oil and have up to 20% solids. Specialist oil recovery companies collect wastes with a higher proportion of oil and typically avoid collecting the more heavily contaminated oily wastes and oil/water mixtures. As a general guide, of every 100 tonnes of oil/water mixtures delivered to a waste management oil/water treatment plant the waste yields approximately 5 tonnes of oil. Once the oil has been separated from water and other contaminants it is sold to specialist oil recovery businesses for between £0.24 and £0.28 per gallon (the equivalent of 5.3p and 6.2p per litre).

A number of waste collectors reported that price levels in the waste oils market had only recently recovered to those of the mid 1980's. During the late 1980's and 1990's the demand for recovered fuel oil declined. Large-scale users with industrial furnaces ceased trading or converted to gas. Greenhouses moved to gas as a source of heating and as the road stone industry slowly consolidated, the number of plants using recovered fuel oil (RFO) declined. The travelling distance to the more remote road stone quarries generally increased and thereby reduced the viability of treating waste oil for this market. Only in the past few years as the power industry started to use significantly greater volumes of RFO, has the price paid for RFO increased from 3 to 4p litre to 7p or 8p. It currently stands at a higher price than at any time in the past.

The waste oils collection, treatment and RFO supply business is broadly structured around three main types of waste oil supply; mixed, garage and imported.

Mixed Oils Sector

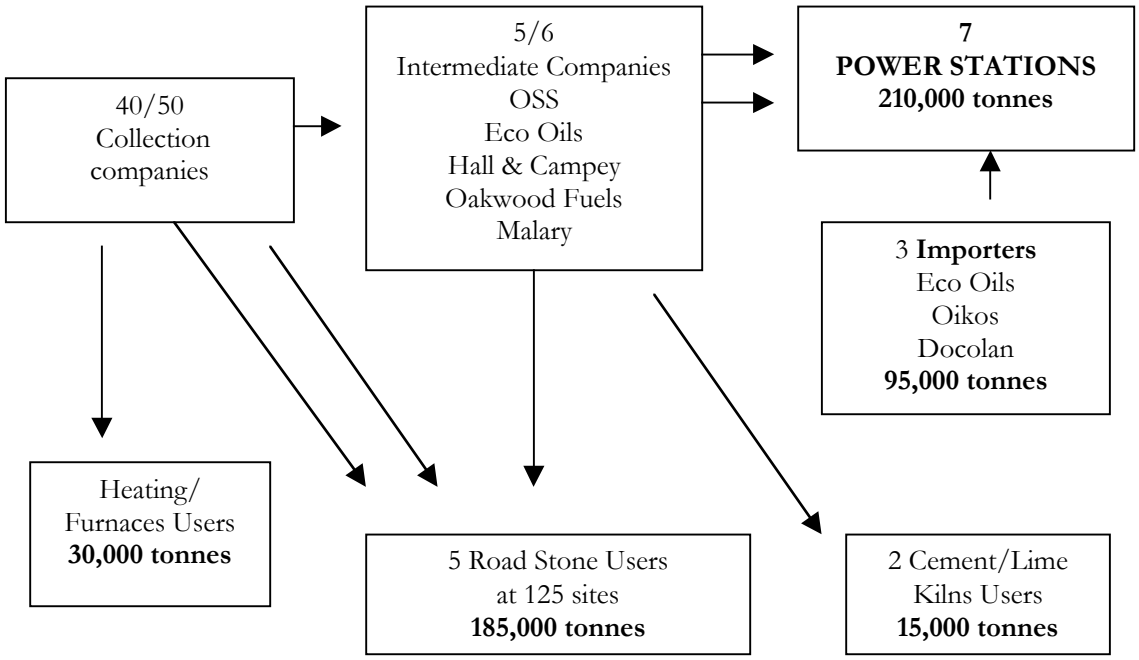
The waste management companies, Shanks, Cleanaway, Onyx and others compete for the mixed oil sector. We estimate that they collect approximately 850,000 tonnes of oil and oil/water wastes for which they are paid approximately £20 million. They sell no more than 40,000 tonnes of oil following treatment of these mixed wastes for which they are paid £2.4 million by specialist oil reclamation businesses.

Garage and Clean Industrial Oils Sector

Although we have described the sector as garage oils, it includes approximately 150,000 tonnes of relatively clean waste oils from industrial sources. The market for the collection of generally cleaner oil wastes in dominated by OSS Ltd. OSS grew significantly following the acquisition of Greenway Holdings plc for circa £7.6 million in March 2000. Annual turnover is estimated to be approximately £30 million and the company is thought to have contracts for the disposal of 225,000 tonnes of used oil to the final disposal/reuse market. Although the rest of the collection market is fragmented with as many as 50 companies, there are clear regional leaders such as Malary Oils in eastern England, handling approximately 15,000 tonnes of used oil. Malary is expected to grow further over the next few months. Eco Oils are acquiring smaller businesses and have recently purchased Merlin Oils from waste management company Onyx.

Waste oils tend not to travel more than 100 miles within the UK and consequently it is possible for regional companies to operate without larger competitors undermining their local competitive position through advantages of scale. If local road stone plants stop taking RFO and black oil following the introduction of the Waste Incineration Directive, the structure of the industry could change significantly as market power moves toward larger companies with contracts for the supply of RFO to power stations.

We estimate that this sector collect 340,000 tonnes of oil and oily wastes, treat it and sell it on with a value of £27 million, they buy and sell on a further 40,000 tonnes of oil from the waste management sector.



For a detailed flow diagram see appendices 1 and 2

Imported Oil Sector

The market for imported waste oil consists of three small companies, Docolan Holdings based at Cardiff Dock, Eco Oils based at Felixstowe and Oikos Oils on Canvey Island. Because of the increase in demand for RFO during 2000, all three companies have imported oil to supply contracts with UK power stations. The amount of waste oil notified is reported as being 183,418 tonnes in 2000, up from 76,919 tonnes in 1999. The amount recorded as having been shipped was considerably below this notification figure and, subject to quality verification of the data; imports for 2000 were recorded as being 79,332 tonnes.

We spoke with all three importers to clarify the position and we estimate that the three companies between them imported approximately 95,000 tonnes of waste oils during 2000. OSS Ltd is expected to begin importing waste oils to meet demand for RFO in the power station sector. We are aware that other companies have investigated the economics of importing waste oils but are not yet seeking contracts. Companies holding waste oil in Germany could send waste oil to cement kilns for which they would be paid approximately 120 DM per tonne (£38 per tonne) or 3.8p per litre. Exporting this material to one of the three UK importers must compete with this price. The oil is sold as RFO for 10p to 11p per litre and increasingly these contracts are being priced against a PLATTS benchmark so that prices change in line with oil fuel prices. Transport and handling costs will not exceed £50 per tonne when loads of 10,000 tonnes are being imported, leaving a margin of between 1.2p and 2.2p per litre to share between the traders to meet administrative and other costs.

Methods Of Treatment And Disposal

The Environment Agencies have collected information on the recorded disposal route for 1.2 million tonnes of oil and oil/water mixes. Estimates provided independently by specialist oil recovery companies suggest that together they process approximately 475,000 tonnes of used oil, 95,000 tonnes of which is imported from other European countries. Almost all of this is used for a replacement fuel in power stations and in the road stone industry.

The recovered fuel oil (RFO) is sold to power stations at a price in the range 9p to 11p per litre displacing heavy fuel oil that would otherwise cost the power station operators the equivalent of 13p per litre. Power station operators claim that RFO is only a substitute for heavy fuel oil, although we regard this as a negotiating position for pricing purposes. In general, heavy fuel oil should not be regarded as being a direct substitute for RFO as it is typically more difficult to handle, requiring heated tanks, whereas RFO has the viscosity to be pumped and sprayed on coal with ease. However, RFO does cause greater levels of corrosion in spray heads and pipe work than would be the case with virgin product. One of the issues that have distorted the demand for RFO in the past 18 months is that traditionally oil reclamation businesses have contracted with RFO users on a fixed price basis. This was understandable since their own costs were generally stable and were not greatly changed by oil price changes. The destruction in value between the point of buying a lubricant and disposing of it into the hands of a waste oil collector is so great that most virgin oil price movements had no impact on the cost of collection and disposal. However, many users of RFO regarded it as a substitute for gas oil, the price of which has been volatile. In the past six months the price has been as high as 23p per litre and is currently 15p per litre. When prices increased, RFO, which could be purchased at fixed prices of 11p per litre, became highly competitive and demand soon outstripped supply. To some extent, suppliers of RFO are addressing these contractual weaknesses so that a differential based on fuel price movements will be maintained by linking future prices to a PLATTS benchmark.

Power Station Users

RFO is used in coal and oil-fired power stations for its flame control properties. Typically, RFO is sprayed on to the coal at start-up and when adding significant new volumes of coal. Unless oil was added heat output would fall as the coal is added making the power generation less reliable.

Not all coal and oil fired power stations have authorization from the Environment Agency to use RFO. However, we would expect there to be a continuing pressure on the Agency to provide additional permits because of the cost savings available to the power generators.

Although there is no correlation between the amount of coal burnt in power stations and the use of RFO, the UK used 40.5 million tonnes of coal in power stations in 1999 indicating that RFO use represented no more than 1% to this total.

The coal-fired power stations in the UK that are known to have an authorisation for RFO have been shown.

COAL-FIRED POWER STATIONS IN THE UK

Operator	Station Name	Installed Capacity (Mega Watts)	RFO Authorisation
AES	Drax	3870	
	Fifoots Point	393	
	Belfast West	120	
Alcan	Lynemouth	248	
British Energy	Eggborough	1960	
TXU Europe	Drakelow	976	YES
	High Marnham	945	YES
	Iron Bridge	970	YES
	Rugeley	976	
	West Burton	1932	
Edison Mission Energy	Ferrybridge	1955	
	Fiddlers Ferry	1961	YES
Innogy	Aberthaw B	1489	Under Consideration
	Didcot A	2020	
London Electricity	Cottam	2008	YES
PowerGen	Ratcliffe	2000	YES
	Kingsnorth	1455	
Scottish Power	Cockenzie	1152	
	Longannet	2304	
	Methil	57	

Source: Derived from the Energy Report 2000 DTI

OIL-FIRED POWER STATIONS IN THE UK

Operator	Station Name	Installed Capacity (Mega Watts)	RFO Authorisation
AES	Kilroot (coal/oil)	520	
	Indian Queens	140	
Coolkeeragh Power	Coolkeragh	293	
Innogy plc	Tilbury B (coal/oil)	714	
	Fawley	518	
	Littlebrook D	755	YES
Midlands Power International	Redditch	29	
	Hereford	15	
PowerGen	Grain	1350	
Premier Power	Ballylumford (oil/gas)	1080	
Thermal	Peterhead (oil/gas)	1550	
Scottish Power	Kincardine	375	
	Clydes Mill (gas oil)	55	

Source: Derived from the Energy Report 2000 DTI

RFO must meet a minimum specification to be acceptable to the power stations. This is being progressively tightened by the Environment Agency such that certain operators claim that it will not be possible for suppliers to provide a waste oil derived fuel that meets the chlorine and sulphur limits.

