Improving Markets for Waste Oils

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Clean technologies
Resource efficiency

A report for
OECD
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1 Introduction

This report reviews evidence of environmental damage caused by inappropriate management of used lubricating oil; provides an overview of the markets for used lubricating oil; reviews the market barriers and failures affecting some of the post-collection markets, and highlights the implications for public policy.1

Of the 37 million tonnes of lubricants sold globally in 2001, 40% to 50% was consumed or lost during use: the fate of the remaining 50% to 60% of the oil which is potentially recoverable is the subject of this report. Typically, 65% of the recoverable oil is engine oil, the remainder being from a wide variety of industrial sources.

Where it is not collected, there is a risk of pollution from waste oil that is dumped in sewers and rivers or tipped on soil. Waste oil can contaminate freshwater, with associated impacts on aquatic plants and fish, water treatment facilities, and even human health. Non-collection, and its attendant environmental risks, appears to be especially likely in sparsely populated regions. In addition, where it is not collected, it is also considered as a waste of resources since waste oils can be used as a fuel and save primary non-renewable resources.

After collection, used lubricating oil is traded as feedstock for a variety of uses:
- Fuel in small-scale space heaters
- Fuel in industrial-scale processes such as power stations and cement kilns
- Re-processing to various qualities of base oils used as fuel
- Re-processing to produce various hydrocarbon products such as drilling fluids
- Re-refining or regeneration to produce new lubricants

The choice between these various options depends upon policy incentives and market conditions. Market demand for burning waste oil directly in small-scale space heaters and in industrial-scale processes is potentially very much greater than the supply. Consequently, depending upon local environmental regulations, the price paid for waste oil is close to its nearest substitute of coal or medium to heavy fuel oil, and can be lower if the environmental impacts of some post-consumption uses are unregulated (or existing regulations unenforced).

In the face of market pressure from using waste oil as fuel, several governments have introduced policies to promote re-refining of waste oil in preference to direct burning. In the face of relatively high costs, many of these policies involve significant public expenditures. Such expenditures are usually justified on the basis of purported environmental benefits (conservation of a non-renewable resource and to avoid air quality issues arising from direct burning). However, life cycle assessments are generally inconclusive over whether re-refining is preferable to recovery of energy uses from waste oils, except in some cases (such as burning in unregulated space heaters).

Moreover, designing policies that favour re-refining is especially problematic as investors confront several market barriers and failures. The major barriers are: information failures relating to waste quality; risk aversion to using re-refined base oils; certain technological externalities and the market power of incumbents. This restricts the market, sometimes requiring significant public expenditures (implicit or explicit) to support the market for re-refining. In other cases the market for re-refining may be undermined by policy failures, such as inadequate enforcement of environmental regulations associated with incineration and disposal.

A key policy question is therefore, the determination of the optimal point of intervention in the market. While the distinction is usually one of degree and not kind, some governments appear to focus on maximising collection rates (leaving the market

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1 To assist in the preparation of this report we visited a number of existing used oil re-refining plants in Europe and used oil collection businesses. We are grateful in particular to Jean Vercheval of Groupement Européen de l’Industrie de la Régénération (GEIR), who provided us with useful information; Christian Hartmann of Baufeld Oel GmbH; Jacques Leduc of SITA Belgium; Renato Schieppati of Viscolube SpA and Paul Ramsden of OSS Ltd for the access given to their treatment and recycling plants. Whilst acknowledging this assistance all errors, omissions and opinions are those of the author.
to determine the ultimate recovery use), while others favour providing support for re-refining. This is environmentally significant. On the one hand, it is possible that the use of scarce public resources to encourage re-refining may have adverse implications for collection rates for a number of reasons reviewed below. On the other hand, some policies designed to maximise collection rates may make re-refining less economic. As such, the determination of the optimal point of policy intervention is key.
2 The Market for Lubricants

3,700 million tonnes of crude oil are refined worldwide, of which approximately 1% is used to manufacture lubricant products. Lubricants derived from mineral oils are by far the most common type of lubricant, and it is on these products that this paper is focused. The small but growing segment of lubricant products derived from vegetable sources and esters are not considered in detail. However, they are usually collected with waste oils and waste fuels and in some cases constitute a contaminant for the purposes of recycling (Boyd 2002).

2.1 Characteristics of Lubricant Oils

A complex variety of compounds, such as detergents, dispersants, anti-oxidants, emulsifiers, corrosion inhibitors etc., are later added to base oils by specialist manufacturers to create an extensive range of lubricant products. These additives can contribute 5-10% of the weight of the lubricating oil.

Once base oils have been blended with additives, packaged and marketed the value-added-multiple for engine oil is in the range 5 to 60 times the average value of crude oil. The exact mix of product sold into each national market varies, but in broad terms 56% of lubricant sold is for automotive uses and 44% for a variety of industrial uses. The most complex lubricants are top-tier engine oils, in particular those offering extended life. Other lubricants are used in sensitive consumer products such as cosmetics and in a variety of medical applications. Table 2.1 provides estimates of global market shares for different uses.

<table>
<thead>
<tr>
<th>Type of Lubricant</th>
<th>% of World Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automotive</td>
<td>55.1</td>
</tr>
<tr>
<td>Industrial Oils</td>
<td>24.5</td>
</tr>
<tr>
<td>Process Oils</td>
<td>11.6</td>
</tr>
<tr>
<td>Metalworking Fluids/Corrosion Preventatives</td>
<td>5.8</td>
</tr>
<tr>
<td>Greases</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Source: FUCHS Petrolub AG Manheim - Paper to 7th ICIS LOR base oils conference 2003

2.2 Base Oil and Lubricant Product Trends

As can be seen in Figure 2.1 world demand for lubricants has been broadly static over the past 10 years, with a slight decreasing trend.

However, static global demand masks regional variations that show demand falling in North American and Western Europe and, to a lesser extent Latin America. Conversely, the Asia-Pacific region and Central and Eastern Europe are exhibiting growth rates in the region of 2% per annum (see Table 2.2).

<table>
<thead>
<tr>
<th>Region</th>
<th>2001 (000 t)</th>
<th>2002 (000 t)</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>N America</td>
<td>8,750</td>
<td>8,590</td>
<td>-1.8</td>
</tr>
<tr>
<td>Latin America</td>
<td>3,050</td>
<td>3,035</td>
<td>-0.5</td>
</tr>
<tr>
<td>Western Europe</td>
<td>4,930</td>
<td>4,885</td>
<td>-0.9</td>
</tr>
<tr>
<td>Cent / East Europe</td>
<td>4,610</td>
<td>4,690</td>
<td>1.8</td>
</tr>
<tr>
<td>Near / Middle East</td>
<td>1,820</td>
<td>1,840</td>
<td>1.0</td>
</tr>
<tr>
<td>Africa</td>
<td>1,790</td>
<td>1,815</td>
<td>1.4</td>
</tr>
<tr>
<td>Asia-Pacific</td>
<td>10,610</td>
<td>10,820</td>
<td>2.0</td>
</tr>
<tr>
<td>WORLD</td>
<td>35,560</td>
<td>35,675</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Source: FUCHS Petrolub AG Manheim - Paper to 7th ICIS LOR base oils conference 2003

This pattern in relative growth rates reflects a certain degree of “catch-up”, with the fastest growing areas those in which demand is at relatively low absolute levels. Table 2.3 gives lubricant demand per capita for the same regions. Global average lubricant demand per capita of 5.9 kg masks significant regional variation, with North American demand over 10 times that of sub-Saharan Africa.

