Executive Summary

Context, Objectives and Methodology of the Project

- One of the main axes of the directive 75/439/EC on Waste Oils (WO), amended in 1987, is that, among the different options for recovery, priority is given to the regeneration of WO over their incineration.

  But several studies clearly demonstrate that Member States (MS) do not favour regeneration of WO, but on the contrary are widely using WO as fuel in industrial installations.

- Launched by the EC in the frame of the revision of this amended directive, the main objective of this study is to undertake a thorough technico-economic and environmental analysis of the literature available about the regeneration of WO and its comparison with their incineration.

- For that purpose, more than 75 studies have been analysed.

  In order to update some of the obsolete information, to overcome some of the inconsistencies, and to gather information about new subjects still poorly covered by the literature (such as new regeneration technologies and thermal cracking), a lot of experts have been interviewed.

  A critical assessment has been performed for the four Life Cycle Analysis (LCA) studies available:

  - Burning or Re-refined used lube oil? - The Norwegian environmental protection agency,1995,
  - WO - Fuel or lubricant? - Examination for precedence in accordance with the waste recycling act - Lower Saxony Minister of the Environment (Germany), post 1997,
  - Recyclage et Valorisation énergétique des huiles usagées - Atouts et faiblesses – ADEME (France), 2000,
  - Ökologishe Bilanzierung von AltölVerwertungswegen - Ökologisher Vergleich von vier wichtigen Altölwertungsverfahren – UBA (Germany), 2000.

  The first International Standard concerning LCA (ISO 14040) has been published in 1997: it describes the principles and framework for conducting and reporting LCA studies, and includes certain minimal requirements. Two studies (ADEME and Germany 2000) have been recognised as compatible with the ISO standards concerning LCA studies: in the both studies, a critical review has been carried out. These studies are correctly designed to compare the waste management options under consideration.

  The two other studies (Norway 1995 and Germany 1997) have been performed before the publication of the ISO standards concerning LCA.

  For different reasons detailed in the report, the results of the Germany 1997 study has not been taken into account to draw the conclusions presented below.

Current Situation of WO Management in Europe

- About 4 930 kt of base oils were consumed in Europe in 2000, among which about 65% of automotive oils and less than 35% of industrial oils.

  About 50% of consumed oils are lost during use (combustion, evaporation, residues left in the containers…). The remaining 50% represent the collectable WO.

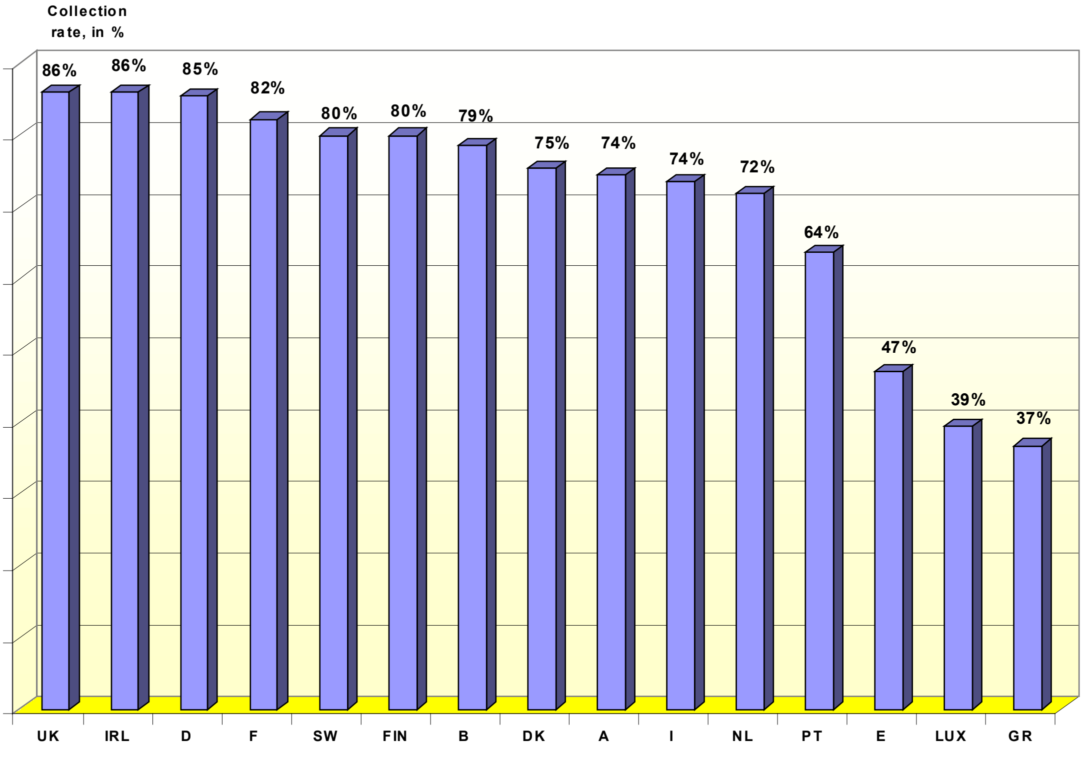
- Engine oils represent more than 70% of 2 400 kt of the collectable WO (black industrial oils about 5% and light industrial oils less than 25%).