TYPICAL SPECIFICATION FOR RFO SUPPLIED TO UK POWER STATIONS

PROPERTIES	MIN	MAX
Water content %	0	3
Density at 15°C (g/cm^3)	0.88	0.95
Flash Point (PMCC)	65°C	
Net Calorific Value (gJ / tonne)	40	
Viscosity @40°C (centi Stokes)	30	55
Sulphur %ww	0	1
Chlorine ppm	0	1100
PCB ppm	0	10
Lead ppm	0	200
Vanadium ppm	0	50
Copper ppm	0	50
Cadmium ppm	0	10
Chromium ppm	0	30
Nickel ppm	0	50

Suppliers of RFO to the power station market are reported to find most difficulty in consistently meeting the chlorine specification. Generally, imported waste oils have been reported as being lower in chlorine possibly because of contamination of used oils in the UK from other waste materials such as certain transformer oils or chlorinated greases.

Authorisations to use RFO are not based on a quantity limit; consequently it is difficult to estimate the amount of RFO being used by each authorised power station. We have spoken with suppliers and operators and from this have estimated the supply during the past 12 months. We have not shown amounts for each power station for reasons of commercial confidentiality.

POWER STATIONS USING RFO DURING 2000

Operator	Station Name	Installed Capacity (Mega Watts)	Estimate of RFO used 2000 (Tonnes)
TXU Europe	Drakelow	976	
	High Marnham	945	
	Iron Bridge	970	Not using RFO in early 2001. HFO only
Edison Mission Energy	Fiddlers Ferry	1961	
PowerGen	Ratcliffe	2000	
London Electricity	Cottam	2008	
Innogy plc	Littlebrook D	755	RFO delivered by barge
England & Wales			210,000
Scotland			None
N Ireland			None
		TOTAL UK	**210,000**

One or two of the operators have said that there may be further waste oil being supplied to power stations as a product and that this is not being accounted for in our figures.

Road Stone Industry Users

RFO has been used in the road stone industry since 1975/76 when the first trial burns were carried out. All five of the largest road stone companies, Tarmac, Hanson, RMC, Lafarge and Aggregate Industries use RFO in some of their 350 quarry locations that produce asphalt. We estimate that approximately 120 of the sites use RFO at least occasionally. For a time during the 1980s, this was the single largest outlet for RFO and prices were forced downwards to 3p or 4p per litre because of the buying power of the largest users, notably Tarmac. Asphalt production is energy intensive, requiring typically 10 to 12 litres of oil to heat each tonne. Although each rotary heater works on a 10% maximum requirement for RFO, the potential demand from this sector is greater than the potential supply, a situation that would normally allow the suppliers to gain a higher price for their product.

We have spoken to most of the major users and estimate that they are currently using 185,000 tonnes of RFO. However, this could be an underestimate since several very small waste oil collection businesses have told us that they are aware of direct deliveries of "black oil" to road stone plant outside of formal contractual arrangements. There is a steady decline in demand due to conversions to natural gas and an increasing use of kerosene and cleaner oils that require less maintenance of fabric filters and pipe work. The waste incineration directive will effectively close this disposal route for waste oils. This may cause particular problems in areas such as Scotland where there are no power stations accepting waste oils and only one cement kiln at Dunbar using them.

Cement Kiln Users

Cement kilns in the UK are increasingly using waste materials to substitute for fossil fuels. Castle Cement has led the way pioneering the use of secondary liquid fuels, a blend of solvent based wastes previously disposed at high-temperature incineration plant or landfill. Blue Circle and Rugby Cement have increased their own use of waste based fuels as have Redland at their Thrislington plant in the north east of England.

The British Cement Association (BCA) were asked to estimate the amount of waste oils used in cement kilns but reported that they believe the amounts to be so small as to be commercially sensitive. The Environment Agency believes that no waste oil is being used in cement kilns. Some of the cement manufacturers in the UK claim that they will not accept waste oils for less than £20 per tonne and whilst this is generally true for the more difficult oily sludges, cleaner oils are also accepted as a support fuel and a price paid for them. Other sources have reported that kilns are being used to dispose of oily wastes and from this we have estimated that 15,000 tonnes of waste oil is being accepted in cement kilns.

We would expect cement kilns to increase the amount of waste oils they accept in the future as they are unlikely to be adversely affected by the Waste Incineration Directive.

Industrial Furnaces Users

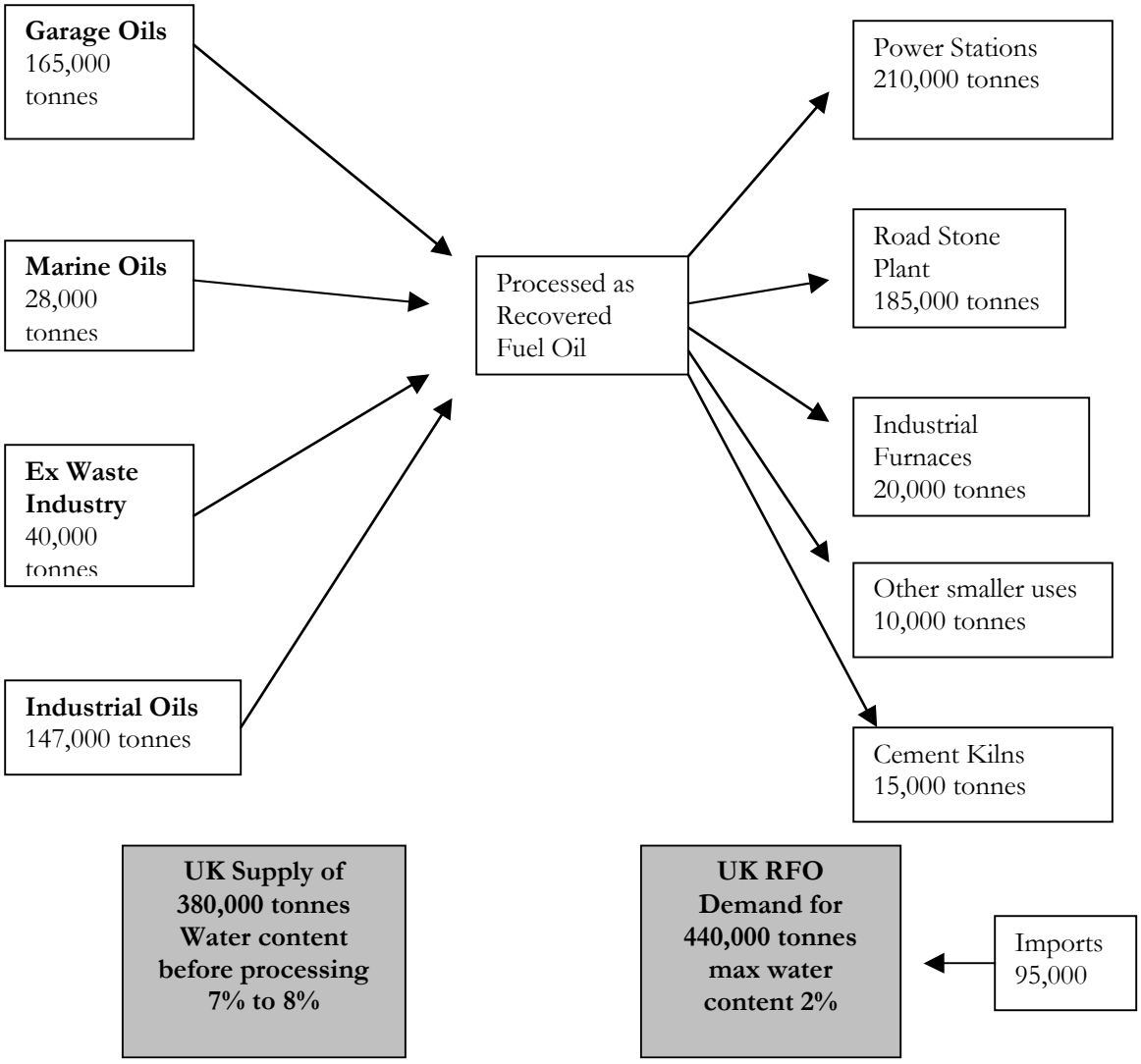
Heavy industrial processes such as steel production have used waste oils in the past and continue to do so. We asked a number of metal manufacturers to comment on the amount of waste oils and RFO used. From this, we estimate that they use no more than 20,000 tonnes annually. This will continue to decline and will effectively end following the introduction of the Waste Incineration Directive.

"Other" Users

Small waste collection companies receive enquiries during the winter months for supplies of waste oils as a low cost fuel in space heaters for use in horticultural, agricultural and light industrial premises. None of the companies we spoke with believed that more than a few thousand tonnes were supplied to this market and

that it is declining. Strictly, these users should apply for an authorisation to use waste oils as a fuel from their local authority the cost of which would make the use of RFO uneconomic. We suspect but cannot prove that, during the winter months, users are supplied without the necessary authorisations. The oil reclaiming business itself uses small quantities of waste oil to reduce water content. A small example is the Lanstar operation in Paisley on the site of the former whale oil and solvent refinery operated by Highgate and Job Ltd. Lanstar has a number of energy intensive operations on site and waste oil is used to fuel the boiler. We encountered some reluctance amongst oil collection businesses to discuss this market and it is possible that we have underestimated its significance. We have estimated that 10,000 tonnes of waste oil is used for these purposes, with a higher proportion of this in the winter months.

We have been unable to reconcile the data for the collection and use of waste oils. However, an important element is the water content of waste oil at various places in the supply chain. Collected tonnages include more than oil and the processing of waste oils is designed to drive off water, solids and other impurities to achieve a specification for the RFO supplied to end users. The loss of weight in these processes may be as much as 15,000 tonnes and will partly explain the discrepancy in the data.



The amount of this waste that is lubricating oil (excluding water) has been estimated by the ORA (Oil Recyclers Association) at 252,000 tonnes with a further 113,000 tonnes that was not fully described but which was likely to consist mostly of lubricating oils. Our trade interviews broadly coincide with this view and it is on this basis that we believe the collection rate of used lubricating oils in the UK to be at least 80%.