While demand is clearly shifting away from the large markets in North America and Western Europe, supply remains relatively concentrated in these regions. This is reflected in the significant capacity surpluses in these two regions. Asia-Pacific also shows a surplus (Table 2.4).
Table 2.3. Regional lubricant demand 2001

<table>
<thead>
<tr>
<th>Region</th>
<th>Kg per Capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>N America</td>
<td>28.7</td>
</tr>
<tr>
<td>Australia/Oceania</td>
<td>18.1</td>
</tr>
<tr>
<td>Western Europe</td>
<td>12.6</td>
</tr>
<tr>
<td>Central / Eastern Europe</td>
<td>11.0</td>
</tr>
<tr>
<td>Near / Middle East</td>
<td>10.7</td>
</tr>
<tr>
<td>Latin America</td>
<td>6.2</td>
</tr>
<tr>
<td>Asia</td>
<td>2.9</td>
</tr>
<tr>
<td>Africa</td>
<td>2.4</td>
</tr>
<tr>
<td>WORLD</td>
<td>5.9</td>
</tr>
</tbody>
</table>

Source: FUCHS Petrolub AG Manheim - Paper to 7th ICIS LOR base oils conference 2003

Table 2.4. Capacity Surplus/Deficit by Region

<table>
<thead>
<tr>
<th>Region</th>
<th>Capacity Surplus/Deficit (-) 000 tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>N America</td>
<td>2,410</td>
</tr>
<tr>
<td>Latin America</td>
<td>-535</td>
</tr>
<tr>
<td>Western Europe</td>
<td>2,405</td>
</tr>
<tr>
<td>Central/Eastern Europe</td>
<td>445</td>
</tr>
<tr>
<td>Near / Middle East</td>
<td>-230</td>
</tr>
<tr>
<td>Africa</td>
<td>-810</td>
</tr>
<tr>
<td>Asia Pacific</td>
<td>1,280</td>
</tr>
<tr>
<td>Marine</td>
<td>-1,585</td>
</tr>
<tr>
<td>WORLD (inc Marine Oils)</td>
<td>3,380</td>
</tr>
</tbody>
</table>

Source: FUCHS Petrolub AG Manheim - Paper to 7th ICIS LOR base oils conference 2003

ICIS LOR (Independent Commodity Information Services-London Oil Reports) prices since 1997 show the degree of correlation between crude oil prices and those of base oil. In broad terms, the refining process adds 2.6 to 3 times the average value of a barrel of crude oil whereas gasoline or diesel adds approximately 1.5 times. Given the high degree of value added in the production of base oil, it is not surprising that the correlation is not particularly strong (Figure 2.2).

But what is of interest is the variation of crude oil prices: because recycled lubricating oil can fully substitute for the product derived from virgin oil, the volatility of crude oil prices as well as high prices can benefit to markets for recycled lubricants by favouring the demand for such materials.

The market is relatively concentrated. Shell, Exxon Mobil and BP Amoco are market leaders in the world lubricant market with approximately 34% of the market. The remainder is shared between 13 companies such as LukOil, Nippon Oil, Conoco Phillips and PetroChina Sinopex.

2.3 Waste Oil and Used Oil

Approximately 40 to 50% of the lubricants sold are being lost through leaks or in the exhaust emissions during use: the fate of the remaining 60% to 50% of the oil is potentially recoverable (European Environment Agency, 2002).<sup>a</sup>

<sup>a</sup> Although the GEIR (Groupeement Européen de l’Industrie de la Régénération) estimates the percentage of recoverable oil in the EU at 46%, ranging from 32% (Italy) to 65% (Finland).

Following a period of use that is typically less than 6 months, remaining lubricant is recovered along with various combustion, friction and heat-related contaminants. This oil, often mixed with other contaminants such as water, solvents, antifreeze, brake fluid, paint and fuels enters the waste management market.

There is however a wide reported variation between similar economies in the amount of waste oil collected compared to the amount of lubricant product sold. In addition, potential recovery rates are likely to differ due to differences in use patterns. For instance, while recoverability is estimated to be as much as 90% for gear oils and 80% for aviation oils, the figures for brake fluids, process oils and greases are 0% (AATSE 2004). In addition, many rolling oils, quench oils, and other process oils are either incorporated into products or else they are lost during production. Furthermore, some waste oils are generated which have not been ‘used’. This includes oil wastes such as fuel storage tank bottoms. In some cases these may be ‘launched’ for limited types of re-use without undergoing re-refining.
3 Environmental Impacts from Waste Oil Management

The environmental impacts associated with lubricating oil arise from extraction, processing, use and disposal. In this section some of the main environmental impacts are reviewed. Given the nature of the study, the focus is on impacts associated with collection and disposal (legal or illegal), and recovery of waste oil.

3.1 Post-collection environmental impacts

Before or during collection from multiple-point sources, waste oil is contaminated from either in-use sources or materials introduced through mixing. As noted above, in-use additives include a variety of compounds added during manufacture to meet performance specifications. In addition, waste oil is also likely to contain metals from engine wear; unburned fuel; PAH (polyaromatic hydrocarbons) from polymerisation and incomplete combustion of fuel; particulates and water. It may also contain - from mixing with other wastes - solvents from parts-cleaning in garage workshops, paints, brake fluids and non mineral-oil based lubricants such as biodegradable vegetable oils. In most countries, waste oil is considered “hazardous waste”.

The nature and extent of in-use contamination in waste oil is changing. In the 1970’s, lead and chlorine were present in significant concentrations but are now declining due to the phasing out of lead additives in vehicle fuels and the tighter restrictions on the use of chlorine as an additive in many industrial lubricants. On the other hand, the presence of esters and vegetable oils is expected to increase (Boyd 2002).

The removal of these contaminants from waste oil through a process of re-refining is complex. Once removed, the contaminants, in the form of a thick black and malodorous sludge, the asphalt bottoms, are usually incinerated in a cement kiln or similar energy-intensive facilities or used to create roofing materials, as in Canada and the United States. This contaminated sludge represents 15% to 20% of the weight of waste oil delivered to re-refining plants.

If waste oil is burned in small-scale space heaters, the environmental impacts can be similar to those calculated for oil-fired power stations, i.e. emissions of atmospheric pollutants derived largely from metal contamination in the waste oil in addition to typical pollutants from fuel oil incineration (CO₂, CO, NOₓ, and SO₂). However, unlike the burning of lubricant in vehicle engines, where the lubricant does not substitute for other fuels, it is likely that the heat generated from small space-heaters burning waste oil would be put to a beneficial use.

Use of waste oil for energy recovery in unregulated markets can, however, have much more significant environmental impacts. For instance, in Australia there are concerns that the use of recovered oil in the hydroponics and flower industries may produce toxic emissions, including polychlorodioxins (AATSE 2004). It has been estimated that this use may represent as much as 25 ML per annum, although there is considerable uncertainty.

A comprehensive and critical review of several LCA (life cycle assessment) studies was published by the EU in 2002. The study, prepared by TN Sofres, summarised the findings of four major LCA studies as follows:

- "For almost all environmental impacts considered, incineration in cement kilns (where waste oil replaces fossil fuels) is more favourable than incineration in an asphalt kiln (where waste oil replaces gas oil);
- A modern regeneration plant may, according to the impact considered, be more favourable than or equivalent to incineration in an asphalt kiln; and,
- Compared to incineration in a cement kiln (where waste oil replaces fossil fuels), waste oil regeneration has environmental advantages and drawbacks depending on the impact considered." b

---

a. Regeneration can be read as being identical to re-refining in this paper.
b. One of 10 summary points made in the study.
Twelve environmental impact criteria were used to evaluate eight comparative studies carried out in Norway, France and Germany since 1995. The study highlights that several environmental impacts were excluded from some or all of the LCA studies. Specifically: noise, odour, biodiversity, land use, toxic emissions and the displacement of non-fossil fuels by waste oils.\(^a\) Significantly, the LCA studies do not provide firm evidence to justify support for either re-refining or direct burning in cement kilns (see Table 2.5). This view is largely supported by a recent review undertaken for the Australian Department of Environment and Heritage (AATSE 2004).

The results from environmental impact studies are especially sensitive to assumptions made concerning: the type of re-refining technology; the type of fuel that is being displaced by the burning of waste oil; and, the scale and type of incineration plant. Studies undertaken by ADEME during 2000 concluded that the latest re-refining technologies produce fewer environmental impacts than older technologies using clay.\(^b\) In general, the studies indicate that the comparative environmental benefits are finely balanced between incineration in cement kilns and re-refining. However, it should be noted that the waste oil re-refining process to lubricants emits less atmospheric pollutants and consumes less energy (50% to 85% less) than the refining of virgin oil into lubricants.