  Engine oils (and to a lower extent black industrial oils) are potentially suitable for regeneration, whereas light industrial oils, clean, join an independent recovery circuit.

- The average WO collection rate reached about 70-75% in the E.U. in 2000. Approximately 1 730 kt of WO were collected. The remaining 675 kt (25-30%) are accounted as illegally burnt or dumped in the environment. It still vary from country to country.

  The efficiency of the WO collection systems is often very high for engine oils (more than 80%) and low for black industrial oils (less than 10%).

WO Collection Rate, in 2000



Appropriate collection and disposal arrangements for WO from industrial or automotive origin (garages…) are generally well established in Europe.
However, WO from 'Do-It-Yourself' (DIY) oil changes are less likely to be collected and so present the greatest risk of improper disposal.

Remark: It is well known that the national databases about collected quantities are still insufficiently developed and heterogeneous between the countries. The quality of the MS declarations could greatly benefit from the implementation of such databases with harmonised definition and calculation rules.

- A lot of treatment processes exist (or are under development) today in Europe. The most significant ones are listed below.

WO	*Type*	*Products*
Clean WO	RE-USE	**Hydraulic or cutting oil** • electricity companies • shipping industry • major engineering companies **Mould oil or base oil** for the production chain saw oil
Engine WO + clean WO	REGENERATION or RE-REFINING	**Lubricant base oil**
All types of WO including synthetic oils	THERMAL CRACKING	**Distillate gas oil products** • gas oil (also called heating oil, diesel oil, furnace oil...) • de-metallised fuel oil • marine gasoil (MGO) • re-refined light base oil
Mixed wastes	GASIFICATION	**Synthetic gas** • hydrogen • methanol
All types of WO, especially heavy polluted ones	SEVERE RE-PROCESSING	**De-metallised fuel oil** (or heavy distillate) • marine diesel oil (MDO) • fuel for heating plants...
	MILD RE-PROCESSING then burning	**Replacement fuel oil (RFO)** • road stone plants, cement kilns, large marine engines, pulverised power stations...
	DIRECT BURNING (waste incinerators, cement kilns, greenhouses, workshops...)	

- An average of 25% of the collectable WO (and 33% of the collected WO) would have entered a regeneration plant in the EU in 1999.

