INCREASING WORLD MARKET PRICES - DRIVER FOR HIGH LEVEL RECYCLING!?

DISCUSSION PAPER ON THE CHALLENGES & PERSPECTIVES FROM THE CHANGING RESOURCE SITUATION ON RECYCLING DECISIONS

- FINAL VERSION -

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Discussion Paper

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1. Objectives

In the light of the dramatic increase of prices for several natural resources in the past month and considering the ongoing debate about the need to increase resource efficiency of the European societies, the Recycling Coalition in January 2008 asked Ökopol Institute to perform a focussed assessment answering the following question:

Which effects have the rapid increase of world market prices had on established recycling cycles and is a change in the regulatory framework necessary to cope with such a changed situation if Europe aims for high resource efficiency?

Waste oil recovery as a well established recycling sector with comparably good market data available has been chosen by the Recycling Coalition for the exemplification of this question.

The assessment has been performed between mid-January and end of March 2008. Aside from own background knowledge from a long list of projects in the respective context, Ökopol based its work on the following data sources:

- Market prices for the relevant product-groups as published by major market index service providers
- Up to date figures on the waste oil streams in EU 27 from a GEIR market research (2007/08) cross checked with available studies on Member State level
- LCA information as published by IFEU- Institute

The following discussion paper summarises major findings in brief.

2. Resource constraints and their effects on waste oil recycling

2.1. Substitution price ratio as driver for recycling

Mass flows and the economic situation of the market actors in the recycling sector are influenced by a set of major drivers Market price ratios between the recovery/recycling products and the equivalent primary products affect the way waste recovery takes place and how recycling products are brought back into use cycle. Other influences are the regulatory framework, the installed recovery and/or recycling capacities and the reputation of recycling products in the different markets (influenced e.g. by guaranteed amounts of quality checked products).

The following picture shows in a schematic way the primary and secondary products in the case of waste oil recycling/recovery.

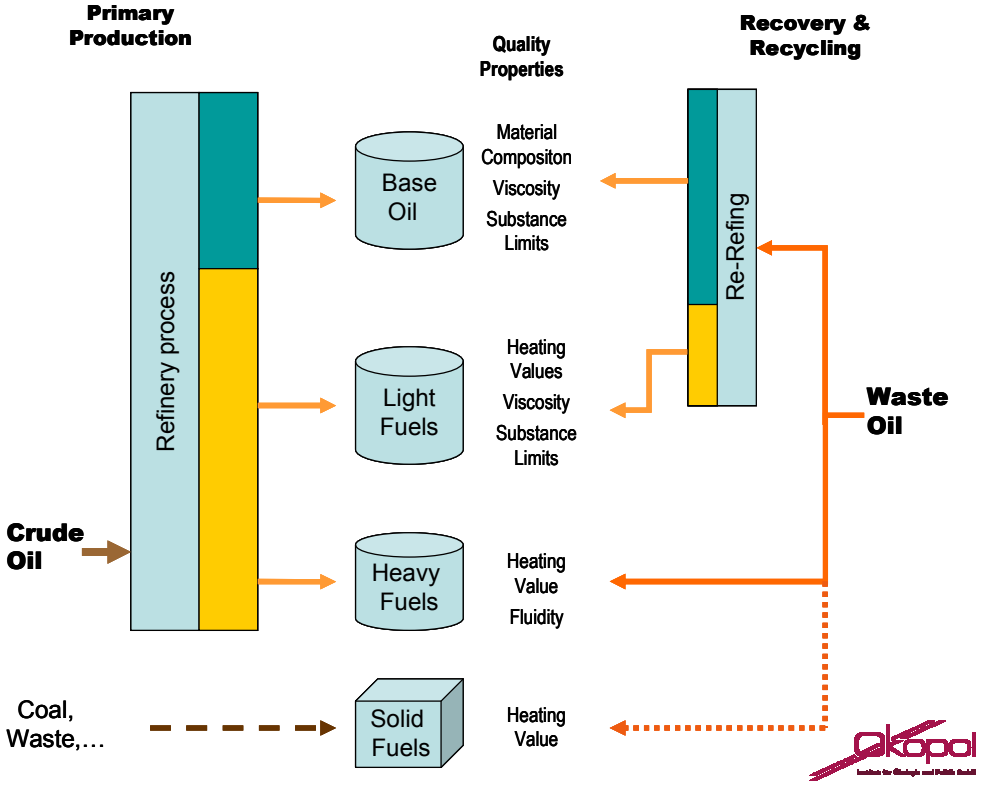

Figure 1: Substitution products with major quality properties

As can be concluded from Figure 1 each substitution route (primary and corresponding secondary resource) is defined by a set of minimum requirements concerning a more or less extended list of parameters ("quality properties").