In a study undertaken in California, Boughton and Horvath (2004) compare the impacts from re-refining used lubricating oil back into base oil for reuse, distillation into marine diesel oil and burning as untreated fuel oil for space heating. They find that the impacts with respect to air and water pollution emissions and generation of solid waste are approximately equal, but that emissions of heavy metals are much more severe for burning. However, they assume that burning is undertaken for space heating, with zero emission controls.

In summary, the present LCA studies are not conclusive about the best management option for waste oils in terms of environmental impacts: re-refining or incineration in industrial furnaces provided with the appropriate pollution control device. On the other hand, it can surely be claimed that production of lubricants from the re-refining process is more environmentally friendly than direct burning in individual small space-heaters or in unregulated industrial furnaces using old technologies. It may also be more environmentally-friendly than production of lubricants from virgin oil, but the aforementioned LCA studies do not make such an assessment.

### 3.2 Illegal Disposal

The most significant environmental impacts associated with lubricating oils almost certainly arise from illegal disposal. The extent of deliberate dumping in the US was highlighted in a survey by the Bureau of Transportation Statistics in 2002. It concluded that 5% of people who change their own motor oil dump the recovered oil in the drainage system, pour it on the soil, or place it in the municipal waste bin. The Bureau estimates that 43 million US residents change their own motor oil (BTS 2002). A recent survey commissioned by the Australian Government found that one in three households have motorists who change their own vehicle oil, and that nearly half of those people inappropriately dispose, store or reuse the oil: uncollected waste oil has been estimated to be in the region of 40-65 million litres (AATSE 2004). Environmental Choice New Zealand estimated that in 1998 of the 30 million litres of lubricating oil requiring disposal in New Zealand, as much as 23 million litres may not have been disposed in an environmentally-sound manner (ECNZ 1998). Similarly, as much as 40 million litres of waste oil in Western Canada is unaccounted for by the collection data and estimated in-use losses (CLMC 2002).

Thus, significant additional quantities of used lubricant are deliberately spilled on the ground or in surface waters. The extent of these illegal activities can be estimated by comparing the amount of waste oil collected with the amount that is potentially recoverable. In most cases this will be between 50% and 60% of the amount of lubricant sold. Studies of collection effectiveness show a wide variation in performance (see Table 2.6).

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\(^a\) The study goes on to point out that there is a lack of data to evaluate some of these excluded factors.

\(^b\) The UOP (HYLUBE) process was compared with older distillation processes that require clay to finish the base oil output.
Table 2.5. Results from Comparative Studies of Incineration and Various Re-Refining Technologies

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total energy</td>
<td>R=I</td>
<td>R=I</td>
<td>R=I</td>
<td>R=I</td>
<td>R=I</td>
<td>R=I</td>
<td>R=I</td>
<td>R=I</td>
</tr>
<tr>
<td>Fossil fuels</td>
<td>R</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>R</td>
<td>R</td>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td>Water inputs</td>
<td>R=I</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Climate change</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>R</td>
<td>I</td>
<td>I</td>
<td>R=I</td>
</tr>
<tr>
<td>Acidifying potential</td>
<td>R</td>
<td>I</td>
<td>I</td>
<td>R</td>
<td>R</td>
<td>I</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>VOC</td>
<td>R</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>R</td>
<td>I</td>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td>Dust to air</td>
<td>R</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>R</td>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td>Human toxicity</td>
<td>R</td>
<td>I</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Ecotoxicity (aquatic)</td>
<td>I</td>
<td>R=I</td>
<td>R=I</td>
<td>I</td>
<td>R</td>
<td>I</td>
<td>R=I</td>
<td>R</td>
</tr>
<tr>
<td>Ecotoxicity (terrestrial)</td>
<td>I</td>
<td>R=I</td>
<td>R=I</td>
<td>I</td>
<td>R</td>
<td>I</td>
<td>R=I</td>
<td>R</td>
</tr>
<tr>
<td>Eutrophication (water)</td>
<td>R=I</td>
<td>R=I</td>
<td>R=I</td>
<td>R=I</td>
<td>R=I</td>
<td>R=I</td>
<td>R=I</td>
<td>R=I</td>
</tr>
<tr>
<td>Solid waste</td>
<td>R=I</td>
<td>R=I</td>
<td>R=I</td>
<td>R=I</td>
<td>R=I</td>
<td>R=I</td>
<td>R=I</td>
<td>R=I</td>
</tr>
</tbody>
</table>


Table 2.6. Waste Oil Collected Compared To Lubricant Sales (1997)

<table>
<thead>
<tr>
<th>Country</th>
<th>Lubricant sold (1997)</th>
<th>Waste oil collected</th>
<th>% Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>85 000</td>
<td>36 337</td>
<td>43</td>
</tr>
<tr>
<td>Finland</td>
<td>97 000</td>
<td>47 000</td>
<td>48</td>
</tr>
<tr>
<td>France</td>
<td>900 000</td>
<td>242 000</td>
<td>27</td>
</tr>
<tr>
<td>Germany</td>
<td>1 159 000</td>
<td>485 000</td>
<td>42</td>
</tr>
<tr>
<td>Italy</td>
<td>713 000</td>
<td>172 000</td>
<td>24</td>
</tr>
<tr>
<td>Spain</td>
<td>451 000</td>
<td>110 000</td>
<td>24</td>
</tr>
<tr>
<td>UK</td>
<td>872 378</td>
<td>422 000</td>
<td>48</td>
</tr>
</tbody>
</table>


Table 2.7. Tonnes of Waste Oil Consumed, Collectable and Collected (2002)

<table>
<thead>
<tr>
<th>Country</th>
<th>Consumption</th>
<th>'Collectable' Oil</th>
<th>Oil Collected</th>
<th>% Total Oil Collected</th>
<th>% 'Collectable' Oil Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>109 000</td>
<td>53 622</td>
<td>33 500</td>
<td>31%</td>
<td>62%</td>
</tr>
<tr>
<td>Belgium</td>
<td>173 100</td>
<td>63 105</td>
<td>60 000</td>
<td>35%</td>
<td>95%</td>
</tr>
<tr>
<td>Denmark</td>
<td>71 718</td>
<td>46 909</td>
<td>35 000</td>
<td>49%</td>
<td>75%</td>
</tr>
<tr>
<td>Finland</td>
<td>88 809</td>
<td>49 596</td>
<td>39 677</td>
<td>45%</td>
<td>80%</td>
</tr>
<tr>
<td>France</td>
<td>841 356</td>
<td>422 197</td>
<td>242 500</td>
<td>29%</td>
<td>57%</td>
</tr>
<tr>
<td>Germany</td>
<td>1 032 361</td>
<td>463 304</td>
<td>460 000</td>
<td>45%</td>
<td>99%</td>
</tr>
<tr>
<td>Greece</td>
<td>878 00</td>
<td>40 161</td>
<td>22 000</td>
<td>25%</td>
<td>55%</td>
</tr>
<tr>
<td>Ireland</td>
<td>39 800</td>
<td>17 794</td>
<td>15 303</td>
<td>38%</td>
<td>86%</td>
</tr>
<tr>
<td>Italy</td>
<td>617 594</td>
<td>196 737</td>
<td>189 595</td>
<td>31%</td>
<td>96%</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>10 170</td>
<td>4 652</td>
<td>4 564</td>
<td>45%</td>
<td>98%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>152 694</td>
<td>66 468</td>
<td>60 000</td>
<td>39%</td>
<td>90%</td>
</tr>
<tr>
<td>Portugal</td>
<td>102 000</td>
<td>52 842</td>
<td>39 620</td>
<td>39%</td>
<td>75%</td>
</tr>
<tr>
<td>Spain</td>
<td>510 980</td>
<td>255 236</td>
<td>160 000</td>
<td>31%</td>
<td>63%</td>
</tr>
<tr>
<td>Sweden</td>
<td>142 814</td>
<td>77 232</td>
<td>61 786</td>
<td>43%</td>
<td>80%</td>
</tr>
<tr>
<td>U.K.</td>
<td>840 834</td>
<td>401 474</td>
<td>352 500</td>
<td>42%</td>
<td>88%</td>
</tr>
<tr>
<td>EU</td>
<td>4 820 130</td>
<td>2 211 329</td>
<td>1 776 044</td>
<td>37%</td>
<td>80%</td>
</tr>
</tbody>
</table>

Source: www.fedichem.be/en/geir

---

“R=I” represents equivalent impact between regeneration and incineration
“I” represents incineration having a lesser impact
“R” represents regeneration having a lesser impact
N - EPA is the Norwegian Environmental Protection Agency
UBA: Umwelt Bundes Amt (Germany)
ADEME: Agence de l’Environnement et de la Maîtrise de l’Énergie (France)
There are three main reasons for doubting the accuracy of the collection data:

- At the point of collection, waste oil may contain significant quantities of water and other contaminants. In the case of bilge oil and emulsions, 20% or more of the weight of waste oil may be water. Oily waters are a common type of industrial waste.
- Where waste oil is heated as a rudimentary treatment process, waste oil is used as a fuel source and thereby may not be included in the data.
- Waste oil collectors also collect confiscated fuels and these may be included in waste oil data.