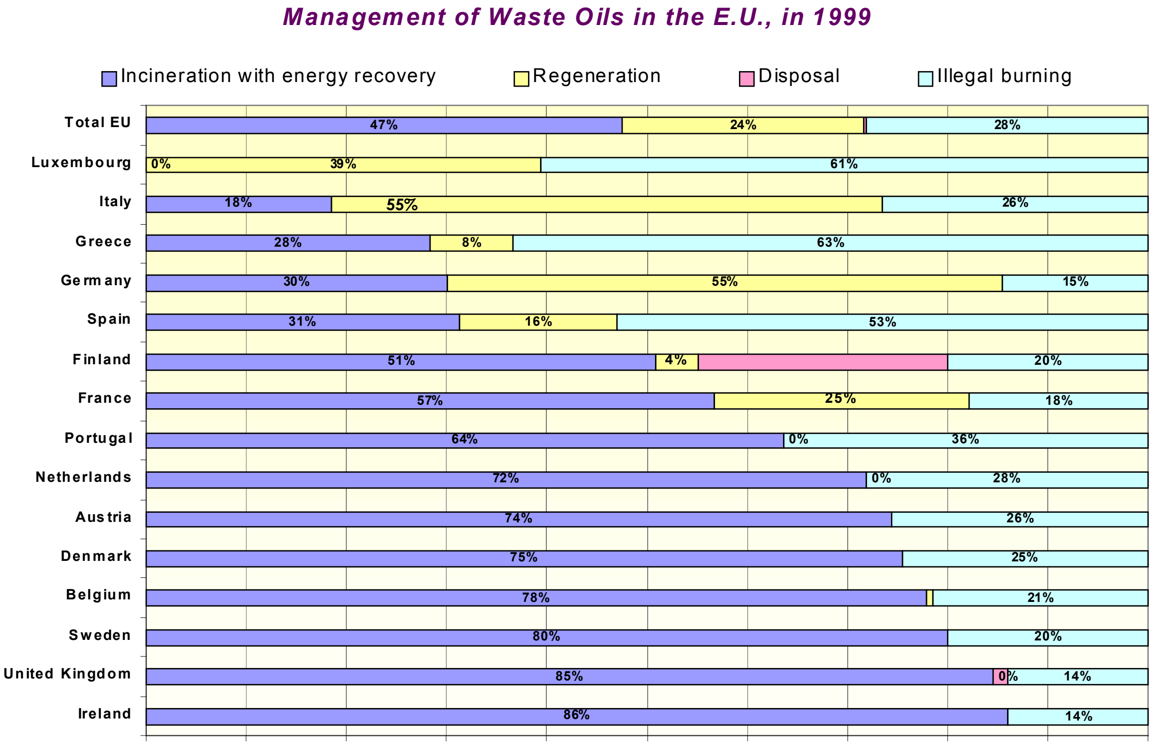
  About 50% of WO were energetically used in the E.U., in 1999.

  Cement kilns play an important role in the energetic use of WO: about 400 kt of WO are burnt in cement kilns at the European level, which represents about 17% of the total WO and 35% of the WO burnt.

  But the importance of that route differs between the countries. It represents:

  - the major route in F, D, Sw,
  - only one of the routes in A, B, It and the UK.

  About 25% of WO were still illegally disposed of in 1999.



Remark: The data regarding the current situation of WO management in Europe are of very poor quality. In particular, we remain reserved about the reliability of the data regarding the regenerated quantities and regeneration rate.

- During the last years, a shrinking of the regeneration is noticeable in some countries which were precursors (such as France, Germany, Italy) and others (such as the UK).

  At the same time, 2 regeneration plants exist in Belgium today according to WATCO.

  The tendency regarding the regeneration development is uncertain for the near future. However, it seems that some projects emerge in several countries: France, Germany, Italy, Spain.

- Most of the MS do not subsidise the collection step.

  As far as the regeneration is concerned, it is subsidised only in Spain and now in Germany too.

  The situation in Italy is evolving. For instance, the partial exemption on the taxation on lubricants when they are produced from re-refined base oil will be suppressed at the end of 2001.

  As for the derogation on excise duty, it still applies for WO used as fuel in 11 of the MS.

Technico-Economic Analysis of WO Regeneration

- There is no major technical bottleneck for regeneration development:
  - the technologies exist,
  - the quality of base stocks produced is comparable to virgin base oils (Group I and even Group II when a severe hydro or solvent treatment is used for the finishing step).