Duty Derogation On Waste Oils

The UK, in common with several EU member states, has a derogation on the duty that might otherwise be collected on "waste oils which are reused as fuel, either directly after recovery or following a recycling process for waste oils". The value of this derogation is 2.74p per litre which is the rate currently applied to heavy fuel oil. This duty rate is equivalent to 10.6p per gallon and £27.40 per tonne although the different densities should result in a 10% differential in favour of RFO.

The derogation was expected, amongst other matters, to provide a greater incentive to ship operators to discharge oily wastes in port in preference to using the waste as a fuel or discharging the waste at sea.

Waste Oil From Marine Sources

There are some 400 ports and 160 marinas in the UK. There is very little information available on the amount of oily waste discharged at these facilities. Collectors such as KD Offshore, owned by Onyx, Eco Oils and Waste Oil Services in Hull specialise in the marine sector. The type of waste collected from ships falls into three broad categories: slop oil, black oil and bilge water. Black oil is taken off generally larger ships operating on heavy fuel oil and forms a significant fraction of the total waste stream, perhaps as much as 60%. After contacting some of the larger ports, Dover, Southampton, Immingham, Felixstowe, Hull and Newhaven, we estimate that 95,000 tonnes of oily waste is taken off ships at British Ports at a cost of £2.4 million from which 28,000 tonnes of oil is recovered for use as RFO in power stations and elsewhere.

Pricing for these waste management services is either in hours, tonnes or as part of an overall package of services, but in broad terms is the equivalent of £25 to £30 per tonne, much the same as the price charged by the waste management industry for oil/water mixtures from industrial sources.

Legislative Drivers

Prior to the 1990 Environmental Protection Act, waste oil collection was predominantly a sector of the waste management industry in which itinerant individuals and organisations were able to operate largely unlicensed and unrecorded. The Environmental Protection Act placed a duty of care on disposers of waste to trade with licensed waste carriers. This had the effect of removing one unregulated element from the market although the commercial scale of many waste oil collection businesses remained very small, reflecting the low barriers to market entry. A further step in improving the level of record keeping in the sector was the extension of the Special Waste Regulations to waste oils in 1996 in response to the requirements of the Hazardous Waste Directive. Used engine oil for example is defined as carrying an H7 hazard property (carcinogenic) from the hazardous waste list where the waste exceeds a threshold level of 0.1%w/w.

The increased level of administrative care required by the regulations, increased the technical barriers to entry and increased the costs associated with collecting and treating waste oils. Most of the leading waste management and oil recovery businesses charge an additional £25 per load of special wastes to meet these costs.

Facilities for the transfer and treatment of waste oils are subject to planning regulations and integrated pollution control authorisations enforced by the Environment Agency. Where the site is used only for transfer the site is licensed under the waste management regulations. The Waste Oil Directive however has little impact on the day-to-day management of waste oil collection and processing.

As a small segment of the waste management sector, drivers for investment tend to ripple out from the effects of regulation on other sectors. The implications of the Landfill Directive have yet to be worked through but may include the opening up of new markets for waste oil as an input for novel treatment processes handling rubber tyre or plastic wastes. It will certainly involve a slight increase in the amount of waste oil directed to the sector from the waste management sector. The impact of the Waste Incineration Directive from 2006 on the customers of the sector is likely to be dramatic and the implications are considered in some detail in this study.

Waste Versus Product

Many of the existing users of RFO argue that RFO is a product and not a waste. Consequently they do not believe that the Waste Incineration Directive will have any impact on the operation of their demand for RFO. This is firmly not our opinion. During our study the High Court considered an application by Castle Cement

to designate Cemfuel as a product and not as a waste. Cemfuel is a high calorific liquid manufactured to a specification by a specialist contractor and used as a fuel supplement in cement kilns. The decision in this case (numbered CO/2635/2000) whilst specific to Cemfuel, has parallels in the manufacture of RFO from waste oils. The High Court decided to reject the application from Castle Cement.

Regeneration Options For Used Lubricating Oils

The Waste Oils Directive contains a presumption in favour of the re-refining of waste oil. However, although there have been a number of attempts in the UK to invest in this technology, all have failed commercially. Instead almost all of the waste oil collected is used as a substitute fuel.

If the Waste Incineration Directive were to prevent or restrict the use of RFO in power stations and similar furnaces, alternative methods of reusing waste oils would become more viable. These include:

- Re-Refining to a base stock
- Re-refining as an Ultra Low Sulphur Diesel Fuel additive
- Reuse as oil refinery feedstock

Re-Refining To A Base Lubricating Oil

The re-refining of used lubricating oils 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-moded acid / clay process.

In the UK, no waste lubricating oil is currently re-refined and sold as lubricant oil. The most recent investment in the re-refining industry of approximately £3 million was by Petrus Oils Ltd and it proved unsuccessful. The company constructed a plant in the West Midlands using novel solvent extraction technology provided by the American company Interline Inc. The main attraction of the Interline process was that it offered lower capital and operating costs than competing technologies. The 25,000 tonne per year plant suffered from severe fouling, accelerated corrosion and highly malodorous emissions to atmosphere. These problems were largely caused by the presence of sulphur and chlorine compounds in the lubricant additives combined with elevated levels of water contamination for this type of process.

As a result of this experience, it is highly likely that any new re-refining plant constructed in the UK in the future will include a range of pre treatment phases and a sophisticated hydrogenation process (or its equivalent), effectively adding £5 to £6 million to the minimum capital costs.

To determine the likely gate fee for a new re-refining plant in the UK we estimated the capital and operating costs for a new build plant based on two standard designs with an input capacity of 35,000 tonnes annually.

The key weakness in any potential business plan to construct a new re-refining plant is the market demand for the base oils that are manufactured.

We encountered some difficulty in this task, as there is a wide range of technologies available with new ones being developed. Viscolube, KTI, and IFP offer the most common process technologies available although there are many others. We consulted with operators in Germany and Scandinavia and with engineering consultants claiming experience with re-refining plants. Using estimates from a variety of sources, we estimated the capital and operating costs for a new 35,000 tonne plant. It is not based on a single proprietary process design but uses standard vacuum distillation and hydrotreating methods as the core treatment methods. The choice of a small 35,000 tonne plant was guided by the prospect of selling the

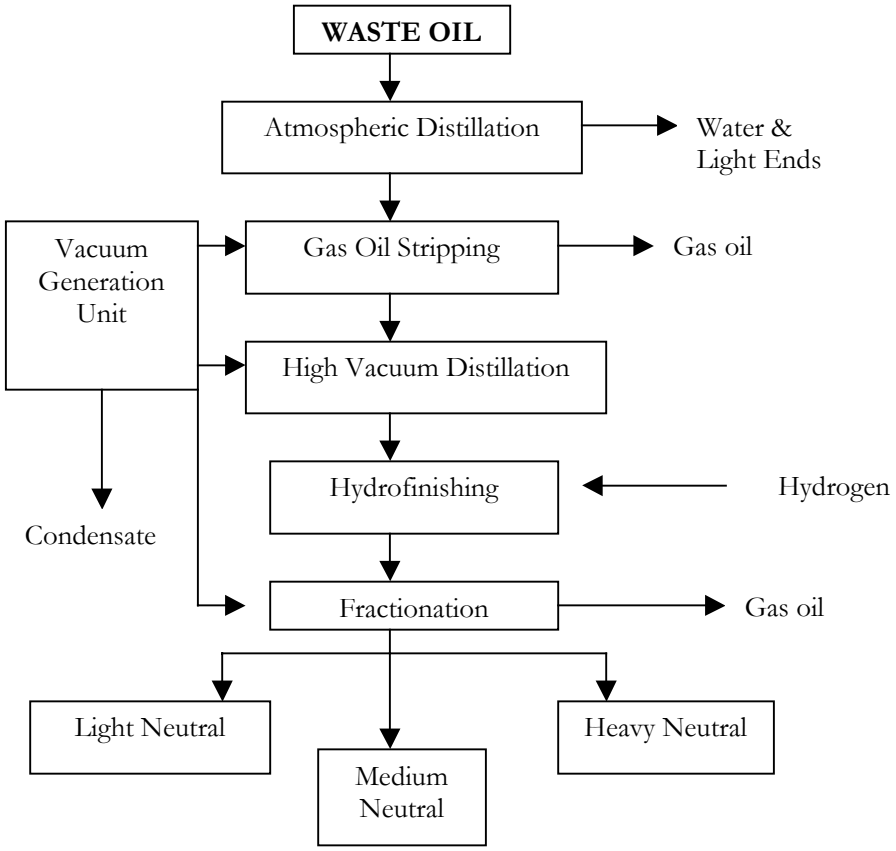
output to the independent lubricant manufacturers sector in the UK. This sector purchases no more than 175,000 tonnes of base oil annually.

According to Mike Ward Associates, the major processes used in North America are:

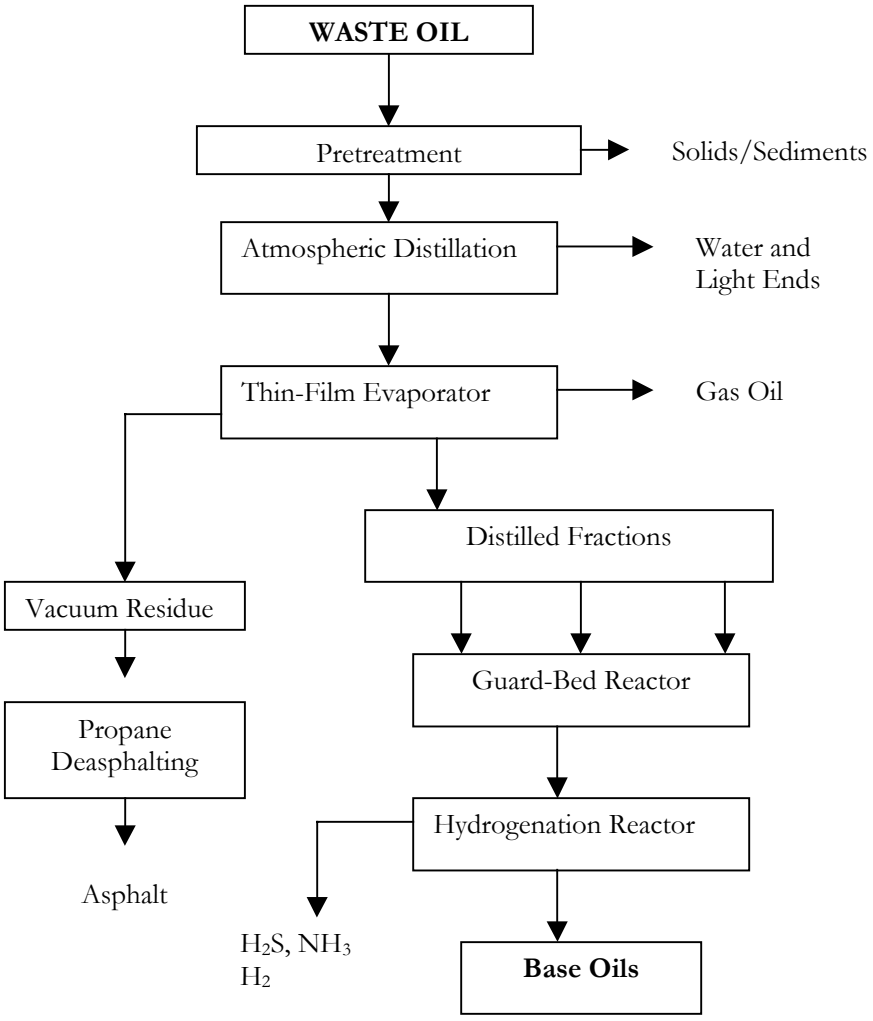
- Proprietary chemical treatment followed by distillation, hydrogenation and re-distillation;
- Distillation followed by hydrogenation and re-distillation (KTI process);
- Demetallisation followed by clay treatment, distillation and hydrogenation (PROP process).