Calculating collection rates on the basis of potentially collectable oil (differentiated by country), the GEIR comes up with the following figures for 2002 (see Table 2.7). For instance, on this basis the figure for the United Kingdom is 88%. Since the calculation of ‘collectable’ is necessarily fraught with difficulties there is no straightforward manner to resolve this discrepancy. Calculating collection rates directly from consumption yields a rate of 42%, not out of line with the figure given above (48%).

Policy measures can have a significant influence on illegal disposal rates. Using American data, Sigman (1998) estimated the extent to which oil dumping incidents increased in response to changes in the costs of collection and disposal caused by tighter regulations. For instance, it was found that the imposition of a ban on landfilling increased incidents of illegal dumping by 28%. Although the correlation between dumping incidents and costs will vary between countries, the environmental impact of any increase could be significant due largely to the persistence of mineral oil in the environment.

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

- Harm to wildlife through depletion of the oxygen supply for fish and other aquatic life;
- Aesthetic and recreational impacts through contamination of surface waters;
- Loss of soil productivity and contamination of groundwater; and,
- Human health impacts associated with the contaminants commonly found in waste oils.

For all these reasons more and more countries, are trying to maximise the collection rate of waste oils by making the collection a legal obligation as well as making it free of charge, i.e. in a way subsidising it. Different policy instruments have been put in place throughout the OECD to finance the collection costs. They will be analysed at a later point in the report.

### 3.3 Conclusion

An important conclusion to draw concerning the types of environmental risks described in this section is that those arising before collection, such as illegal dumping, are considerably greater when compared to the net increase in the risk of environmental damages from preferring any one recycling route over another. Consequently, if the policy objective is to minimise the risk of environmental damage, maximising the collection of the recoverable proportion of lubricants should be a priority. In the case of waste oil, the threat presented to water resources by just a few litres demands attention.

The oil industry group CONCAWE concluded their 1995 study by recommending a policy focus on collection efficiency. While they may have a vested interest in reaching this conclusion, there is little question that collection is key to reducing environmental impacts. However, at the post-collection stage, there is considerable debate on the best environmental waste management option: material recycling (i.e. re-refining to lubricants) versus energy recovery. Direct burning in unregulated small space-heaters or small industrial boilers and furnaces without any pollution control devices has been clearly identified as being the worst environmental option, to be rejected or even forbidden.

Member countries are more and more concerned about environmental problems and remediation costs related to waste oils and are

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<sup>3</sup> CONCAWE report 5/96 concluded “It is therefore more important in the first instance to ensure that this oil is collected and safely disposed of than to specify any particular disposal option.”
trying to solve them by developing various recycling policies and regulations. However, in many cases those policies are facing difficulties. The markets which are needed to support the different options are not operating as efficiently as required. In some cases this may be due to the presence of non-environmental market failures and barriers.
4 Market Failures and Barriers

Clearly the most important determinant of market participants to adopt one waste management option over another is financial cost. Some routes are more costly than others due to the importance of different factor inputs required. Public policy measures can play an important role in determining these factor input costs, whether implicitly or explicitly. For instance, a landfill tax will clearly have an impact on waste generation costs if the effects of the tax are transmitted back to the generator through waste fees. Analogously, technology standards for landfill sites will affect the costs of waste management, and thus costs for generators.

Costs can also be significantly affected by the efficiency of the conditions in which the market operates, and thus any failures or barriers which may exist in such markets. Since the market for the collection and processing of waste oil for sale as an industrial fuel appears to work efficiently, we are concerned here only with barriers confronted by those seeking to re-refine waste oil as to base oil for non-energy uses, such as lubricants. Investors in this market confront several market failures and barriers, some of which are common to market entrants using either crude oil or waste oil as a feedstock to manufacture base oil and lubricants. These are principally: information failures relating to waste quality; risk aversion to using re-refined base oils, technological externalities associated with lubricating oil specifications, and the market power of virgin product incumbents.

4.1 Information failures relating to recovered oil quality

Re-refining plants are more sensitive to contaminants in the waste oil pool than all other competing uses. While tankers tend to have separate compartments to allow for segregation of waste oils of different qualities, collectors (buyers) of waste oil can never be certain that the oil is free of these and other liquid contaminants to which re-refining is sensitive.

Unless a comprehensive mobile testing programme is in place, the cost of concealment is negligible and the cost of detection substantial since most waste oil collected is immediately mixed with other oil in a road tanker, and the risk of those responsible for contamination being identified is small. Even disposers (sellers) may not be certain of the quality since waste oil stores are sometimes less than secure.

The impact of this asymmetry is revealed through the costs of testing undertaken in Italy before waste oil is accepted into the re-refining process. Tests are carried out before waste oil is placed in the 26 regional storage tanks and again on acceptance at the re-refining plant. These costs are estimated by the Italian waste oil consortium to be €45 - €60 per tonne of collected waste oil. Conversely, where waste oils are taken for direct burning in a cement kiln, the testing protocols are less costly since the acceptance criteria at cement kilns are less sensitive than those required by re-refiners.

As such, in the absence of effective control of waste oil quality at the collection stage a disposer of waste oil has an incentive to place contaminated oil on the market. For instance, excessive water content will lower the value of the waste oil and if sellers believe that this will not be detected, this can result in significant market inefficiency. This problem is particularly important if the waste oil is contaminated with excessive levels of metals, PCB's or halogens.

The diffuse nature of waste oil generation – and thus the mixing of a variety of sources in collection strategies in order to reduce overall collection costs - makes detection difficult. Moreover, “reputation effects” may be negligible. As such, the cost of discovery falls most especially on re-refiners who are forced to direct a greater proportion of their oil feedstock to incineration than would otherwise have been necessary.

The estimated cost of concealment in Italy is less than 1% of the retail purchase price of standard lubricating oil for car engines.

---

a. This is not to say that there may not be important policy failures (i.e. non-internalisation of externalities), a point to which we return below.

b. This represents less than 1% of the retail purchase price of standard lubricating oil for car engines.
4.2 Risk aversion to using re-refined base oils

As noted above, buyers of base oils typically blend base oils with additive packages to achieve a consistent product that delivers specified performance attributes. These buyers are highly sensitive to the risk of using materials that may cause their own products to fail in use or for their own production process to be stopped as additive packages fall out of suspension. Moreover, lubricants offer performance-critical attributes for a value that is typically insignificant when compared to the equipment motor vehicle or industrial equipment it is protecting.

Consequently, a significant degree of "disappointment aversion" (see Gul 1991 and Grant et al 2000) best describes the conservative approach of buyers in the market for base oils. Downstream, buyers of lubricants are reluctant to risk damaging their vehicle engine or industrial equipment by purchasing re-refined oils, whereas the quality of re-refined base oils is equivalent and in some cases better than primary-sourced equivalents. This undercuts the market. This risk-aversion can persist for a considerable length of time, even if a strong technical case can be made for the equivalent quality attributes of re-refined oil, relative to lubricants manufactured from base oils derived from virgin crude.

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

Moreover, this is reinforced by industry standards. The American Petroleum Institute restricts the use of “alternate” base oils (including re-refined) to 10% of lubricating oil production input. Such intense conservatism in the market for lubricating oils for passenger cars is less a feature of markets for products such as gear oil, transformer oil, hydraulic oil and some engine oils. For some of these products, the additive packages are simple to blend. In some cases, re-refiners have invested in blending plants to enter these markets.