Waste oils can thus be used to satisfy market demands concerning primary products on quite different levels of secondary use. This reaches from a simple energy carrier up to a specialised chemical product with a well defined molecular structure.

From the perspective of a resource strategy it seems of major importance that state of the art re-refining technologies provide the potential to produce high grade products (base oils) which have quality properties similar in any aspect to primary base oils. The following Table 1 shows respective product quality values.

Table 1: Corresponding product Standards/parameters [GEIR; 2008]

Parameter	Unit	Typical quality values		Test-Method
		re-refined base oil	virgin base oil (SN 150, API group I)	
Viscosity @ 40 °C	mm²/s	29 - 32	29 - 31	ASTM D-445/ DIN 51562-1
Viscosity Index		105 - 115	95 - 100	ASTM D-2270/ DIN ISO 2909
Colour		L 0,5 - 1,0	L 1,0	ASTM D-1500/ DIN ISO 2049
Sulfur	ppm	10 - 2000	2000 - 6000	ASTM D-4294 /DIN EN ISO 8754/ ASTM D-5453
Total Acid No.	mg KOH/g	<0,03	<0,05	ASTM D-974/ DIN 51558-1,2,3/ IP 1A
Vapour Loss (Noack)	wt. %	8 - 12	12 - 16	ASTM D-5800/ DIN 51581/ CEC L40 A93
PAC	wt. %	<0,2	<1,0	IP-346
Benzo(a)pyrene	ppm	<0,3	not available	Grimmer Method (GC/MS)

Separate collection of waste oils differentiated by the respective qualities is a prerequisite for stable process operation of re-refining and for the fulfilment of said quality parameters.

2.2. Price trends in the substitution markets

The following assessment of market prices show that there are not only different product qualities but as well different (sub-)markets with decoupled sensitivity regarding pricing and resource constraints.

As already mentioned above the price ratios between the different possible products to be substituted are a major incentive for the decision on recycling/ recovery routes for waste streams.

The the following figure shows the development of market prices for the main primary products possible to be substituted by waste oils since 2000.

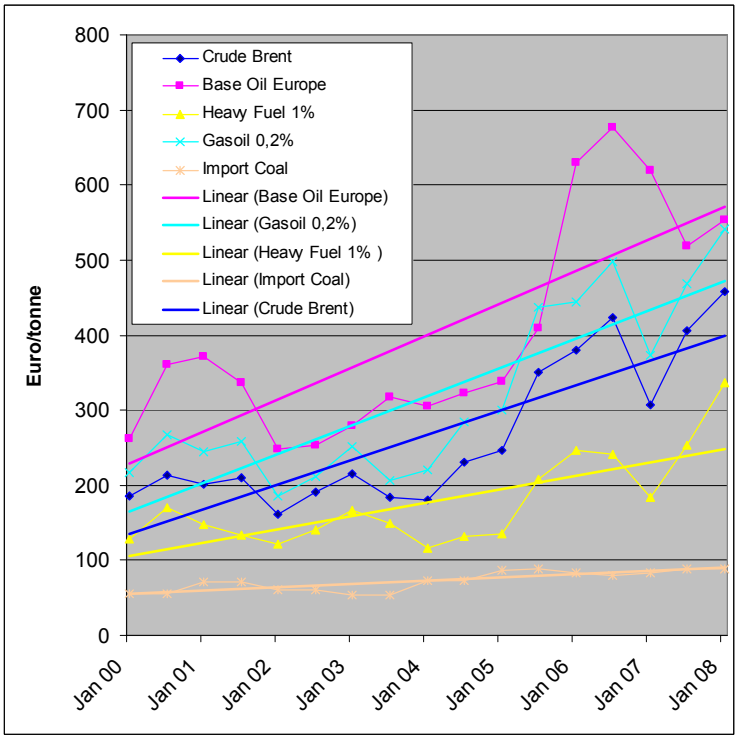

Figure 2: Market prices and linear regression on trend development for selected products[1]

While all product prices have risen significantly during the past 8 years, a clear further differentiation can be seen regarding the different product quality levels. The price ratios between *crude oil* and the high quality products *base oil* and *low sulphur gas oil* increased significantly while the price for *heavy fuels* developed a bit less dynamically. So between the different products based on mineral oil an increasing price differentiation connected with the "quality level" can be observed.