In Western Europe the major processes used are:

- Distillation followed by acid treatment and clay treatment
- Distillation with propane deasphalting and clay treatment or hydrogenation
- Distillation with hydrogenation and re-distillation (KTI)



Block Diagram of the KTI Relube Process



Block Diagram of Vacuum Distillation/Hydrogenation Process

Technology Uncertainty

The growing international interest in waste oil re-refining has created a heightened level of technological uncertainty. Processes claiming to offer significantly reduced capital expenditure and operating cost profiles are the Vaxon process that uses cyclone distillation and solvent extraction, and two American processes that use steam stripping technology and hot atmosphere distillation. In the UK a novel filtration process proposed by De Montfort University shows some promise and if successful would offer much lower operating costs and a small minimum efficient scale. Unfortunately, whilst technical innovation is to be welcomed, from a potential investor's perspective, the technical uncertainties increase the level of risk and consequently the minimum required rate of return.

Whichever process is used, it remains to be seen whether the latest technical advances in re-refining prove to be sufficiently flexible to handle the changing composition of waste oils over the next 10 years. These are likely to include an increasing use of dispersants in engine oils as well as increasing use of esters and PAOs (poly-alpha-olefins). Dispersants are increasingly required to allow engine lubricants to operate for longer periods and to carry the dirt that builds up in use. The implication for re-refining is that used oils will become more complex and dirty over time and that blenders will increasingly demand a more consistent base lube

oil product making hydrotreating or solvent extraction or other equivalent methods less of an optional extra than has been the case in the past.

Scaling Uncertainty

There are scale advantages in most standard process designs for re-refining and these favour larger plants where there is sufficient demand for the re-refined base stock. Certain components of some of the processes place limits on through put. Thin-film evaporators (TFE) are typically relatively small and slow, handling less than 1 tonne per hour. The largest TFE in use can handle up to 3 tonnes per hour. Scaling each process such that it suits the type of inputs and outputs is complex. The costs and scale of some of the non-core plant and equipment will vary. Storage tanks for example may be very modest where the majority of the output is pumped to an adjacent blender. Alternatively, large storage tanks may permit better price management and improved product consistency for bulk orders.

Output Quality Choices

The two key decisions that determine the level of investment are the planned final quality of base lubricating oil and the scale of the plant. It may be possible to market a relatively inferior product to a few blenders in the UK at a significant price discount in which case a small plant based on out dated but proven technology would be appropriate. A higher quality base lubricating oil would require severe hydrotreating at high pressure, above 100 bar, and high temperature, above 350^{o}C. This product would meet the same initial resistance as the inferior product but may enjoy a wider market once it was seen to produce a consistently high quality output. A small plant would suffer from higher costs per tonne and would need to be expanded as the market for the product grew.

For the purposes of our analysis, we have taken two plants of 35,000 tonnes and assumed that one will produce a very high quality product using severe hydrotreating (or its equivalent) (process B) whilst the other will manufacture a less highly refined product (process A).

ESTIMATED CAPITAL COSTS FOR A NEW 35,000 TONNE RE-REFINING PLANT

	PROCESS A			PROCESS B	
	Min £ m	Max £ m		Min £ m	Max £ m
Site acquisition	0.5	0.75	Site acquisition (larger)	0.5	1.0
Planning, site preparation, licensing, design work	0.75	1.25	Planning, site preparation, licensing, design work	0.75	1.25
Sub Total (1)	1.25	2.0	Sub Total (1)	1.25	2.25
Core Processes (2)			**Core Processes (2)**		
Chemical Pretreatment			Atmospheric Distillation	0.2	0.3
TFE water removal			Vacuum Distillation	3.0	3.2
2 stage TFE Distillation			Severe hydrotreating or equivalent Centrifugation	2.0	2.2
Clay contact finishing (or light polishing)			Fractional Distillation	5.2	5.5
Steel work, Pipe work			Steel work, Pipe work		
Electrical, Construction			Electrical, Construction,		
Instrumentation etc			Instrumentation etc		
Sub Total (2)	4.0	4.3	Sub Total (2)	10.4	11.2
Non-Core Processes			**Non-Core Processes**		
Weigh Bridge			Weigh Bridge		
Laboratory, Offices			Laboratory, Offices		
Hard Standing			Hard Standing		
Utilities,Storage etc	3.2	3.7	Utilities, Storage etc	4.0	4.5
TOTAL	**8.45**	**10.0**	**TOTAL**	**15.65**	**17.95**

Operating Costs

Operating costs vary significantly between processes and within these processes different management systems can create a wide range of operating costs. The purchase and disposal costs of contact clays for the most out dated clay contact process can be avoided by using a more modern hydrotreating process. However, the hydrotreating process is typically very much more capital intensive and requires the use of costly hydrogen. Hydrotreating the distillate will yield a far higher quality product; possibly group 2 base oil, attracting a higher price than clay-treated distillate.

The management of the process carries implications for operating costs. Operating the reactor for hydrotreating the product at temperatures above 350^{o}C will improve the colour and reduce the level of sulphur, nitrogen and halogen levels but considerably increase the consumption of hydrogen.

Similar issues of using certain types of catalyst in preference to others and opting for certain processes in combination with others in the expectation of optimising either the efficiency of the process or else the type of base oils can dramatically alter the anticipated operating costs. There has been so little experience of operating re-refining plants in the UK that actual operating costs are likely to be higher than expected during the first 12 months of operation.

Maintenance costs can be considerably higher in poorly managed plants. Poor pretreatment can lead to coking and fouling, elevated levels of chlorine can lead to accelerated corrosion in pipe work.

Operating costs for smaller plants (less than 30,000 t.p.a) were reported to be in the range £60 to £85 per tonne. For larger plants (greater than 50,000 t.p.a) the costs were reported to be lower, ranging from as low as £26 per tonne for one plant in Germany to £75 per tonne. For the purposes of our benchmark 35,000 tonne plant we have based our estimates on 13 refinery staff costing £0.35 million annually and direct production costs of between £2.5 million and £3.2 million excluding hydrofinishing costs of £0.75 million. Income from base oil sales is more complex to forecast and is highly dependent on the market reception for the product over time. Non-hydrotreated product will not, in our opinion, achieve sales of more than 25,000 tonnes annually and average prices above the range £215 to £230 per tonne.

Average Gate Fees

Using our capital and operating costs, we have estimated a gate fee for a new 35,000 tonne re-refining plant.

GATE FEE ESTIMATES FOR A NEW 35,000 TONNE RE-REFINING PLANT

	PROCESS A			**PROCESS B**	
70% efficiency	35 000 tpa input		70% efficiency	35 000 tpa input	
	Min £ m	Max £ m		Min £ m	Max £ m
Income[1]	3.0	5.0	Income	5.5	6.7
Capital Costs	8.45	10.0	Capital Costs	15.65	17.95
Operating Costs	2.5	3.1	Operating Costs	3.2	3.5
Depreciation costs	0.85	1.1	Depreciation costs	1.6	1.8
Risk adjusted rate of return on project finance	15%	20%	Risk adjusted rate of return on project finance	15%	20%
Implied Gate Fee £ per tonne input	**- £46**	**- £34**	Implied Gate Fee £ per tonne input	**- £47**	**- £62**
Equivalent p / litre	**- 4.6**	**- 3.4**	**Equivalent p / litre**	**- 4.7**	**- 6.2**

1. The minimum level of sales of £3m assumes that not all of the production can be sold as base lubricating oil and is sold for alternative uses. The maximum level of sales of £6.7 million assumes that all 24,500 tonnes are sold at virgin price equivalent price of £273 tonne

The internal rate of return required on an investment in re-refining capacity is likely to be of the order of 15% or more. The history of commercial failures, uncertainty over technology and uncertainty over the changes in the consequences for plant reliability from future changes in the additives and type of oils present in waste oils increase the level of risk and therefore the level of return required from the investment.

Any commercial company seeking to invest in re-refining capacity would be unlikely to build an entirely new plant on a new site. Constructing the plant adjacent to existing facilities such as weighbridges, laboratory and offices would reduce the capital requirement by approximately £2 to £3 million and we are aware of a number of sites in the UK at which new investment could be added to existing plant and equipment, thereby reducing the implied gate fee;

- Stourbridge OSS Ltd
- Point of Ayr, Evergreen Ltd
- Stoke, Petrus Oils Ltd
- Newport, S Wales, Park Environmental Ltd
- Halesowen, Lanstar (CSG)
- Bristol, Chemical Recoveries

Existing but redundant re-refining plant is available at Stourbridge, owned by OSS Ltd. Until recently, this plant accepted no more than 8,000 tonnes of carefully selected waste oil to manufacture a group 1 base stock for sale into blenders mostly owned by the OSS group of companies. It is understood that the operating costs on this plant were modest, typically £60 per tonne of output over an 8,000 hour operating year.

The Point of Ayr plant in North Wales is a large site that was developed for coal products refining. It was purchased by Evergreen with the intention of converting it to a re-refining plant. However, for commercial and technical reasons it has not been operational for some time and would require a major refit. Nevertheless, the conversion costs are likely to be considerably below our estimates of the capital required for a new 35,000 t.p.a. plant.