This risk-aversion on the demand side in some markets is reinforced by the strategies pursued by many suppliers. While lubricant demand in most economies is static or declining in volume terms, it is increasing in value terms. Market incumbents seek to signal the quality of their products to their customers by adding brand names such as "Mobil 1" and meeting international and OEM (Original Equipment Manufacturers) product standards. Although it is technically possible to manufacture the branded and highly-specified lubricant products from a base oil manufactured from re-refined base oils, buyers avoid doing so for fear that competitors will signal this to lubricant users (see AATSE 2004).

In an attempt to distance re-refined base oils from the association with poor quality, from September 2003 Viscolube will begin shipping high quality oils manufactured from waste oil from their plant near Milan. The quality of the base oil will be superior to that produced in the majority of European refineries. It remains to be seen whether this strategy of exceeding expectations of technical standards amongst buyers is effective.

4.3 Switching costs and barriers to entry

Incumbents seek to protect their market position and since volume growth in the lubricant market is small, it is customers of the incumbents who must switch to the entrant. The minimum efficient scale of 60,000 tonnes for a re-refining plant presents a major challenge in such a market. Once production starts, the existing market will need to accommodate the new source of supply. The existing vendors are typically large integrated oil companies who can respond to the new competition from re-refiners. Moreover, the
scale of such refineries is growing (see Figure 2.4).

**Figure 2.4. Rationalisation of US Refineries**

Where re-refiners are independently owned and operated they are susceptible to a short-term change in pricing policy from such large-scale incumbents. A reduction in the price of base oil for 12 months may be sufficient to undermine the profitability of any new re-refining plant: a risk that investors will consider and value in the cost of capital.

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

The re-refiner must meet the testing costs without certainty of success in selling the output to a mature and risk-averse market. The product tests cannot be carried out until the re-refining plant has been made operational. Furthermore, as the tests require at least several months to complete, the base oil output will have to be sold to alternative markets or else put in storage. This can have the effect of increasing testing costs to $2 million or more for a new re-refinery.

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

### 4.4 Technological externalities

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

Some of the most problematic additives for re-refiners are chlorinated hydrocarbons and dithiocarbamates (containing lead) used as extreme pressure agents, polysulphides and several sulphur containing compounds that can cause malodorous emissions. Additives such as styrene butadiene (SBR) and styrene isoprene (SIP) used in engine oils to provide shear stability appear in the thick black waste from re-refining that requires disposal to incineration in Europe.

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

Technological externalities caused by the use of certain lubricant additives and new lubricant products may be best addressed through restrictions on their use. For instance, a restriction on the use of chlorinated additives has been especially significant. However, continued use in certain, mostly high-pressure applications, continues to present a diminishing contamination risk for reprocessors.

The environmental preferences of consumers may lead to reduced potential for re-refining. For instance, one type of consumer response to the threat of environmental damage from lubricant spillage has been to demand biodegradable lubricants, many manufactured from vegetable oils instead of mineral oils. When collected for re-refining this vegetable oil based lubricants are a contaminant and can lead to the rejection of entire batches of waste oil. Typically the rejected batch is used instead as a substitute fuel.
5 Policy Responses

The policy responses in the countries reviewed can be broadly divided into two categories; those targeted primarily at collection efficiency and those designed to address the multiple market barriers to re-refining waste oil. While all countries have sought to improve collection rates by establishing some form of free collection system and regulating the management of the collected waste oil, there appears to be significant differences in the effectiveness of these systems. Similarly, the support provided to re-refining relative to reuse of waste oils as fuel differs markedly.

5.1 United Kingdom

A Government statement from 1985 describes the UK position on post collection uses: “The Government favours the regeneration of waste oil as lubricant wherever practicable but sees no reason, environmental or otherwise, to discriminate against the use of base oil as supplementary fuel...It is highly questionable whether regeneration is always the most rational way of re-using waste oil, and the decision as to whether to regenerate as lubricant or to use as fuel is best left to the operation of market forces”

William Waldegrave, Parliamentary Under Secretary of State, Department of Environment 2nd April 1985

Although the policy is supposed to be indifferent between post-collection uses, the use of waste oil as a substitute for fuel oil is supported by derogation in excise duty on the waste-derived fuel product. At 2002/03 prices this is worth the equivalent of £27.40 per tonne, or approximately 15% of the delivered product price. This has the effect of guaranteeing a positive value for most waste oils at the point of collection and favouring the demand for recovered fuel oil to the extent that the United Kingdom is importing about 100,000 tonnes (in 2001) of waste oils from Europe and elsewhere.

The costs of managing pollution from waste oil, collecting oil at public facilities without charge and for the 'Oil Care' campaign are met from general taxation and sponsorship from retailers and oil companies. Lubricant carries a sales tax of 17.5% recoverable by almost all commercial and industrial users but not by those buying oil for personal use.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lubricant Sold (a)</td>
<td>803,667 t</td>
</tr>
<tr>
<td>Waste oil Collected (b)</td>
<td>380,000 t</td>
</tr>
<tr>
<td>Collection Rate (b/a * 100)</td>
<td>47 %</td>
</tr>
<tr>
<td>Recycled as a Base Oil</td>
<td>0 %</td>
</tr>
<tr>
<td>Other Recycling/Reuse</td>
<td>0 %</td>
</tr>
<tr>
<td>Direct Burning /Energy Recovery</td>
<td>100 %</td>
</tr>
</tbody>
</table>

Source: Defra (2001)

There is competition to collect and treat waste oil. Attempts to operate a re-refining plant to produce new lubricants and a merchant laundry operation in this market ended in closure. The operations were not viable, in part because they confronted the market barriers detailed in the previous section. Policy makers have not actively intervened to try and support the market for re-refining to lubricants.

5.2 Italy

In contrast to the UK, long-term enthusiasm for the re-refining of waste oil has led policy makers to support the manufacture of base oil from waste oil sources. From July 2003, new regulations were introduced to reform a system of subsidies paid to re-refiners and collectors of waste oils.

A statutory consortium consisting of representatives from the manufacturers of lubricants, waste oil collectors and re-refiners as well as public regulators manages the contractual arrangements for waste oil collection and processing in Italy. It also manages the equivalent of the UK Oil Care campaign, albeit with an annual publicity and promotion budget of €1.5 million, significantly greater than the equivalent UK scheme.

All lubricants attract a three-part variable levy of €325 per tonne. Of this variable levy, €67 is to pay a subsidy to operators of certain re-refining and fuel manufacturing plants. The average cost
of subsidy per tonne of waste oil collected in 2002 was €166.50 or approximately €31 million. Base oil output will receive a subsidy more than twice that of fuel products, although the final ratio has not yet been agreed.

The consortium requires that the 85 contracted collectors deliver a minimum of 90% of the collected waste oil to re-refiners and that not more than 10% is delivered to cement kilns for energy recovery. The contracts offered by the consortium are arranged over three regions, north, central and south. The waste oil can be stored in 26 registered storage tanks before delivery. Cement kilns pay a market based price that is currently €30 per tonne for each tonne delivered and re-refiners €50 per tonne. (The structure of the policy is set out in Figure 2.5.)