Furthermore while regarding *imported coal* as a reference for other solid fuels, a kind of decoupling of the prices can be observed.

The latter is not that surprising because in "robust" solid fuel burners the energy content of one solid fuel can be substituted by a wide variety of other fuel types (e.g. solid recovered fuels) with a better ratio of price per energy input into the process in most cases. This is not the case for liquid fuel burners which need to use fuels following the crude oil availability/price.

Overall the development of price ratios between the different products to be substituted by waste oil recovery/recycling result in a clear market pull for the high level recycling of waste oil to high quality base oils and *low sulphur gas oil*.

[1] Crude Brent (Oil Market Report Rotterdam, monthly average); Base oil Europe (ICIS-LOR - SN 150 European Export price, minimum notation); Heavy Fuel 1% (Platts -Barges FOB Rotterdam, monthly average); Gas Oil 0.2% (Platts - Barges FOB Rotterdam, monthly average); Import coal (www.kohlenstatistik.de)

But while for the direct burning (substituting *heavy fuels*) only sufficient logistics and a simple dewatering are necessary, for *low sulphur gas oils* and even more for *base oils* a complex refining process has to be operated. To cover the additional cost for re-refining the price for *base oil* needs to be about 150 – 300 €/t higher than the one for *heavy fuels*[2]. From the overall trends as shown in Figure 2 such conditions are increasingly likely but especially the *base oil price* is not directly linked to the *crude oil price* but object of market turbulence from time to time. A more detailed analysis of the market development in the last two years shows some examples for such deviation.

E.g. 2006/2007 a mixture of the following events led to an extreme increase of base oil prices:

- The hurricane Katrina with respective shut down periods for US refineries in the golf region
- A fire in one of the major US base oil refineries
- Maintenance and turnaround activities in some EU base oil refineries

In addition fuel prices affect the base oil production in the way that the resources are assigned to fuel production routes when the fuel prices are high and thus the resources assigned to base oil production are consequently reduced and vice versa.

In 2007/08 a respective correction of prices took place resulting in falling base oil prices. The following Figure 3 shows this “peak event” in a graphic.

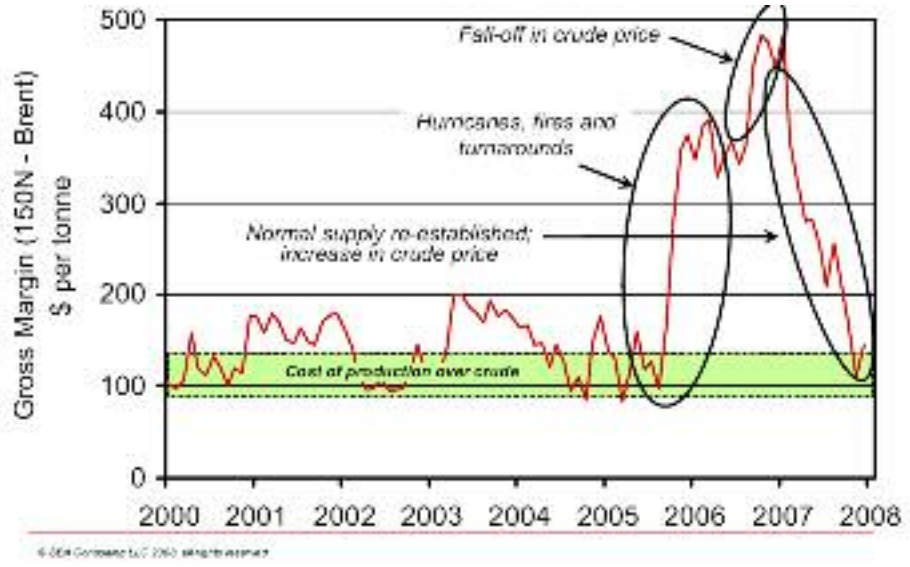

Figure 3: Example for a peak event in the primary base oil market 2006-2008[3]