  However, it remains to be seen whether the latest technical advances in regeneration prove to be sufficiently flexible to handle the changing composition of WO over the next 10 years and the possible increase of bio-lubricants consumption.

  This uncertainty generates risks for investors in regeneration facilities.

- The economic bottleneck is obvious.

  In most of the cases, a regeneration plant (with a 10% return on investment) is not economically self sufficient from the beginning, not only when the costs of collecting WO and delivery to the plant are included but even when they are not included. It would need to receive between 10 and 100 Euros for each tonne delivered to the plant, depending on the technology, the capacity and the market conditions.

  It is only after some years, once the capital cost are at least partly paid off, that the regeneration activity can be profitable.

  On the contrary, some large plants (but not all according to our analysis), located in countries where the re-refined base oil can be sold for a good price, can benefit from both scale advantages and high revenues, allowing them to purchase the WO, but at a relatively low price, between 15 to sometimes 50 Euros / t.

  In all the cases, the revenues of a regeneration plant are extremely sensible to the crude oil price fluctuations.

- The WO supplies often represent another bottleneck.

  Under free economic conditions, a regeneration plant is often unable to compete with untreated or re-processed combustion of WO (except in the case of some large plants with favourable local conditions).

  Even when the gate fee is negative, first the price that the plant can pay is not high enough to cover the overall collection and delivery costs (between 25 and 100 Euros/t depending on the country.

  Secondly, the regeneration plants suffer from the competition with industrial sectors buying the WO for an energetic use, such as cement kilns, brick kilns, power plants ...

  - As a matter of fact, due to the structure of their cost and the price of the fuels that the WO substitute, these companies are able to buy the collected WO often at a higher price than the regeneration plants (e.g. between 40 to 120 Euros per tonne when considering Italy, Germany and Spain). As a consequence, the market can often not guarantee the regularity of the supply of a regeneration plant. The situation may be improved a little bit for the regeneration activity when the new Directive on Incineration is implemented (in 2003 for new plants and 2005 for old plants), forbidding the burning of WO in many plants which are currently using WO as fuels and thus decreasing the financial interest of plants used to burn WO directly.

- The supplies of regenerators are also weakened by the WO excise duty derogation which are still in use in 11 Member States (A, B, D, E, F, Fin, Ire, It, Lux, Pt, UK): it consists in a derogation on the duty that has otherwise to be collected on WO which are used as fuel, either directly after recovery or following a recycling process. This fiscal measure, prolonged until 2006, encourages the use of WO as fuel.

  For instance, the UK excises are so high (43 Euros/t) that it brings the classic product (heating fuel) up to prices higher than the EU average. The total exemption for WO burnt as fuel makes WO very attractive for energetic use (that is why the UK is importing a large quantity of WO from other EU countries) and creates rarity of raw material for regenerators producing base oils.

- The vertical concentrations from collectors to processors which exist in some countries can create shortage of raw materials for regenerators because integrated companies would prefer to sell to cement kilns or other WO energetic users which offer higher prices (in particular in the case of crude oil price increase).

■ As for the outlet, potential users of re-refined base oils, in the automotive or industrial sector, are still reluctant to use regenerated products.

Besides, the size of the automotive lubricants is shrinking in a context of over-capacity of lubricant production and the demand progressively displaces from conventional mineral-based auto lubricants to ‘synthetic’ products with high performances. These tendencies are unfavourable to the increase of the re-refined base oils demand under free market conditions.

In any case, in this context of an increase of the quality required for lubricants, large regeneration plants will have to produce high quality re-refined base oil, even if niches will still absorb small quantities of lower quality.

■ To promote regeneration, it will be necessary to assist the regenerators with incentives (non financial in all cases and sometimes financial too).

Specific measures and arrangements have also to be taken by the regenerator himself.

All these measures aim at diminishing the risk profile of investment in regeneration projects by guaranteeing the existence and durability of the supply and outlets and, when the gate fee is positive, by covering it.