Figure 2.5. The Structure of Lubricating Oil Policy in Italy

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The collection of waste oil is free of charge, regardless of location and amount. However, not all waste oil is collected as emulsions and oils contaminated by fuel are excluded. Testing of the waste oil prior to collection and again at the 26 registered storage tanks is required and ensures that the least acceptable waste oils are diverted to less sensitive cement kilns and other fuel uses. Testing costs are met from the variable levy on lubricant products. The implied price signal in this system is that a free collection service is available for qualifying waste oils. Those oils that fail to meet the quality criteria fall outside the system and should be collected by independent (non-consortium) businesses at a cost. Consequently, the collection performance of the Italian system appears to be inferior to that in other countries, notably the UK and Germany (see Table 2.9).
Table 2.9. Waste Oil Collection in Italy

<table>
<thead>
<tr>
<th>Year</th>
<th>Waste Oil Collected (000 tonnes)</th>
<th>Lubricant Sold (000 tonnes)</th>
<th>Collection Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>172</td>
<td>625</td>
<td>28%</td>
</tr>
<tr>
<td>1998</td>
<td>177</td>
<td>636</td>
<td>28%</td>
</tr>
<tr>
<td>1999</td>
<td>183</td>
<td>634</td>
<td>29%</td>
</tr>
<tr>
<td>2000</td>
<td>183</td>
<td>648</td>
<td>28%</td>
</tr>
<tr>
<td>2001</td>
<td>192</td>
<td>605</td>
<td>33%</td>
</tr>
<tr>
<td>2002</td>
<td>190</td>
<td>578</td>
<td>32%</td>
</tr>
</tbody>
</table>

Source: Consortium Data 2002

Table 2.10. Base Oil Manufactured From Waste Oil in Tonnes in 2002

<table>
<thead>
<tr>
<th>Operator</th>
<th>Location</th>
<th>Nameplate Capacity</th>
<th>Base Oil Output 2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscolube</td>
<td>Ceccano</td>
<td>84,000</td>
<td>38,000</td>
</tr>
<tr>
<td>Viscolube</td>
<td>Pieve Fissiranga</td>
<td>100,000</td>
<td>48,000</td>
</tr>
<tr>
<td>SIRO</td>
<td>Milan</td>
<td>9,000</td>
<td>5,200</td>
</tr>
<tr>
<td>RAM Oil</td>
<td>Naples</td>
<td>35,000</td>
<td>7,900</td>
</tr>
<tr>
<td>DISTOMS</td>
<td>Porto Torres</td>
<td>18,000</td>
<td>4,300</td>
</tr>
<tr>
<td>ECENER</td>
<td>Ravenanu sa</td>
<td>15,000</td>
<td>Nil</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>261,000</td>
<td>103,400</td>
</tr>
</tbody>
</table>

TFD = Thin Film Distillation. Source: Industry Interviews 2003

Table 2.11. Summary of Programme Outcomes

<table>
<thead>
<tr>
<th>Measure</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lubricant Sold (a)</td>
<td>578,000 tonnes</td>
</tr>
<tr>
<td>Waste oil Collected (b)</td>
<td>190,000 tonnes</td>
</tr>
<tr>
<td>Collection Rate (a/b *100)</td>
<td>33 %</td>
</tr>
<tr>
<td>Recycled as a Base Oil</td>
<td>54 %</td>
</tr>
<tr>
<td>Other Recycling/ Reuse</td>
<td>36 %</td>
</tr>
<tr>
<td>Direct Burning/ Energy Recovery</td>
<td>10 %</td>
</tr>
</tbody>
</table>

Given the support provided to re-refining it is not surprising that there is a relatively active industry with six plants, with capacities ranging from 9,000 to 100,000 tonnes per annum.

However, it is significant that output is considerably below capacity for many of the plants (see Table 2.10.)

The outcomes of the policy are summarised in Table 2.11. Re-refining rates are high relative to most other countries, but the collection rates are relatively low.

Indirectly, the policy may have supported the market for re-refined oils on the demand side. When AGIP was a state-owned oil company, it was possible for the Government to require the company to integrate with Viscolube to overcome the multiple barriers to marketing base oil manufactured from waste oil. Although AGIP is only one of several customers for re-refined base oil, the availability of this marketing route allows re-refined base oil to lose its separate identity. AGIP and its many related companies are able to add their brand names to guarantee buyers that the base oil and lubricants meet the quality standards expected by buyers.

In addition, the inclusion of lubricant manufacturers on the consortium encourages a flow of information between manufacturers and re-refiners. This allows the waste management implications from the introduction of new additives or products to be balanced with the performance advantages expected from the new product. International trade in lubricant products and the exclusion of companies such as Cargill who manufacture vegetable-based biodegradable oils undermines the value of such an information exchange in this forum.

However, some features of the programme – i.e. limiting deliveries of waste oil to cement kilns to 10% and excluding many sources of waste oil - may be inhibiting collection rates since this would have the effect of reducing the potential scope for a use of waste oil which is financially viable. Since non-consortium oil is collected at a cost, this may have perverse environmental consequences.

Presumably, any uncollected oil is being managed inappropriately thereby imposing externality costs. These costs are likely to arise in additional water treatment costs, fish stock decline and loss of amenity value. 80% of the levy on lubricants is paid to Government for...
environmental enforcement and clean up costs. Moreover, whether or not it is equitable to impose an additional €325 per tonne price on all lubricant users when recovery rates for different types of lubricant vary considerably is questionable. It is further complicated by the differential rates of excise duty on oil products. Two-stroke engine oil for example may qualify as a lubricant but it is effectively used as a fuel.

5.3 Australia

"The Commonwealth will fund the development of a comprehensive product stewardship arrangement and provide transitional assistance to ensure the environmentally sustainable management and re-refining of waste oil and its reuse. It will support economic recycling options and the development of stewardship arrangements. Any diesel extenders or other products manufactured from recycled waste oil will be required to meet the relevant Commonwealth environmental standards." Prime Minister’s Statement 31st May 1999

Australian policy (the Product Stewardship Arrangements for Waste Oil) might be categorised as being somewhere between that of Italy and the UK. On the one hand it is focused on improving collection efficiency by using funds generated from an advanced disposal fee (a product stewardship levy) on lubricants to increase the number of free collection points. However, the funds generated are returned in part through a benefit scheme, for which benefit rates for recovered oil used for re-refined lubricating oil are 10 times that received for heavy grade burning oil, and 7 times that for diesel fuel (AATSE 2004). (See Table 2.12.)

In practice, the Australian system has excluded certain lubricants from the levy payment on the grounds that the lubricants are unavailable for recycling and pose little risk to the environment. In addition, an effective exemption through the provision of a benefit payment for multi-use oils that cannot be recycled and pose little risk to the environment, has recently been provided.

While Australia has a system that does not explicitly favour re-refining over other forms of re-use of waste oil, the system does encourage the development of markets for waste oil through subsidies (funded by the levy on new oil). Significant subsidies ($34.5 million) are provided to a range of schemes. The majority is expected to go toward support for collection schemes. By the end of 2003 approximately $6 million had gone toward collection infrastructure (AATSE 2004). However, the single largest grant ($1.3 million), excluding those made to State governments, was recently disbursed for the capital costs of a re-refining plant (AATSE 2004). Other grants have gone toward “waste oil market development” projects. An Oil Stewardship Advisory Council including representatives from oil producers, waste management companies, trade associations, NGOs and public authorities advise on the management of the fund.

<table>
<thead>
<tr>
<th>Category</th>
<th>Subsidy (cents/litre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Re-refined base oil achieving the highest quality standard</td>
<td>50</td>
</tr>
<tr>
<td>2 Re-refined base oil for chain bar oil etc</td>
<td>10</td>
</tr>
<tr>
<td>3 Diesel Fuels</td>
<td>7</td>
</tr>
<tr>
<td>4 Diesel Extenders</td>
<td>5</td>
</tr>
<tr>
<td>5 High Grade industrial burning oils</td>
<td>5</td>
</tr>
<tr>
<td>6 Low Grade industrial burning oils</td>
<td>3</td>
</tr>
<tr>
<td>7 Industrial process oils that are laundered</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Environment Australia PSA Benefit Rates 2002/03

Prior to the introduction of the programme, waste oil was collected free of charge by commercial businesses except in rural areas where a modest fee of between 8 and 12 cents per litre was charged. Public provision of collection facilities was poor. Since the programme has been introduced, collection rates have risen from 165 ML per year prior to the introduction of the programme to 220 ML in 2002-2003. Estimated collection rates are now 81% of potentially recoverable oil (AATSE 2004). The effects on post-collection practices are less apparent. Prior to 2000, approximately 75% of collected waste oil was used as a burner fuel in a variety of industrial furnaces including cement and lime kilns, 20% was used to manufacture a high sulphur diesel fuel and a small fraction was re-refined. Re-refining remains very low (3 ML in 2002-2003) and 85% of the oil recycled is still for energy recovery. However, it is expected to
grow with the new subsidised plant at Wagga Wagga, which has a projected capacity of 15 ML (AATSE 2004).

