Optimised Handling of Commercial Waste

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Optimierter Umgang mit gewerblichen Abfällen

Abstract

For many elements of commercial waste, recycling the material brings on advantages from an ecological point of view. This also goes for plastics – especially when they can be used as recycled granules, thus able to be used as an intermediate good in the plastics industry. Plants for sorting and converting commercial waste into fuels should therefore also be able to generate such products in addition to sorting out PVC. In view of the situation on the waste disposal market and the risks involved in constructing substitute fuel power plants, a material-specific disposal of commercial waste could provide an important contribution to overcoming bottlenecks regarding waste disposal.

Keywords

Commercial waste, greenhouse effect, material recycling, plastics, PM10-risk, refuse derived fuels, thermal recycling

1 Background

Since mid-2005, residual waste disposal has changed fundamentally. Due to the prohibition of the disposal of untreated municipal waste on landfills new ways to dispose of residual waste flows had to be found. This especially applies to commercial wastes.

The widely propagated solution of fuel production and its marketing in cement or power plants proved to not work out as hoped, nor can it correspond to the significantly increased amounts of waste. There are several reasons for this:

- The original idea to market the high calorific fractions recovered from sorting plants or mechanical-biological treatment directly as fuels could not be implemented. Without further treatment these high calorific wastes are not up to the customer’s demands on a fuel. The separated high calorific fractions neither have defined or constant fuel characteristics, nor have they been sufficiently depleted of contaminants or other substances that might be problematic for the plants or the combustion.
- Furthermore, there are still too little sorting and treatment plants, or plant capacities, which could recover high-quality defined fuels from high calorific sorting fractions or mixed commercial wastes by treating them further.

- A lot of them have to be modified or re-designed in order to enable a separation of the different waste parts (paper, plastics etc.) known to have the desired fuel characteristics (high calorific value, low level of harmful substances) from the waste flow in a positive sorting process. In case the plants are even designed to work the other way round, which means they sort out problematic waste parts (negative sorting), experience showed that quality demands cannot be met or not in a sufficiently secure way.

According to BKB's evaluation (KAUFMANN 2007), only a few coal-fired power plants will incinerate substitute fuels derived from municipal and commercial waste in the long term. In most cases, they are hard coal-fired power plants with melting chamber combustion firing which will be decommissioned within the next 15 years because of their low efficiency. The co-incineration in cement plants will, according to this estimation, concentrate on specific fractions such as paper sludges and other product specific wastes.

As a consequence, there are lacking capacities for the energy recovery of high calorific wastes since mid-2005, which applies to wastes with a medium or a high calorific value at the same time. This situation results in the fact that large amounts of high calorific wastes are currently either being stocked on the properties of the waste disposal companies or in interim storage facilities (partly former municipal solid waste landfills).

A solution for the disposal dilemma is at present seen in the building of refuse derived fuel power plants, i.e. the waste disposal industry is building its own energy recovery plants. At the moment, there are only 10 of those plants with a total capacity of 660,000 tons per year and an average calorific value of 11 to 16 MJ/kg. This strategy was already implemented with Trockenstabilat, which is rather difficult as a fuel. These "power plants" are in most cases grate-firing plants (sometimes fluidized bed combustion plants) with an extensive flue gas cleaning, which makes them comparable to waste incineration plants (WIPs). Furthermore, not all of those plants can be included in an optimal energy use concept (heat use). The prevailing idea in many cases is the disposal of the wastes (fuels).

Against this background and in view of investment decisions to be made, the question is raised whether at least partial fractions of commercial wastes should be treated in a material-related rather than energy-related way. Commercial waste sorting plants can be technically equipped and designed in a way which enables them to provide high-quality sorting fractions e.g. from recyclable plastics. Sorting plants in the field of lightweight packaging may serve as examples.

The following explanations will illustrate that for many kinds of material from commercial waste, a material recovery is more ecological and sustainable. In the following we will look at the example of two partial fractions from the field of plastic waste and examine in how far a material and energy-related recycling or disposal in WIPs is sensible from an ecological point of view.

Plastics have a major influence on the calorific value of commercial wastes and their suitability as fuels. The question whether the material-related recycling of commercial wastes is sensible must therefore be especially considered regarding this waste fraction.

2 Disposal alternatives for plastics

The following examination and evaluation of the disposal alternatives assumes that the effort for the waste collection, sorting and transportation is the same for all ways of disposal. These expenses hence figure outside the system limits, i.e. they did not enter the assessment and comparing evaluation. Furthermore and consequently, the question of the disposal of sorting residuals was not included, i.e. it was assumed that sorting and treatment processes for the generation of fuels or materially recyclable fractions have approximately the same share and composition of sorting residuals.

We will discuss two examples: PE (polyethylene) e.g. from packaging films and so-called blends or mixed plastics, a sorting fraction that derives for example from the recycling of lightweight packagings. The latter has the worst characteristics for a material-related recycling, PE as a kind of plastic is suited best.