No spontaneous investment will occur unless clear signals regarding these issues are given to investors.

A set of measures and incentives is presented below, classified according to:

- the issue they are addressing: the supplies, the outlets and the profitability,
- the effect which is expected: to secure the feedstock, to secure the outlets, to cover a positive gate fee…

For instance:

Possible measures and incentives	Expected effect
Supplies	
• Medium or long term WO supply contracts and voluntary agreements between collectors and the regeneration plant • Participation (shares) taken by collectors in the regeneration activity	To secure feedstock supplies on which depends the profitability of the invested capital (to use the available regeneration capacity as much as possible)
• Collection and delivery costs covered, at least partly, by a disposal charge paid by generators / holders, a product charge on sold lubricants, a subsidy from governmental bodies…	To decrease the WO gate fee for regenerators Rem: This measure is necessary to improve the WO collection rate. Regeneration could then benefit from it.
• Application of the excise duty on WO that are used as fuel	To secure the supplies to regeneration plant
• Segregated storage and collection	To supply regeneration plants with regenerable WO to increase the quality of the outputs
Outlets	
• Marketing strategy of the regenerator to define the appropriate positioning of its products on the market (e.g. the distinction between products sold below the market price and those at the market price) • Medium or long term voluntary agreements between the regeneration plant and lube producers or large lube users • Financial incentives for blenders and lubricant manufacturers to purchase specified re-refined base oils	To secure the outlets and if possible to lighten the effect of the crude oil fluctuations
• Public procurement	To impose or at least encourage the use of lubricants containing or manufactured with re-refined base oils
Profitability	
• Stimulation of co-operation between the EU 15 countries	To obtain economies of scale and thus to decrease the WO gate fee
• Exemption of tax on sold lubricants (if any) for lubricants produced from re-refined base oil	To increase the re-refined base oil selling price (and the revenues) and thus to decrease the WO gate fee
• Subsidies (from a product charge on sold lubricants, a disposal charge paid by generators / holders, governmental bodies…)	To cover the residual positive WO gate fee of the regeneration plant (if any)

Technico-Economic Analysis of WO Thermal Cracking

- Thermal cracking can accept various types of hydrocarbon feedstock: WO, waste marine fuels, deep frying oils and, possibly with design considerations, waste plastics (e.g. DIY WO returned in their original container).

- The strategy of thermal cracking is to produce high quality products ranging from de-metallised heavy fuel oil to re-refined light industrial lube oil, including gasoil products.

- Thermal cracking is a common refinery process that is well known and proven.

  No plant already exists in Europe for WO: the first plant will be operational by the end of 2001 in Belgium.

- Experts agree that thermal cracking with its lower capital cost allows plants to be profitable at the 30 kt/yr plant size. No subsidies are necessary.

  The evaluation performed in the scope of this project on the basis of the Belgium plant being built confirms that point.

Critical Assessment of LCA Studies Comparing Regeneration and Incineration

- The results (more the tendencies than the absolute figures) from the four LCA assessed comparing regeneration and incineration can be considered sound and representative of a wide diversity of situations prevailing in Europe for the following environmental impacts categories:

  - Consumption of fossil energy resources,
  - Contribution to global climate change,
  - Contribution to regional acidifying potential,
  - Emission of Volatile Organic Compounds (VOC).

  As a matter of fact, three technologies have been considered, which can be considered being representative of a diversity of regeneration technologies existing in Europe, including modern processes:

  - Vacuum distillation + clay treatment,
  - Vacuum distillation + chemical treatment,
  - Hydrogen pre-treatment + vacuum distillation.

  And two of the incineration options existing in Europe are covered by the LCAs discussed:

  - Incineration in cement kiln,
  - Incineration in asphalt plant.

A large proportion of the collected WO in Europe are sent to one of these two types of plants. The environmental impacts of these two plants are different. The choice of two different types of plants reflect the fact that in reality there is a big variety of burning plants that use waste oils as fuel (e.g. power generation plants, tarmac production plants, cement kilns, asphalt plants, etc).