Petrus Oils are currently dismantling their 40,000 tonne throughput Interline-designed solvent extraction plant. It is likely to be rebuilt in Germany and a hydrogenation process added to it. The existing site infrastructure would reduce the capital costs of building on an entirely new site.

In Newport, south Wales, Park Environmental operate a large liquid waste treatment plant. The plant was built in the early 1990s by Browning Ferris Industries of the USA but sold to Park Environmental when market conditions made the plant unprofitable. We understand that included on the site, but unused, is equipment for the atmospheric distillation of waste oils.

We would expect that one or more of these sites would be used to build new capacity if the market could sustain a re-refining plant and they would seek to build a plant that operates with a gate fee of not more than 1p per litre.

GATE FEE ESTIMATES FOR A 35,000 TONNE RE-REFINING PLANT ON AN EXISTING SITE

	PROCESS A			**PROCESS B**	
	Min £ m	Max £ m		Min £ m	Max £ m
Income[1]	3.0	5.0	Income	5.5	6.7
Capital Costs[2]	4.75	5.55	Capital Costs	11.15	12.45
Operating Costs	2.5	3.1	Operating Costs	3.2	3.5
Depreciation costs	0.46	0.56	Depreciation costs	1.1	1.2
Risk adjusted rate of return on Finance	15%	20%	Risk adjusted rate of return on Finance	15%	20%
Implied Gate Fee £ per tonne input	**- £19**	**+ £1**	**Implied Gate Fee £ per tonne input**	**- £13**	**- £14**
Equivalent p / litre	**- 1.9**	**+ 1.0**	**Equivalent p / litre**	**- 1.3**	**- 1.4**

1. The minimum level of sales of £3m assumes that not all of the production can be sold as base lubricating oil and is sold for alternative uses. The maximum level of sales of £6.7 million assumes that all 24,500 tonnes are sold at virgin price equivalent price of £273 tonne
2. Capital costs have been reduced by the value of site acquisition and all non-core capital costs that are assumed to be shared with existing facilities.

It might be argued that our risk-adjusted rate of return for investment in re-refining plant is unreasonable as some of the potential investors in the market will be able to borrow funds at rates of interest between 8% and 10%. The risk could be reduced if contracts for the output of base lubricating oil were secured prior to the investment being made, however our enquiries have given no indication that this is likely without support by major oil companies. We have included an estimate of gate fees at a 10% rate of return on capital.

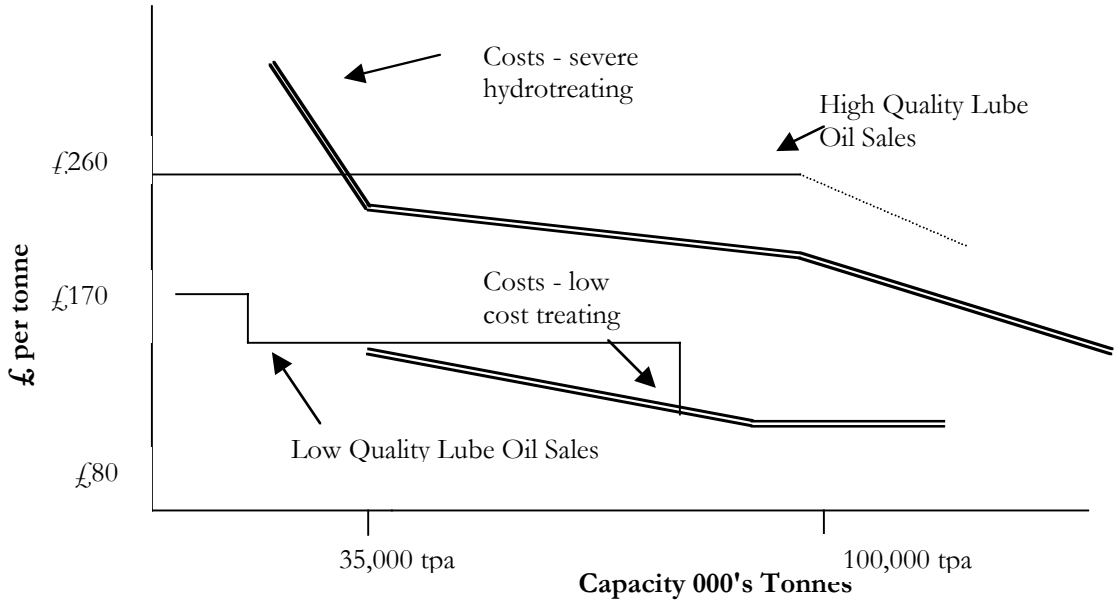
GATE FEE ESTIMATES FOR A 35,000 TONNE RE-REFINING PLANT ON AN EXISTING SITE

	PROCESS A			PROCESS B	
	Min £ m	Max £ m		Min £ m	Max £ m
Income[1]	3.0	5.0	Income	5.5	6.7
Capital Costs[2]	4.75	5.55	Capital Costs	11.15	12.45
Operating Costs	2.5	3.1	Operating Costs	3.2	3.5
Depreciation costs	0.46	0.56	Depreciation costs	1.1	1.2
Risk free rate of 5% plus a corporate premium	10%	10%	Risk free rate of 5% plus a corporate premium	10%	10%
Implied Gate Fee £ per tonne input	**- £12**	**+ £22**	**Implied Gate Fee £ per tonne input**	**- £8**	**+22**
Equivalent p / litre	**- 1.2**	**+ 2.2**	**Equivalent p / litre**	**- 0.8**	**+ 2.2**

1. The minimum level of sales of £3m assumes that not all of the production can be sold as base lubricating oil and is sold for alternative uses. The maximum level of sales of £6.7 million assumes that all 24,500 tonnes are sold at virgin price equivalent price of £273 tonne
2. Capital costs have been reduced by the value of site acquisition and all non-core capital costs that are assumed to be shared with existing facilities.

If the scale of the plant were larger, the implied gate fee would fall although the cost of transporting waste oil to the plant would begin to erode the advantages of scale. As a general guide in the UK, we would expect the advantages of scale to begin to decline for plants larger than 100,000 tonnes input. We carried out an exercise to evaluate the advantages of scale using a limited range of data. Using the minimum level of capital investment, assuming that plant was built on existing sites and a 10% rate of return we plotted the cost curves against expected income from high and low quality base oil output. There is a very limited market for poor quality output and the horizontal income line stops at what we believe to be the limit to the market. We have used costs per tonne of *output* and taken an average plant efficiency of 70%.

MINIMUM COSTS PER TONNE OF RE-REFINED OUTPUT COMPARED TO POTENTIAL INCOME



The graph takes the most optimistic investment scenario are indicates that a gate fee of zero to 1p per litre is achievable in the UK. It also shows that a larger scale plant of 100,000 tonnes or more offers a better opportunity to earn a positive return but that this is only achievable where there is strong market demand for the re-refined product.

Investments in re-refining techniques in the past have been based on the expectation of selling the output at a price comparable to virgin base lubricating oils. The poor market position of re-refined oils as a consequence of these investments has made it more difficult for re-refiners investing in high quality manufacturing plant to have any confidence of selling their output at prices comparable to virgin lubricating oils.

The commercial risks associated with an investment in re-refining waste oils are intensified by the possibility of waste oils being taken back at oil refineries after rudimentary treatment or taken to plants designed to manufacture a diesel fuel extender. We have discussed both possibilities with leading oil companies. None has expressed any enthusiasm for developing a return to refinery system on the grounds of health and safety issues at the refineries. One major oil company is developing proposals to build a plant in a European country that will use waste oils to manufacture a low-sulphur diesel extender. There are fewer scaling issues for a plant of this type since the market for the output is assured and massive relative to the scale of output. The gate fee is likely to be zero.

MARKETING RE-REFINED BASE OILS

Independent blenders and manufacturers of lubricant products who hold approximately 25% of the UK market generally perceive re-refined base oils as inferior to virgin base oils. As such there is an expectation that the price for re-refined base oils should be at least 10% less than virgin products. Even at a 10% to 15% price discount, a number of the larger integrated companies have reported to us that they would not purchase re-refined base oils. Russian sourced virgin lubricating base oils are being marketed in the UK at a 20% discount to virgin prices of £280 tonne, and there is resistance to this product at this level of discount. Those displaying strongest resistance to re-refined oils are manufacturers of branded automotive oils. European vendors of re-refined oils and those with some experience of selling re-refined oils in the UK strongly feel that the technical qualities of re-refined stock are no different from any group 1 base oils. Nevertheless, this is not a perception that is currently widely held amongst potential customers for base oils.

Approximately 1.1 million tonnes of lubricating base oils are manufactured annually in the UK, 30% of which is exported. Approximately 750,000 tonnes of base oils are sold to lubricant manufacturers, 75% of it to companies owned by major base oil manufacturers. We investigated the potential market for re-refined base oils because of the high degree of sensitivity amongst certain large purchasers of base oils concerning the consistency and quality of re-refined base oils. We have concluded that no more than 75,000 - 100,000 tonnes of re-refined base oils could be sold without price discounts of more than 20%. This is a theoretical maximum and in practice we doubt whether more than 20,000 tonnes could be sold in the first year of operation because of intense market scepticism and the very real technical barriers to the independents being able to purchase re-refined oils. As a perceived inferior good, discounted prices merely reinforce the market signal that the product is inferior.

The main barriers are different for various types of lubricant product. In the automotive sector, the costs of testing automotive oils to meet specification and performance standards make the use of small quantities of variable, re-refined base oils, prohibitively expensive. One brand manager reported to us his fear of an irrational media campaign against a product that uses cheap, inferior and possibly carcinogenic base oil.

In other product sectors, buyers have emphasised past experience with re-refined products, claiming that they have seen re-refined oils that "smell burnt or rotten and appear dirty". Some of these experiences were relatively recent.

The product areas where we found least resistance to using re-refined base oils were in the gear and hydraulic oils segments. Although this sector represents as much as 130,000 tonnes of manufactured product, re-refined base oils would be used as part of a blend and might only be expected to sell 25,000 to 35,000 tonnes into the segment.

Applications in other, mostly industrial and marine products could offer a further 25,000 to 35,000 tonnes of demand for re-refined base oils.

The engine oil market is the largest sector into which re-refined oil is effectively excluded. However, there is a large domestic and export market for low-price 20:50 engine oil that might offer an outlet for re-refined base stock. The extent to which this sector could use re-refined base oils has been difficult to estimate since positive comments about using the base stock have been made only with caveats about consistency.

The difficulty in selling re-refined base stock during the early 1990s led Orcol Ltd, now owned by OSS, to vertically integrate their waste oil collection and re-refining business with a lubricant manufacturer. This type of market restructuring can only be successful if the lubricant products manufactured by the integrated business are not regarded as inferior in their end markets following the integration.