[2] Taking the cost structure and output ratio of a modern re-refinery as a reference

[3] Detailed explanation of Base oil margins as presented by SBA Consulting LLC during 12th world Base Oil & Lubricants Conference London, UK, 21st February 2008

This example shows that the base oil market – like many other markets for specialized high quality products – is not only determined by the price of the primary resource but as well by specific events (e.g. like decisions of major market actors).

2.3. Waste oil flow in Europe

In Europe (EU27) over 5.7 Mio t lubricants are marketed per year. While a minor share is dedicated to be lost during use phase (e.g. grease for chain-saws) most lubricants (approximately more than 4.5 million tonnes[4]) are used in applications where significant parts can be collected after the use, e.g. like motor oils or gear oils.

In these applications rising efficiency per unit (prolonged use cycles and reduction of losses) is outweighed by a still increasing number of units. This is e.g. true in the mobility sector. In Europe the amounts of marketed and collectable lubricants/waste oils stay constant in midterm perspective, while on the world market base oil demand increases by 2-3% per year.

Major components in the collectable waste oils (70 - 75 %) are the so called base oils – Hydrocarbons with a well defined spread of molecular chain lengths.

Results from a GEIR market survey

Unfortunately no official EU-wide statistics are available e.g. using the European List of Waste (LoW). So any analysis of waste oil amounts, collection rates and final destination has to be based on specific investigations. The following Table 2 shows the results of such a survey performed by GEIR showing for the first time the waste oil flows for all EU 27 Member States.

The survey came to the result that around 2 million tonnes of waste oils[5] have been collected.[6] These are about 35% of the lubricant oil consumed in the same year in EU 27 while more detailed analyses show that at least 40-45% of lubricants marketed should be collectable from a technical perspective.[7]

[4] data from GEIR 2008 and EUROPALUB 2006

[5] Waste oil without water, covering mainly EWC 13 01 , 13 02 and 13 03

[6] Cross checks performed by Ökopol with other available waste flow information for single (groups of) Member States indicate that the figures provide realistic data, taking into account the level of uncertainty in such EU wide analysis.

[7] see [Ökopol, 2005]

Tabelle 2: Waste oil flows in Europe in 2006 [GEIR 2008]

Member State	Collected waste oil in 2006 [tons]	Destination of waste oil [tons]			
		re-refining (base oil)	burning (replacing coal)	burning (replacing heavy fuel oil)*	other/unknown
Austria	**39.596**	12.396	24.700	2.500	
Belgium	**60.000**	15.000	500	25.000	19.500
Bulgaria	**17.000**			1.200	15.800
Cyprus	**4.300**			4.300	
Czech Republic	**32.867**	986	4.800	27.081	
Denmark	**20.000**	15.500	2.000	2.500	
Estonia	**5.400**		2.700	2.700	
Finland	**22.500**		11.250	11.250	
France	**224.759**	99.403	39.130	61.439	24.787
Germany	**525.000**	135.000	70.000	295.000	25.000
Greece	**36.000**	36.000			
Hungary	**27.823**		6.000	7.823	14.000
Ireland	**20.000**				20.000
Italy	**216.300**	172.600		34.600	9.100
Latvia	**11.000**		5.500	5.500	
Lithuania	**14.000**		7.000	7.000	
Luxembourg	**5.364**	5.364		0	
Malta	**1.200**				1.200
Netherlands	**50.000**	18.000		32.000	
Poland	**76.500**	63.500	3.000	10.000	
Portugal	**28.700**	6.800	3.550	13.550	4.800
Romania	**27.663**		9.500	16.147	2.016
Slovenia	**3.967**			3.499	468
Slovakia	**15.000**		6.000	9.000	
Spain	**216.045**	140.084		74.362	1.599
Sweden	**45.000**	8.000	37.000		
United Kingdom	**350.000**			270.000	80.000
Total:	**2.095.984**	**728.633**	**232.630**	**916.451**	**218.270**
Percentage (%)	**100%**	**35%**	**11%**	**44%**	**10%**

* including direct burning and simple treatment

Overall these figures show some very clear results:

- Substituting waste oils against mineral oil based products (79% to base oils and fuels) is most prevalent,
- More waste oils were used for direct burning (44%) than for re-refining (35%),
- Only relative small amounts of waste oils are still used to substitute coal (share of 11% substituting solid fuels) while in the nineties this was a dominant use. This development is not surprising considering the given price ratios as outlined in chapter 2.2.
- For relevant parts of collected waste oils (10%) the final destination remains unclear.