The following conclusions drawn from the LCAs analysed are those considered sound.

- From a local impacts perspective, when considering only the recovery treatments, the impacts generated by the regeneration plant are generally lower than those generated by the incineration plant.

- The environmental performance of an old regeneration process can be improved with a modern technology.

- The environmental impacts due to collection and transport of WO and primary materials are not significant within a life cycle perspective compared to the impacts of the industrial processes (this is often the case in LCAs performed for waste management options, e.g. packaging waste).

- The environmental burden of the recovery treatment (regeneration or incineration) by itself is generally less important than the one of the avoided process (virgin base oil production or traditional fuel or energy production).

  Within a life cycle perspective, the total contribution of the management system under consideration is indeed the result of the difference between two different quantities: the impact of the recovery treatment minus the impact of the main avoided system (this latter representing a bonus). The environmental impacts of WO recovery systems are mainly determined by this bonus and less by the direct impacts of the recovery processes themselves.

- All the WO recovery options under consideration are favourable in terms of environmental impacts (i.e. they contribute to avoid impacts) by comparison with a 'do nothing' system.

- The amount of the bonus brought by the avoided process is determined by the choice of the substituted process (this is also the case for other wastes with a high calorific value as plastic wastes).

  Especially in the case of the incineration of WO with energy recovery, the type of fuels that the WO replace is crucial: fossil fuel, hydroelectricity, thermal electricity, other wastes….

  This explains that, in the LCAs analysed:

  - for almost all environmental impacts considered, incineration in cement kilns (where WO replace fossil fuels) is more favourable than incineration in an asphalt kiln (where WO replace gas oil),
  - a modern regeneration may be, according to the impact considered, more favourable than or equivalent to incineration in an asphalt kiln,
  - compared to incineration in a cement kiln (where WO replace fossil fuels), WO regeneration has environmental advantages and drawbacks depending on the impact considered.

  It appears that regeneration would present advantages for all environmental impacts in all scenarios if the WO would replace non fossil fuels (e.g. hydroelectricity, nuclear electricity and maybe other wastes).

- According to the LCAs studied, as regards the comparison of regeneration to fuel and feedstock conversion:
  - Compared to thermal cracking, WO regeneration would have environmental advantages and drawbacks depending on the impact considered.
  - Regeneration would be preferable to gasification for all impacts except solid waste and water input.
  - A modern regeneration technology would become preferable to refinery recycling for some impact categories or equivalent for the others.

  Nevertheless these results ought to be validated by other studies in the future

- The following issues have not been addressed in the LCAs available and can be considered as gaps:
  - noise,
  - odour,
  - nature conservation (biodiversity, etc.),
  - land use,
  - toxic emissions.
  - the displacement of non fossil fuels by waste oils.

  As for toxic emissions (heavy metals, organic pollutants…), the LCA methodology is not currently relevant to quantify and compare reliable indicators with respect to human toxicity and ecotoxicity.

  An attempt to compute such indicators has been made in two LCAs but using different methods and obtaining highly uncertain results.

  More generally, few studies have been reported on the toxicity and potential health effects of re-refined base oils. And chronic impacts have not been studied.

  Nevertheless, it seems that re-refined base oil are not acutely toxic, nor are they skin or eyes irritant.

- The following considerations, which may have a significant influence on the environmental impacts have not been covered by the available studies as well:
  - the situations when WO replace other energy sources or wastes and not traditional fuels at the burning plants,
  - the influence of the base oil quality standard produced and / or regenerated on the environmental impacts of the different management options,

- Although one of the studies integrates the analysis of a modern regeneration technology under development, the main results from the reviewed LCA studies are based on today's situation and mean technology.

  In view of defining a waste management policy, this can just constitute a starting point**.** A prospective evaluation, taking into account the possible evolutions of technologies in the mid term, has to be integrated.