It should be noted that the Australian policy for waste oil management recently changed direction to improve the collection rate instead of financial support re-refiners. Indeed, recent figures “suggest that up to 100 million litres of waste oil go missing each year”, said Dr Kemp, the Federal Minister for the Environment and Heritage in May 2004. An extensive infrastructure of 300 new collection sites (in addition to the 400 existing ones) will be developed by the end of 2004 through a fund of 10 million Australian $ provided by the Australian government. The development of more free collection facilities, especially in rural areas, should increase the proportion of waste oil that is collected. However, the mixed oil quality may limit the amount of waste oil that can be directed to re-refining.

5.4 Alberta, Canada

A comprehensive description of the Alberta EPR system was prepared for the OECD in December 2002 (CMCL 2002). The system imposes an ADF (the Environmental Handling Charge) on most lubricant and oil filter products at point of sale and distributes payments (Return Incentives) to collectors to provide an incentive to return waste oil, packaging and oil filters to almost 600 specified facilities. The policy is broadly revenue-neutral, and the programme, which has been developed and is directed by major oil refiners and filters manufacturers, does not receive any financial public support.

The focus is on increasing collection in order to ensure that waste oil is not disposed of inappropriately. There are no quantitative data available on how much of the waste oil collected is burned for energy recovery versus re-refined. While there is a recovery market, the waste oil goes mainly toward asphalt paving or burned for energy recovery. Moreover, since the return incentive is based strictly on volumes (discounted by water content) and the oil collected is not tested for contaminants, the potential for re-refining from the oil collected is limited.

The programme has been very successful with respect to collection and recovery for the two uses mentioned above. Based on an assumption that 65% of lubricant sold is recoverable, the scheme has achieved a recovery rate of 71%, equivalent to 465% of lubricant sold. This is similar to the 47% achieved in the UK and 48% in Germany. The system is setting higher targets for future years.

The focus on collection reduces the greatest risk of environmental damage; that of deliberate or accidental spillage into water resources before collection. The system is much less concerned with distinctions between re-refining waste oil and recycling it as a fuel substitute or asphalt additive. The Alberta re-refiners complain about the fact that the Western Canadian EPR programme has not been designed to avoid contamination of collected waste oils, which severely restricts the re-refining potential. Indeed, the funding of the collection of used lubricants without testing procedures has created an incentive for waste oils generators to blend used lubricants with “no value” hazardous recyclables such as parts washer solvents, glycol or unburned fuels. Such waste oils are thus more suitable for incineration rather than re-refining. The high demand for fuel by industry for energy purposes combined with imperfect enforcement of emissions regulations result in making the re-refining process less competitive. And finally, there is also some concern on the part of re-refiners that refiners have undue influence over the programme.

5.5 European Union

The Commission of the European Communities issued a Directive on Waste Oils in 1975\(^a\), whose purpose is to protect the environment against the harmful effects of illegal dumping and of treatment operations by ensuring safe collection, storage, recovery and disposal of waste oils. It requires Member States to give priority to the regeneration of waste oils in preference to other disposal methods, regeneration being considered as the most energy efficient option. Otherwise, waste oils have to be burned under environmentally acceptable conditions.

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However, the report on the implementation of the Directive on waste oils indicates that, in 1997, more than half of the EU countries do not regenerate any waste oils - or only a very small quantity - and that the re-refining is decreasing relative to incineration in many of the countries where there is a market (France, Germany, Italy and the United Kingdom). Presently most of the EU countries have not complied with the Directive and the Commission has taken legal action against Austria, Belgium, Denmark, Finland, France, Germany, Ireland, the Netherlands, Greece, Sweden and the United Kingdom for non transposition of the EU Directive into their legislation.

One should say that the Directive itself states that, “where technical, economic, and organisational constraints so allow, Member States shall take the measures necessary to give priority to the processing of waste oils by regeneration” (Article 3). Thus, a great number of countries have argued that, given a number of constraints, they were not in a position to implement the Directive. In summary, most of the countries targeted give the following reasons:

- There is a high demand for waste oils used as a fuel compared to a small demand for regenerated lubricants;
- There is the typical obstacle of “risk aversion”: consumers think that regenerated lubricants are of lower quality;
- There is a base oil overcapacity (France and Germany are closing plants)
- New lubricants are of better quality and lower cost.
- Re-generation is not economically viable.

Also it should be noted that countries which do not re-refine waste oils (Austria, Belgium, Denmark, Ireland, and the Netherlands according to the EU report) are small countries, where the quantities of collected waste oils are not sufficient to economically justify investing in the re-refining industry. In summary, the countries targeted argue that the demand for regenerated lubricants is relatively small in comparison to their high production costs, and does not make the regeneration of waste oils an attractive commercial option.

In addition, the European Commission has given contradictory signals to potential re-refiners: it has issued, on one hand, the Directive on Waste Oils which encourages industrial investment in re-refining capacity, and, on the other hand, a Directive on Waste Incineration\(^a\), which allows lower emission limit values and less stricter requirements for co-incineration, i.e. industrial boilers or cement kilns burning hazardous wastes, than for municipal waste incineration. In addition, there is a duty derogation on waste oils used as a fuel until 2006 for 11 Member States. This creates incentives to burn waste oils rather than to recycle it, which is not at all in line with the Waste Oils Directive and may explain why so many Member States have not been able to favour waste oil regeneration.

### 5.6 Comparative Assessment

Given the paucity of data and the differences across the programmes it is difficult to provide a systematic comparative assessment of their relative efficiency. However, there does seem to be a distinction between governments which have introduced policies designed to favour the re-refining of waste oil and those which have sought to maximise collection rates. The former have necessarily sought to overcome the barrier of unsuitable quality waste oil undermining the viability of the re-refining process.

On the other hand, where policies favour a high collection rate of waste oils by making the waste oil collection mandatory for example, as in France (80 % of waste oils are collected) and grant subsidises according to the volumes collected, the quality of waste oils is usually low because all kinds of waste oils of different qualities are mixed and the water may be used to inflate volumes. This makes the re-refining to lubricants more difficult and costly and most of waste oils must be directed to incineration processes.

In general, policies which seek to maximise collection, make it free of charge or provide positive incentives to ensure that generators bring back their waste oil to the collection point. In addition, it is common to exclude certain types or sources of oil from the collection system to reduce potential for contamination and increase the potential for re-refining. This

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exclusion is applied as a proxy method to segregate poorer quality oils in the absence of accurate information about the precise quality attributes at a more disaggregated level. This proxy in the form of an exclusion rule such as "no marine slops" or "no amounts less than 400 litres" is designed to reduce the risk of whole batches being made unsuitable for re-refining.

Table 2.13. Summary of Policies and Outcomes in Selected Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Lube sold ('000 tonnes)</th>
<th>% Collected</th>
<th>% Re-refined as base oil</th>
<th>% Reused or Recycled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>450,000</td>
<td>38</td>
<td>0</td>
<td>38</td>
</tr>
<tr>
<td>Alberta</td>
<td>141</td>
<td>51</td>
<td>0</td>
<td>51</td>
</tr>
<tr>
<td>Catalonia</td>
<td>81</td>
<td>33</td>
<td>17</td>
<td>16</td>
</tr>
<tr>
<td>Germany</td>
<td>1,100</td>
<td>48</td>
<td>8.6</td>
<td>39.4</td>
</tr>
<tr>
<td>Italy</td>
<td>578</td>
<td>33</td>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td>UK</td>
<td>804</td>
<td>47</td>
<td>0</td>
<td>47</td>
</tr>
</tbody>
</table>

As a percentage of lubricant sales
*+* Represents the additional subsidy from the derogation of excise duties when substitute fuels are made from waste oil.
This is estimated at €34 per tonne in European countries. The Australian rate is A$70 per tonne

Sigman (1988) highlights one relationship between price signals and dumping and it is likely although uncertain, that once excluded from the free collection system, some of this waste oil may be dumped. Nevertheless, policies are needed that encourage segregation of good and bad waste oil without causing this externality to arise. The development of a low cost, rapid result testing kit for use at the point of collection could be helpful in this regard but only if used to enable waste oils unsuitable for re-refining to be collected separately. This would reduce the information asymmetries in this market.

The Catalonian policy of offering free collection for a minimum of 400 litres of pre-tested waste oil reflects the high cost of testing a batch of waste oil relative to its market value. The policy of volume segregation could successfully improve the quality of oil delivered to a re-refinery, but at the risk of excluding a significant proportion of waste oil from multiple small point-sources.