- Priority to regeneration might be a "driving force" for better and more transparent waste lubricant management. In countries where regeneration is a priority the percentage of unknown disposal is significantly low.

When discussing waste oil flows, the capacities for recovery and recycling are of importance as well.

About existing re-refining capacities the GEIR survey presents the last update of the given situation. According to this information the re-refining capacities for waste oil 2006 in EU 27 added up to around 1.6 million tonnes in 32 installations. The following Table 3 shows in which member states major re-refining capacities are located today.

Table 3: Major Re-Refining capacities in 2006 Europe [GEIR 2008]

Country	Re-Refineries [installations]	Total used oil capacity [t /anno]	Used oil capacity for base oil production [t /anno]
Germany	10	715.000	370.000
Italy	4	258.000	258.000
France	1	125.000	125.000
Spain	5	124.000	124.000
Total	**20**	**1.222.000**	**877.000**

Some further capacities are located in Belgium, Denmark, Greece, Netherlands, Poland and the UK.

But while discussing these capacities it is important to consider that only about 580.000 t/a are base oil capacities from modern re-refining plants able to produce base oil quality as described in Table 1 with a market price close to primary base oils (API I/API II).

On the other hand, waste permits, which are necessary for the co-incineration (direct burning) of waste oil, are today not a limiting factor for recovery/disposal capacities. As long as waste legislation does not bindingly exclude direct burning, permits for low contaminated waste oils (as discussed here) can be obtained by plant operators in all Member States. In a recent study about status of co-incineration in EU 27 about 900 plants have been identified that obtained a waste permit for the co-incineration of waste[8]. So in the co-incineration sector capacities far above the total amount of collected waste oils are available in Europe.

2.4. LCA considerations concerning the given situation

From LCA perspective the following consideration can be made:

- The collected waste oils represent a huge economic and ecological value. By reference experiences it can be estimated that about 80% of the col-

[8] Ökopol, 2007: Assessment of the application and possible development of community legislation for the control of waste incineration and co-incineration – commissioned by EU COM DG Env, Brussels, 2007

lected waste oils are suitable for re-refining[9]. By an estimated market price of 150 €/t for such waste oils the amount of 1.6 million t/a[10] roughly account for 240 million € and a calorific value of 61 million GJ. And considering a base oil share from still 70 - 75 %, they represent a crude oil equivalent of 1.82 million tonnes.

- Recovery or recycling of these waste oils leads to respective decrease of environmental burden.
- Reallocation from a simple recovery - substituting heavy fuels - towards high level recycling – producing high quality base oils by re-refining – further increases the environmental benefit significantly

Recycling in modern re-refineries leads up to 72% high quality re-refined base oils, to about 17 % gas oil and to 5 % waste for energy recovery – depending on the original composition of the waste oil.

Based on commonly accepted LCA data such an up-to-date re-refining compared to the direct use as heavy fuel equivalent[11] leads to the following environmental effects (IFEU 2005)[12]:

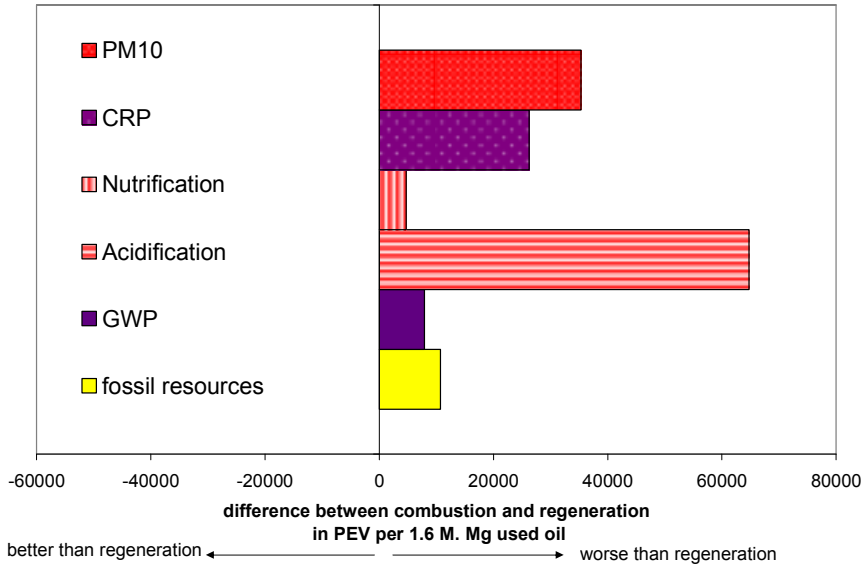

Figure 3: Overview of impact-related and normalized differences between average regeneration and combustion (substitution of heavy fuel oil); scaled up to 1.6 M. Mg which is the total mass of collected waste oil[13]

[9] see [Ökopol, 2005]

[10] 80% from about 2 million t/a collected in EU 27.

[11] A comparison with the use as coal substitute as made in some LCA published in 90s and first half of 2000 does not make sense under given market conditions.

[12] IFEU 2005: Ecological and energetic assessment of re-refining used oils to base oils: Substitution of primarily produced base oils including semi-synthetic and synthetic compounds; on behalf of GEIR; Heidelberg 2005; This calculation considers a proportion of 85 % API class I base oil and 15 % synthetic oil.

[13] Normalisation: Calculation of the magnitude of the category indicator results relative to reference values (specific contribution). The unit is PEV (Person Equivalency Value) which represents the average per-capita load of one inhabitant (e.g. 12 Mg CO2 equivalents per year)

So in total 96,800 t CO_2-eq and 25,300 t RO eq. could be saved by reallocating all waste oils collected in EU 27 to re-refining.

3. Considerations concerning the regulatory framework

From a perspective of the regulatory framework the assessment of the waste oil recovery/recycling situation gives an ambivalent message.

On the one hand:

- Enough treatment capacities are available to ensure a proper handling of all accumulating waste oils in Europe
- Following the increase of world market prices for crude oil and the demand for high level products like base oils and low sulphur fuels, a clear market pull towards high level recycling of waste oils (re-refining) can be observed.
- Some modern installations for the high quality recycling (re-refining) of waste oils have been installed in Europe during the past years.
- Considering that the development of resource prices and price ratios between different mineral oil based products will follow the trend of the last years, such modern recycling plants can be operated economically.
- The percentage of unknown disposal is significantly low in such countries giving priority to waste oil regeneration.

On the other hand:

- Still a lack of transparency can be observed concerning relevant shares of waste oil flow in Europe
- Data from recent market surveillance show that relevant amounts of waste oils are probably not collected separately.
- The majority of (recyclable) waste oils are (still) used for direct burning substituting other heavy fuels.
- Compared to high level recycling this is suboptimal from an overall environmental perspective (LCA consideration).
- Compared to re-refining the necessary investment and operating cost of pre-treatment before direct burning are quite low. Considering given risks from

Grouping: Ranking the impact categories in a given order of hierarchy, such as very high (bar in violet colour), high (bar in red colour), medium (bar in yellow colour) and low priority (not applied).

interim turbulences at the market for high quality recycling products this determines strong short term economic incentives for the recovery route.

- Major investments in up-to-date re-refining plants have only been made in member states that either give clear legal priority to this waste treatment option (e.g. Italy) or that granted subsidies for such investments (e.g. Germany).

Overall it seems reasonable to conclude that increasing resource constraints and the connected development of market prices support recycling operations leading to secondary products that can compete with primary products under quality aspects.

To ensure that necessary investments into the respective recycling infrastructure are made, the regulatory framework needs to include, besides general priorities, clear procedures that help operators of recycling plants to “bridge” interim turbulences in their respective markets.

Furthermore proper enforcement of waste regulations regarding separation of waste with different properties/qualities is important as prerequisite for all recycling activities.

4. Sources

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