Without the support of major lubricant manufacturers, re-refined base stock producers will continue to have only a relatively small market into which to sell their product. The main difficulty this presents is that the potential size of the market is such that investors in re-refining plant will be concerned about where to sell the product should demand from one or two customers fall by reason of corporate activity. This commercial risk will be reflected in an increase in the minimum rate of return required on the investment in re-refining plant.

In other countries, re-refined base lube oils may have been used in the past without acknowledgement on the final product. Examples include Elf in Belgium, Valvoline in the Netherlands, LPC Hellas (Voyager and Vector brands) and BP Oil in Greece (Energol HD and Visco 2000). The Spanish company producing the Urania range makes no claims about re-refined oils and neither does Repsol a competing company also based in Spain. Mohawk in Canada is a notable exception to this theme and sells motor oil with a strap line "Environmental choice - over 50% recycled". Shell Hellas (Helix, Myrina) could use re-refined base oils supplied from local sources but Shell Group advise that their present policy "is to avoid the blending or marketing of any product containing re-refined base oils". Experience elsewhere demonstrates that re-refined oils can be used without significant difficulty but in the UK market there is no clear source of demand for the product, merely different degrees of resistance.

SUMMARY OF POTENTIAL BUYERS OF RE-REFINED BASE OILS

Sector	Companies	Comment
Additives	25/30 competitors marketing additive packages. The additives are carried in base oil	Re-refined oil tends to be inconsistent and this adds to the complications of adjusting the carrying oil so that the additives do not fall out of suspension. **Strong resistance**
Automotive	50 competitors, dominated by a few large ones	Market is moving toward group 2 and group 3 oils although re-refined oils could be used in cheaper 20:50 oils. Problems of quality testing a major barrier. **Strong resistance**
Food Processing Lubricants	25/35 competitors, including all of the majors. Growing market	End customer resistance because of food safety concerns. **Strong resistance**
Gear Oils	50 competitors marketing a range of gear oils	Possible uses if prices are right since most gear oils operate at lower temperatures and are less sophisticated than other automotive products. **Mild resistance**
Hydraulic Oils	10/20 competitors	Possible uses if prices are right since additive packages are sometimes malodorous and operating temperatures are low. **Some interest from non-branded product manufacturers**
Other Industrial Oils	30/40 competitors marketing wide range of metal working fluids, quench oils, process oils etc	A large segment in which certain products might be suitable for re-refined product (metals sector) but only if it is smell free and reasonably clear. Strong resistance for certain uses and end customers e.g. pharmaceutical. **Some limited interest**
Industrial Engine Oils	15/20 companies supplying this small market	Increasing trend toward more sophisticated lubricants but some interest in a good quality product. Problem may be with end users or in meeting quality standards. **Mild resistance**
Military Engines	Supplied mostly by the majors	Specific requirements in certain cases make re-refined base stocks unsuitable. **Strong resistance**
2 & 4 stroke Engine oils	10/15 suppliers but mostly dominated by branded products	Branded product resistance but some potential for a god quality re-refined product. **Mild resistance**
Rolling Oils	5/10 competitors in this small and declining segment	Some potential for re-refined product at the right price. **Mild resistance**
Transformer Oils	15/20 competitors	Uncertainty about contaminants in re-refined product because of long term use of transformer oils make for resistance in a segment that should be a market for re-refined product. **Resistance**

Phone enquiries made during February 2001

Economic Costs and Benefits Of Four Policy Options

The four main policy options that we have been asked to consider are:

1. Business as usual;
2. Removal of the excise duty derogation which currently applies in the case of waste oils used as a fuel;
3. A ban on waste oil combustion, except in hazardous waste incinerators
4. Combinations of the above

To evaluate these options we have prepared a forecast of prices and volumes from waste oil collection through to waste oil disposal/reuse. All options have assumed a stable oil price of between $25 and $28 barrel.

Business as Usual Option

The "business as usual option" takes account of proposed legislative changes, notably the Waste Incineration Directive, that may require quarries, industrial furnaces and possibly power stations to cease using RFO. It assumes that there will be no change to the level of duty paid on the use of RFO. It takes account of anticipated increases in gate fees at landfill sites and the introduction of the Landfill Directive. The impact of increasing gate fees and the Landfill Directive is relatively modest during the period to 2006. In general, the additional processing of oily wastes currently directed to landfill is likely to create no more than an additional 3 to 5,000 of waste oil suitable for blending into RFO. Improving rates of oil capture at garages might broadly compensate for a reduction in the volume of engine lubricant sold due to longer service intervals and improved lubricant performance. Overall, we would expect to see no growth in the volume of collected and treated waste oils. The oily wastes currently sent to landfill are unsuitable for treatment and for the most part are likely to be incinerated in cement kilns except where they have significant water content.

Although conversions to natural gas and closure of coal-fired power stations will continue, the potential demand from these sectors for RFO will be diminished by compliance with the Waste Incineration Directive from 2006. We would expect power stations to continue using RFO on the basis of it being a product until this dispute is settled at some date after 2006. However, we would expect all other users to abandon the use of RFO. This will cause a sharp fall in the value of RFO and that part which is not taken to power stations will be consigned to cement kilns. The fall in value of waste oil will lead to a reduction in the amount of oil collected although the amount is difficult to forecast. We have assumed a 10% reduction.

This option should be compared with the 4th, "combination" option. The combination option assumes that the duty derogation will be removed and that demand at the power station sector will reduce slightly by 2006.

"BUSINESS AS USUAL" SCENARIO 2006 FORECAST

	2000/ 01		2006 Forecast	
	Prices per litre	**Tonnes**	**Prices per litre**	**Tonnes**
Mixed Waste Oils Collected	-2 p	1 200 000	-3 p	1 200 000
Treated Waste Oils	5 p	385 000	Nil	345 000
RFO Sales Power Sector	10 p	210 000	6 p	230 000
RFO Sales Road Stone Sector	8 p	185 000	Banned W.I.D	Nil
RFO Sales Cement Kilns	7 p	15 000	-2 p	70 000
RFO Sales Industrial Furnaces	8 p	20 000	Banned W.I.D	Nil
RFO Sales Other Sectors	8 p	10 000	Banned W.I.D	Nil
Unaccounted for but including water content/solids removed during processing		40 000		30 000
Merchant Plants Laundering hydraulic/gear oils	In-house	Nil		15 000
Re-refined as base lube stock		Nil		Nil
2005 Spec Diesel		Nil		Nil
Imported Waste Oils		95 000		Nil

Removal of Excise Duty Derogation Option

The excise duty derogation was introduced to encourage ship operators to discharge oily slops and tank washings in port rather than at sea. Our enquiries suggest that the volume of oily waste from marine sources is falling as ship operators manage the waste more carefully. However, the oil content of the waste is increasing thereby reducing the cost of having it pumped off the ship. We estimate that 95,000 tonnes of oily wastes are removed from ships at British ports from which 28,000 tonnes of oil are processed for use as an RFO.

The waste oil, once treated, has a value of 9p to 11p per litre as an RFO. The user avoids paying 2.74p per litre duty on the fuel. A duty of 2.74p per litre would raise approximately £9.7 million at current levels of RFO demand. The marginal tonnage of RFO is the waste oil imported from other European countries. This trade would diminish as prices (net of duty) fall by approximately 2 to 3 p litre for RFO. However, there is sufficient margin for the duty to be paid and for this trade to continue for certain loads of waste oil, it would become marginal at a price of 9p per litre and below. Only a modest increase in gas oil prices above current levels would encourage resumption in imports to meet increased demand from RFO users.

The reduction in price paid for RFO would be reflected at the point of collection, where prices charged or fees paid for waste oil would be adjusted by approximately 20%. There is likely to be a fall in the amount of waste oil collected in certain rural areas, notably in Northern Ireland, parts of Wales and parts of Scotland. In these areas, the cost of waste oil collection is higher because of the greater distances between the point of collection and disposal. Although waste oils are subject to the special waste regulations, waste oils collection companies in Northern Ireland and Scotland have reported to us that their experience in the past has been to see the volume of collected waste oil fall when market prices at the point of collection have reduced. We are not convinced by the argument that the collection infrastructure will collapse following the imposition of a 2.74 p per litre duty since the variation in prices for RFO over the past 5 years has been greater than 4p per litre. The additional costs of the special waste regulations that have been absorbed by the higher prices paid for RFO will be felt at the point of collection. Overall, we would not expect more than 2

- 5,000 tonnes of waste oil to be illegally dumped as a result of the change in duty. The impact on marine based waste should be negligible if the change in derogation occurs in all European countries.

One of the most marginal activities in waste oil recovery is the processing of oil filters. The value of the metal recovered from oil filters has fallen to zero. The oil recovered has a positive value but as this would fall by approximately 3p litre, the fee for collecting filters would increase. An unknown amount may be disposed inappropriately in the future but we do not find credible the argument that once collected these wastes will be dumped to landfill instead of being processed to remove the oil and recycle the metal. The cost of landfill disposal would be prohibitive at approximately £50 per drum load and will not be possible once the Landfill Directive has been implemented.

This option forecasts the changes in 2005 and disregards any effects caused by the Waste Incineration Directive.

"DUTY DEROGATION REMOVAL" SCENARIO 2005 FORECAST

	2000/ 01		2005 Forecast	
	Prices per litre	**Tonnes**	**Prices per litre**	**Tonnes**
Mixed Waste Oils Collected	-2 p	1 200 000	-3 p	1 200 000
Treated Waste Oils	5 p	385 000	2 p	375 000
RFO Sales Power Sector	10 p	210 000	8 p	210 000
RFO Sales Road Stone Sector	8 p	185 000	6 p	120 000
RFO Sales Cement Kilns	7 p	15 000	5 p	15 000
RFO Sales Industrial Furnaces	8 p	20 000	6 p	5 000
RFO Sales "Other" Sector	8 p	10 000	6 p	5 000
Unaccounted for but including water and solids content removed during processing		40 000		40000
Re-refined as base lube stock		Nil		Nil
2005 Spec Diesel		Nil		Nil
Imported Waste Oils		95 000		20 000
Duty raised on RFO			£9.7m declining to £5.8 m in 2006 and possibly nil thereafter	

Ban On Waste Oil Combustion, Except In Hazardous Waste Incinerators Option

If the combustion of treated waste oils were to be banned, the market structure would alter dramatically in response to entirely different price signals. The process of change would need to be managed with care if significant quantities of used oils were not to be disposed of inappropriately.