The Australian policy of offering comparatively large output subsidies to all recycling uses was designed to compensate re-refiners and others for the additional treatment, maintenance and production costs from receiving mixed poor quality waste oil. Policies were not directed at improving segregation and no particular waste management option for waste oils (re-refining versus energy recovery) was favoured by the government. However, it is interesting to note the change of policy from the Australian government who quite recently decided to improve the collection rate of waste oil instead of financial support for re-refiners.

Moreover, even after waste oil feedstock has been delivered to a re-refinery further intervention has been required from Governments in Italy and Catalonia to address risk aversion in the base oil market. In Italy, the "arranged marriage" of AGIP and Viscolube was effective in giving re-refined base stock a guaranteed market outlet. In Catalonia, public vehicles were used as a market for engine oil manufactured at the single re-refining facility (C.A.T.O.R) In the United States, the Postal Service and the National Park Service use re-refined oil in their vehicles. Public purchasing policies can usefully guarantee outlets for re-refined waste oils and promote their use.

The development of high-quality lubricating oil by Viscolube is likely to address risk aversion amongst consumers more effectively. This base oil product will display superior attributes to that manufactured in almost all European oil refineries. However, the €20 million capital costs of the hydro treating plant have been underwritten by the consortium distributing the ADF (advanced disposal fee) in Italy. There is, therefore, an important cross-subsidy which may be difficult to justify on purely environmental grounds.

Switching costs make base oil buyers less likely to use re-refined base oils. This barrier can be addressed for market entrants by meeting the costs of engine tests to enable re-refiners to demonstrate that base oils meet the minimum quality standards required by the market. In Spain, the costs of engine tests for the development of a new branded motor oil product have also been met by the state. Seeking to develop a new motor oil brand manufactured from re-refined base oil is ambitious but as a first step, making grant awards toward the cost of establishing a quality signal for re-refined base oil may be an initial means of seeking to address this barrier.
6 Conclusions

Getting the shares between re-refining, different forms of energy recovery, and other waste management options is clearly a delicate balancing act. Moreover, it is a moving target – with demand for lubricating oil stagnant and changing technologies of production, re-refining, and even detection of impurities. Against this background, some countries have placed the emphasis on maximising regeneration, while others have targeted collection without favouring one post-consumption use over another (except to restrict illegal and unregulated energy recovery). As a general rule it is, of course, best to ensure that environmental damages are regulated effectively and efficiently, and then let the market determine the optimal shares. However, this is easier said than done in the area of lubricating oils and a few specific policy recommendations emerge from the case study.

6.1 Targeting environmental policy objectives

It is clear that use of waste oil in unregulated small burners or dumping of waste oil into the natural environment results in significant environmental damages. As such, it is important to maximise collection rates, ensuring, to the greatest extent possible, that waste oils (and any associated contaminants) do not end up being discharged into the natural environment, whether through illegal dumping or incineration.

A secondary issue is the ultimate use to which the waste oils are put after they have been collected. LCA studies are not conclusive about the best environmental option between re-refining to lubricants and reprocessing waste oil to recovered fuel oil in industrial furnaces provided with the appropriate pollution control device. Depending upon assumptions made, in particular about the type of fuel that is displaced by burning used oil, one or the other may be preferable.

As long as environmental regulations for both of these processes are appropriate, there is no environmental reason to favour one over the other. If an environmental case can be made for the adoption of one waste management option over the other (e.g. re-refining over energy recovery), this should be directly reflected in the environmental regulations to which they are subject, and not indirectly through interventions in the market (e.g. subsidies, tax preferences, etc...). Thus, it is vitally important to ensure that air pollution regulations for ‘legal’ energy recovery of waste oils are enforced, a point which is taken up below.

6.2 Providing information to market participants

For markets to operate efficiently, market participants must have access to reliable information. There is, therefore, a strong case to be made for an active government role in informing small and medium enterprises generating waste oils and “do-it-your-self” households about the potential environmental damages to the environment of illegal dumping and unregulated burning, and the fines they will incur if they adopt such a strategy. This should be complemented by information campaigns concerning the location of collection points, and other practical advice to ensure safe management.

In addition, it may be possible to support the demand for re-refined lubricants by 1) informing customers on the quality of re-refined lubricants; 2) developing identical standards for virgin and re-refined lubricants; and 3) using the public purchasing tool as a demonstration tool. However, it must be recognised that government measures designed to change ‘preferences’ in markets where there is significant risk aversion are likely to be more successful if they focus on the quality characteristics of the product themselves, rather than any associated environmental benefits.

6.3 Discouraging illegal dumping and burning

It is not a straightforward task for the regulatory authorities to discourage illegal dumping and/or burning. Waste oils are generated diffusely and it can be relatively easy to dump them.
clandestinely. Moreover, in many countries there is a vibrant market for burning in a variety of unregulated uses, such as space heaters and greenhouses. The administrative costs associated with monitoring and enforcement to prevent such uses of waste oils can be costly.

In the face of high administrative costs, it is preferable to complement the ‘stick’ of regulatory incentives (i.e. fines) with a ‘carrot’ (i.e. benefits payments or refunds). The resources required to fully prevent illegal uses of waste oil through the application of penalties are beyond the capacity of most regulatory agencies. It is for this reason that many jurisdictions try to pull the waste oil back into the system through positive incentives rather than trying to prevent illegal options through negative incentives.

Administratively, the simplest means of providing these positive incentives is through return incentives, often financed out of upstream charges on lubricant oil sales. However, these return incentives are usually granted on the basis of volumes returned in an undifferentiated manner. Unfortunately this can provide perverse incentives with respect to the quality of oils collected (see below). Differentiating return incentives according to waste oil quality would, however, be dependent upon accurate and timely assessment procedures.

6.4 Maximising collection without restricting re-refining

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

This possibility is exacerbated by the fact that it can be easy to conceal (and difficult to detect) waste oils of low quality at the collection stage. Indeed, this can provide a ‘race to the bottom’ with many suppliers dumping low quality waste oils into the collection system. Since reputation effects within the market cannot always prevent this arising, there is a strong case to be made for government intervention. Support for the development of low-cost testing equipment is one route.

Even in the absence of comprehensive testing it is possible to combine periodic and random testing with stringent penalties for the dumping of low-quality waste oil. Even if the probability of detection is low, if the penalty is sufficient this may dissuade the entry of contaminated waste oil into the collection system. Such enforcement schemes have been used successfully in other markets where the costs of monitoring are high.

6.5 Removing market and policy distortions

As noted above, allowing direct incineration of waste oil without any pollution control device or imperfect enforcement of air emissions regulations result in an unfair competition between re-refining and energy recovery. In effect, there is a market distortion if externalities are left internalised in one waste management option but not in the other.

However there are other potential distortions in the market(s) which may favour one or the other waste management option. For instance, in the United Kingdom it has been argued that derogation on excise duties for waste-derived fuels oils used for energy recovery provides a significant cost advantage, undermining the potential development of the re-refining industry which is competing for the use of the same material input. It has been estimated that the duty would add 50% to the current cost of recovered fuel oil. This derogation is to be rescinded in 2006, removing a significant market distortion.

Needless to say, unless removal of the derogation (and other market and policy distortions of this kind) is combined with effective enforcement, there is a danger that it
will reduce collection rates by driving the waste oil into illegal dumping or burning, rather than into the re-refining industry. The need for effective co-ordination is key.

6.6 Ensuring policy consistency

If it was possible for market participants to switch easily between different waste management options, changes in relative costs and policy incentives could be absorbed relatively easily by the market. However, as has been noted the start-up costs for re-refining can be very significant, not only because of the physical capital but also due to other factors associated with market entry such as testing costs.

As such it is extremely important that policymakers provide clear incentives to investors. For instance, the imperfect enforcement of the European Waste Oils Directive has sent contradictory signals to investors. On the one hand, the priority given to regeneration in the Directive appeared to provide the basis for the development of a market. On the other hand, the Directive has been imperfectly enforced due in part to the apparent inability of some countries to support such an industry without significant public financial support. In addition, the incentives provided by the Waste Oils Directive and the Waste Incineration Directive need to be consistent, something which is far from certain.

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