Used garage oils would have a negative price of approximately 5p per litre, representing the cost of transport and disposal to one of three high-temperature incineration facilities. Shanks, at Fawley near Southampton and at Pontypool in South Wales, operate two of these. Cleanaway operates the third at Ellesmere Port in the North West of England. In view of the gate fees charged for high-temperature incineration, we would not expect more than a few hundreds of tonnes of waste oils to be incinerated. However, the still bottoms and other wastes from re-refining processes may also be sent to incineration, if cement kilns could not accept the material. Only those oils contaminated by substances such as PCBs would be incinerated. The remaining oil would be directed to various laundry processes, re-refining and a range of novel processes such as combining waste oils with plastics and or tyres. These novel processes may also include the production of extenders for 2005 specification diesel fuel.

Only one large plant would be necessary to take waste oils to process into 2005 specification diesel. One major oil company is considering this option and although they will not be investing in the UK until price signals change, they are actively pursuing an investment opportunity in Europe. The main advantage over re-refining is that the market for their product is assured since the demand for 2005 specification diesel is robust and growing. Demand for lubricants on the other hand is modest, static and complex.

Should a single large diesel extender plant be established in the UK, it is likely that at least one and possibly two re-refineries would be established because of the transport costs of moving all waste oils to a single location. As a rough guide, tanker operators budget for a cost of £45 per hour, the equivalent of 0.5p per litre per 100 miles with a full load.

We would also expect to see an increase in the volume of lubricant laundered and reused before disposal to the re-refining and diesel extender route. This increased intensity of use would tend to make waste oil more difficult to reprocess and may reduce demand for lubricants slightly.

Should cement and lime kilns accept waste oils they would take the more difficult sludges and mixtures of waste oils as well as some of the process wastes from re-refining and laundry processes. We assume that the Environment Agency will look carefully at the disposal route of still bottoms and similar wastes from the re-refining process.

A difficult issue to evaluate is the impact on the waste oil collection infrastructure. All waste oil, even that which is comparatively unmixed, would be costly to have collected. In these circumstances, an unknown amount of waste oil may be burned or tipped down drains to avoid the increased collection costs. Assuming that re-refining, laundry and various other novel processes are established with gate fees in the range nil to 2p litre, the collection fees for garage oil for example may be 5p per litre, whereas more complex mixed oils might be 6p per litre. These costs are significantly above current prices.

"COMBUSTION BAN" SCENARIO 2006 FORECAST

	2000/ 01		**2006 Forecast**	
	Prices per litre	**Tonnes**	**Prices per litre**	**Tonnes**
Waste Oils Collected	-2 p	1 200 000	-3 p	1 100 000
Treated waste Oils	5 p	385 000	-4 p	340 000
RFO Sales Power Sector	10 p	210 000	*Banned*	Nil
RFO Sales Roadstone Sector	8 p	185 000	*Banned*	Nil
RFO Sales Cement Kilns	7 p	15 000	*Banned*	Nil
RFO Sales "Other" Sector	8 p	10 000	*Banned*	Nil
Unaccounted for but including water+solids removed		40 000		
Re-refined as base lube stock		Nil	-1 p	35 000
2005 Spec Diesel		Nil	Nil	280 000
Merchant Plants Laundering hydraulic/gear oils	In - house	Nil		15 000
Novel reuses with waste plastics/rubber etc			Nil	10 000
High-Temperature Incineration / Cement Kilns	Mostly waste from re-refining and diesel extender production		-2p / -15p litre	300
Imported Waste Oils		95 000		Nil

The combustion ban scenario would transform the economics of waste oil collection and processing. Certain sectors would benefit whilst others would incur greater costs. We have summarised these in the following table. We estimate that this option would incur additional costs of £67.5 million annually. The oil refining industry would see sales of diesel fuel and some base lubricant oil reduced by approximately 300,000 tonnes annually as re-refined stocks and diesel extenders are manufactured from used oils. Sales of heavy fuel oil, coal, gas oil or natural gas would increase by an equivalent amount to those sectors that had previously used RFO. An unknown amount of used oil would be disposed of inappropriately, mostly in rural locations but the environmental costs of burning waste oils in power stations and rotary heaters in road stone quarries will have been averted.

SUMMARY OF COSTS IMPOSED BY A TOTAL BAN ON RFO USE (AT 2001 PRICES)

Sector	Sales/Costs £m		Cost met by
	2001	Post ban	
Waste Oils Collection	20.0	46.6	£26.6m of additional costs met by industry
Power Station Costs	21.0	27.3	£6.3m of additional costs passed on in electricity prices
Road Stone Costs	14.8	20.3	£5.5m of additional costs passed on in asphalt prices
Waste Oil Importers	4.75	Nil	£4.75m of trading activity ceases

Combination Option

This option represents what we expect to be the outcome from the various pressures on the sector over the period to 2006. It takes account of the potential impact of the Hazardous Waste Incineration Directive on the burning of waste oils as RFO and the possibility of a change in the duty levels for RFO. We have used the 2000 study for the department by ENTEC consultants as a general guide and have spoken to industry representatives and Environment Agency staff. The study forecasts that road stone plants will cease to use RFO as a source of fuel following introduction of the Waste Incineration Directive. The main power station users, TXU, PowerGen, Innogy and London Electricity, regard RFO as a product and not waste. To this extent, they may defend the definition of RFO as a product and thereby avoid pressure from the Waste Incineration Directive at least for a few years beyond 2006.

The switching costs of moving from RFO use to alternative fuels are low. As RFO prices have increased in response to greater competition from power station users, the economic benefit to the road stone industry from using RFO has declined and there is a general acceptance that post 2006, road stone plants will not use it. Tarmac in particular, the largest user has decided to reduce use of RFO and increase the use of natural gas. We have assumed that demand from this sector will decline over the period to 2006 and cease thereafter.

If power stations were to cease taking RFO from 2006, this would have a dramatic effect on the market for waste oils (see option 3 above). We have forecast a slight increase in demand from the power station sector up to 2006, but insufficient to replace falling demand from the road stone sector and industrial furnaces. For reasons of greater supply over demand, increased market power amongst a smaller group of RFO purchasers and additional transport costs we forecast that most waste oils will be taken at the point of collection for a fee and not collected free of charge, as at present. This will reduce the amount of collected waste oil, we expect by a greater amount than any increase resulting from the imposition of the Landfill

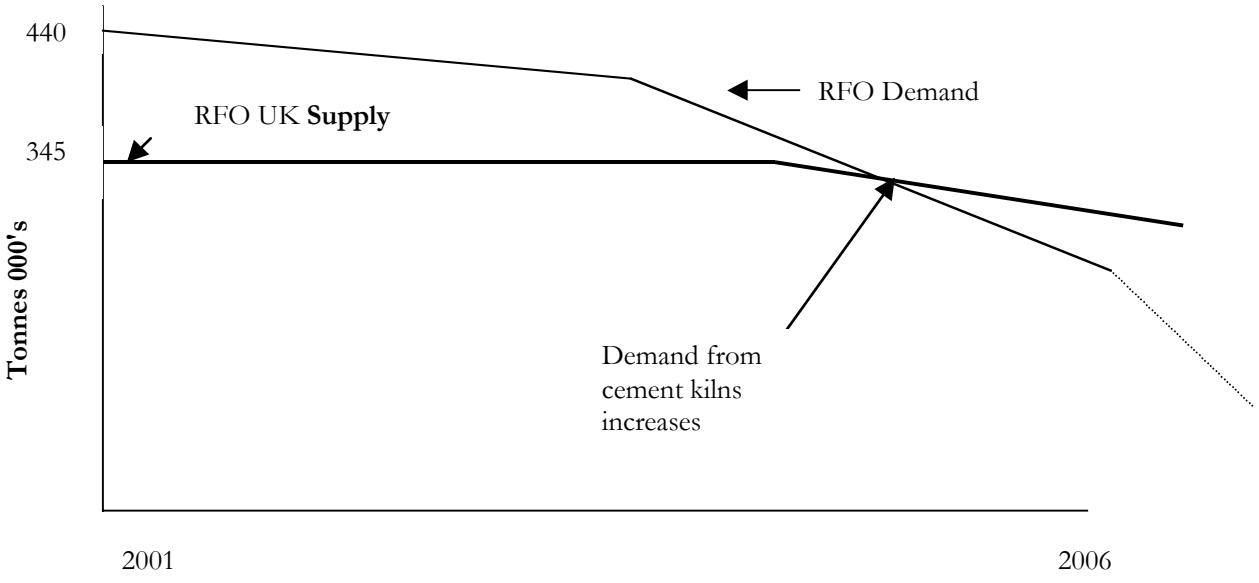
Directive. Cement kilns will take a larger volume of oily sludges currently consigned to landfills, we expect to see no more than a few thousand tonnes of treated oil on the market from this source.

We have also assumed that the duty derogation on the use of RFO will be removed.

"COMBINATION" SCENARIO 2006 FORECAST

	2000/ 01		2006 Forecast	
	Prices per litre	**Tonnes**	**Prices per litre**	**Tonnes**
Waste Oils Collected	-2 p	1 200 000	-3 p	1 100 000
Treated Waste Oils	5 p	385 000	-1 p	340 000
RFO Sales Power Sector	10 p	210 000	4 p	200 000
RFO Sales Road Stone Sector	8 p	185 000	*Banned - W.I.D*	Nil
RFO Sales Cement Kilns	7 p	15 000	-2 p	90 000
RFO Sales Industrial Furnaces	8 p	20 000	*Banned - W.I.D*	Nil
RFO Sales "Other" Sector	8 p	10 000	*Banned - W.I.D*	Nil
Unaccounted for but including water/solids removed during processing		40 000		
Re-refined as Group 1 base oil		Nil	-1p litre	35 000
2005 Spec Diesel		Nil	Nil	Nil
Merchant Plants Laundering hydraulic/gear oils	In - house	Nil		15 000
Imported Waste Oils		95 000		Nil

DEMAND AND SUPPLY FORECASTS FOR RFO IN THE UK 2001 TO 2006 ASSUMING DUTY DEROGATION REMOVAL AND ENFORCEMENT OF WASTE INCINERATION DIRECTIVE



Changes On The Waste Oil Collection Infrastructure

Removal of the 2.74p per litre duty derogation on the use of waste oils would have no impact on the number and scale of waste oil collection companies, at least until the impact of more restrictions on the specification of RFO and the introduction of the Waste Incineration Directive drive down prices for RFO. After 2006, it seems unlikely that there will be very much duty to collect from RFO use unless power stations and others successfully argue that RFO is a product and not a waste.

2001-2004

During the period 2001 to 2004 we would expect to see the number of medium sized waste oil collection companies increase and possibly the acquisition of some of these companies by waste management businesses or other external investors. These changes will be driven by new contract structures amongst the customers of waste oil collection businesses, specifically the trend for garages to offer large national contracts for general waste management services, including oil collection.

During this period the demand for RFO will remain broadly constant. Power stations will seek further authorisations from the Environment Agency but will be required to specify lower amounts of chlorine, sulphur and other compounds thereby making it more difficult for suppliers to use a broad range of mixed oils. It is possible that virgin oils will be used to blend with RFO to achieve the specification, activity that is illegal but nevertheless difficult to regulate.

Road stone RFO users will slowly demand less waste oils as they switch to kerosene and natural gas. However, this switch will be slow and should oil fuel prices increase dramatically any decline in use will be reversed.

If duty derogation is removed from 2002/3, prices for RFO will fall by between 2p and 3p per litre. This will encourage a number of very small businesses that collect oil to cease trading in the expectation that they will need to start charging their customers for the disposal of oil. These changes will be minor.

2005 Onwards

By 2005, the extent to which the Waste Incineration Directive will prevent waste oils from being used as substitute fuels will be clearer. During 2005 and 2006 we would expect to see major changes in the ownership structure of the waste oil collection sector if it is likely that road stone heaters and industrial furnaces will be banned from using waste oils. These changes will be intensified if power stations are also to be banned from using waste oils.

Small waste oil businesses will recognise that the Waste Incineration Directive will erode their remaining competitive advantage. At present they can collect waste oil and deliver it to a local user of waste oil at a price that no other collection company can compete with since they need to transport the waste oil over greater distances. Once there are only 15 points of disposal, small local businesses will be forced to collect on behalf of a company that holds a contract with one of the operators of a disposal point.

The expectation of change in 2006 will encourage three main groups to compete for control of waste oil supplies; cement kiln operators, waste management businesses and petroleum companies. Cement kiln operators and petroleum companies may seek to contract with a single large waste management company to supply waste oils to them to supply their kilns or a single diesel fuel extender plant. Alternatively, they may seek to control the collection infrastructure. Whatever the outcome, the competition between the various interests will drive consolidation in the sector. More significantly, in terms of the output of this study,

the outcome will determine the disposal route for waste oil in the UK after 2006. The most likely outcome, in our opinion, is that the majority of waste oils will be consigned to cement kilns for a period of years until alternative investments are developed.

None of the large-scale investment that we expect to be attracted to the sector after 2006 is likely to be focused on re-refining to manufacture base lubricant oil. This is only likely to occur if major lubricant producers are given a reason for using the output from re-refineries as none of the competing interests in the sector are motivated by a need to develop re-refining capacity.

Increased Transport and Transfer Costs

At present, a significant proportion of waste oils are collected and taken to road stone plants, horticultural, agricultural and industrial burners that are within 20 miles of the point of collection. The storage capacity of many of the small businesses that collect oil is limited to the capacity of a single 5,000-gallon road tanker supplemented by a small tank in a depot. Very few have significant storage capacity.

Storage Capacity

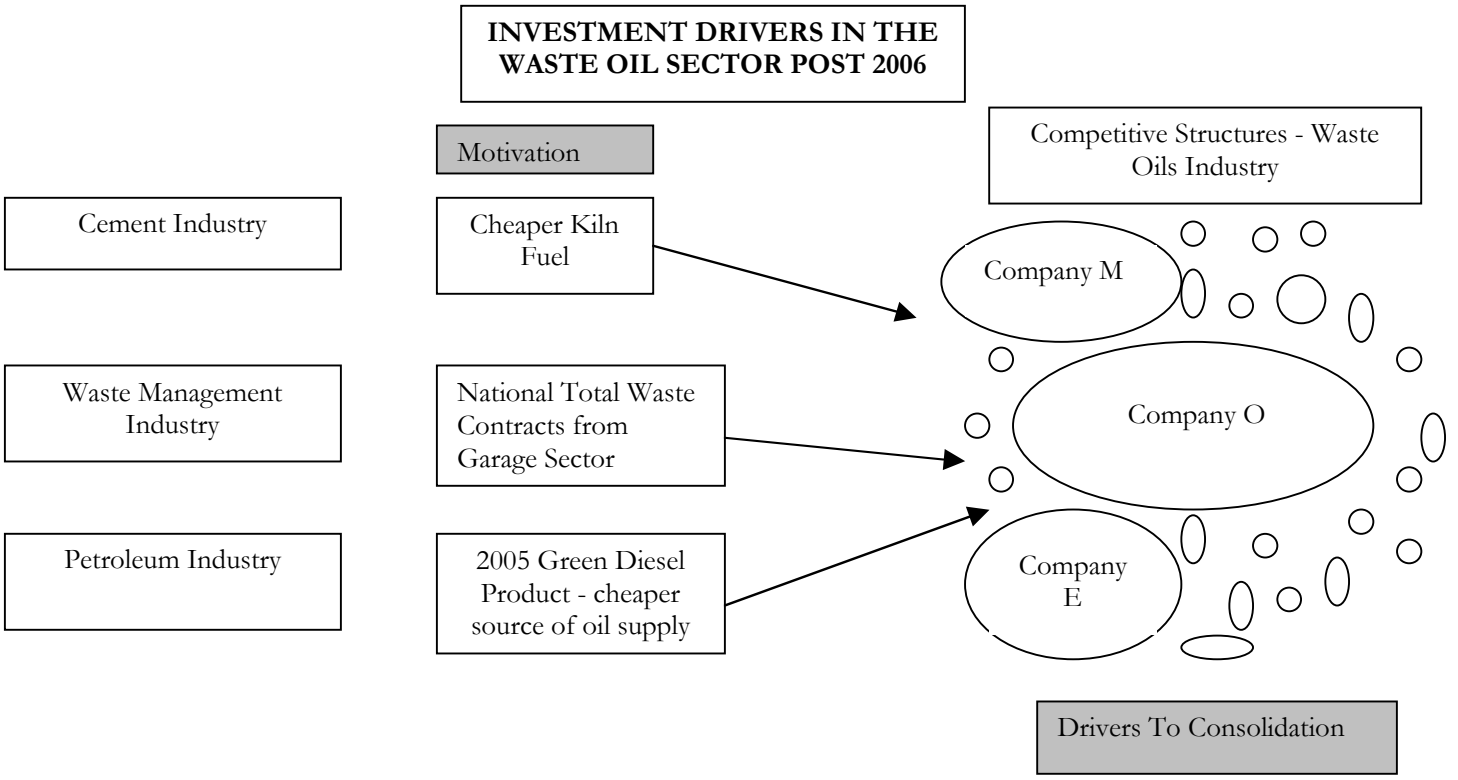
Inadequate storage capacity tends to reduce the negotiating power of the waste oil collection business and has been a factor in prices for waste oil being low even when prices for fuel oil have increased.

From 2006, the number of local points of disposal will fall dramatically as the Waste Incineration Directive prevents them from burning waste oils as a fuel. At present we estimate that there are at least 350 different locations in the UK at which waste oil is disposed as a fuel, 125 of them at road stone quarries. From 2006, this number could be less than 10 and certainly less than 15.

The need to collect and store waste oils will be one of the reasons that will drive very small waste oil companies out of the market. As they leave the market and prices for waste oil disposal increase, there has to be some expectation that an unknown amount of waste oil will not be collected but will be disposed of inappropriately. The oil collected from civic amenity sites will need to be subsidised by the county councils that own them. At present, most of the operators of civic amenity sites are paid 10p per gallon for the waste oil they collect from the public.

The additional costs involved in these changes are the cost of licensing and operating the transfer station and the cost of transporting oil in bulk approximately 200,000 tonnes of oil to one of the final 15 disposal points. In most cases, we would not expect to see new waste oil storage and transfer stations constructed, as there are numerous licensed facilities that could be used for these purposes owned by waste management companies.

In broad terms the additional costs will be represented by 10,000 tanker movements taking 30,000 hours at a cost of £1.3 million and the additional cost of storing 5,000 tonnes of oil at 40 transfer sites estimated to be no more than a further £25,000 per site or £1 million. The additional costs of £2.3 million are the equivalent of £11.50 per tonne or 1.2p per litre of waste oil, less if the costs were spread over all the waste oil collected.



- Possible Acquisition
- Increased Costs of Collection & Storage
- 15 disposal outlets instead of 350

Conclusions:

1. Removal of the excise duty derogation of 2.74p per litre on the use of waste oil as RFO would cause a reduction in the price paid for RFO by major users and would not cause a significant change in the amount of waste oil collected and processed during 2001/2. Evidence to support this conclusion is that prices have increased by more than 4 p per litre for the use of RFO during the past 18 months. However, after 2006, and possibly sooner, prices for RFO will fall and the demand for it will be greatly reduced by the introduction of the Waste Incineration Directive. The issue of duty payments on RFO may become a focus of complaints, as it is likely that an uncertain amount of waste oil will be disposed of inappropriately as prices fall.

2. The introduction of special waste regulations to the movement of waste oils combined with a restructuring of the collection business is already leading to an increase in charges for waste oil collection regardless of any proposed duty or oil price changes.

3. By 2006, we would expect at least one major waste oil collection business to be integrated within a leading oil company, cement manufacturer or waste management business in preparation for the investment in alternative disposal routes implied by the Waste Incineration Directive. This ownership structure will determine the type of investment that occurs for waste oil processing, whether as support fuel for cement kilns or as a feedstock for a diesel fuel extender or re-refining to a base lube oil.

4. The technology least likely to benefit from new investment will be re-refining to manufacture a base lubricating oil. Significant investment in this technology is only likely to occur if the Government intervenes to alter the risk profile of investment in re-refining projects.

5. The introduction of financial incentives for blenders and lubricant manufacturers to purchase specified re-refined base oils are highly unlikely to be effective in raising demand. Reducing prices through subsidy for inferior goods merely reinforces the signal that the good is inferior. Subsidies should be supplemented with measures to deal with the poor market perceptions of the re-refined product.

6. The supplementary measures might include one or more of the following: voluntary agreements with certain large lubricant producers to use a minimum quantity of re-refined base oils that meet agreed quality standards; producer responsibility measures aimed at specific lubricants; voluntary agreements with certain large industrial lubricant users that they will specify the use of high quality re-refined oils in new contracts; grants toward the cost of establishing a separate re-refined oil quality standard.

7. WRAP (Waste and Resources Action Programme) may wish to investigate the development of these market measures since they will require the cooperation of major oil companies to create the market conditions suitable for an independent investor to develop re-refining capacity.

End