PE-film has among other characteristics a water content of 16 %, a calorific value of 30.5 MJ/kg, an inert content of 1 % and a C_{fossil} content of 717 g/kg. Blends are assumed to have a water content of 21 %, a calorific value of 35 MJ/kg and an inert content of 4.5 %. The content of fossil carbon is 786 g/kg.

In order to discuss the very basic strengths and weaknesses of a material or energy recovery of these plastics in a comparative way, the following recycling approaches were taken as examples:

- extrusion into technical films (no option for blends)
- compaction into thermoplasts (substitution of wood or concrete)
- recycling of raw material in a blast furnace
- recycling of raw material by gasification
- energy recovery in a cement plant
- energy recovery in a power plant
- thermal treatment in a WIP

The material recycling is carried out by granulating the PE-film; this granulated PE-film can replace primary PE granulate in the production of new films. The re-granulated PE and the primary PE are assumed to be up to a basically equal technical standard, so that a substitution of 100 % as regards the granulate mass is taken into account. Primary PE is considered to consist of one half PE-HD (high density) and one half PE-LD (low density). The environmental pollution resulting from the primary production are usually slightly higher for PE-LD than for PE-HD. The information about the production of PE-HD and PE-LD from primary raw materials are based on data published by the Association of Plastics Manufacturers in Europe (APME).

Another form of material recycling is the compaction into mouldings. The energy expenditure for this way of recycling is not different from the expenditure for granulation, in this case too, no further processing losses occur. The produced plastic mouldings replace products made from materials other than plastics, such as wood and concrete palisades for example. When calculating the substitution factors, the following facts have to be considered: the density of concrete is 2.6 times higher than the density of plastic; the density of wood, however, corresponds to only 0.75 times the density of plastic. Apart from that, products made of recycled plastic that replace the different uses of wood have a lifetime of up to 4 times the lifetime of wood products (e.g. seawater construction). A lifetime of 2.5 times on average is assumed. Concluding from these factors, the substitution factor for the replacement of concrete is 2.6; the factor for wood is calculated 0.75 * 2.5 = 1.875.

The differences result from the different composition of the two kinds of plastic. When, for example, blends are compacted for the production of mouldings, 10 % of the incoming material is released in the form of water. This results in an accordingly decreased mass equivalent substitution potential. Furthermore, the electricity needed for the production of mouldings from blends is lower (350 kWh/t instead of 1.000 kWh/t for PE).

Raw material-related recycling processes include all production methods that replace fossil raw materials either as resource or product of a process.

In blast furnace processes, PE-films or plastic blends substitute heavy fuel for the generation of the redox potential needed for steel production. The clearing of the equivalent quantity is carried out via the respective energy content (calorific value).

Again, raw material-related recycling shows differences in the processing of blends as compared to PE-films. In this case, an agglomerate must be produced from the comparatively moist blends in a first step. This of course requires energy (electricity consumption 330 kWh/t) and additional transportation. Surplus water (11 % of the input) is released in the form of water vapour. Only when the blend agglomerate is treated it can be recycled in blast furnace processes and gasification.

The gasification produces methanol; thermal energy is generated as a by-product. It is assumed that the thermal energy has a potential of 70 % effectively useable steam. The methanol produced from the PE-film substitutes synthetic methanol 1:1, which in Germany is usually generated from 75 % natural gas, 15 % lignite and 10 % heavy fuel.

In Germany, the useable heat replaces 82.6 % of district heat and 17.4 % of process heat on average (deduced from ITAD 2002). The mix of the process steam generation in Germany (not incl. waste incineration) can be deduced from (ITAD 2002) as follows:

Table 1 Mix of process steam generation in Germany

Forms of process steam generation	share in %
Coal boiler	21.3%
Lignite boiler	4.2%
Light oil boiler	7.5%
Heavy oil boiler	9.2%
Gas boiler	57.8%

District heating is used to warm up rooms in private households und currently replaces mainly decentral heating systems (88.5 %; it also replaces 1.5 % of local heating and 10 % of district heat from power plants) and of these especially fuel oil-fired systems (85 %; besides 10 % of gas heating, which is at the moment only marginally substituted by district heating, and 5 % of electrical heating).

Energy recovery processes include approaches which use plastics to generate energy. At the moment, plastic replaces coal in cement plants, the clearing of the substitution potential is carried out via the respective energy content (calorific value). The co-incineration of waste material in power plants is exclusively applied in coal-fired power plants, which means that PE-film or plastic blends replace coal; the clearing of the substitution potential is once again carried out via the respective energy content (calorific value).

For the incineration of plastic in a WIP, a modern WIP with an electrical efficiency of 10 % and a thermal efficiency of 30 % acted as basis. The generated power replaces electricity which is produced in a conventional way in Germany. The following table lists the average energy source mix of net electricity generation in Germany (data of 2003 according to the Electricity Industry Association VDEW 2004).

Table 2 Energy source mix of net electricity generation in Germany

Forms of power generation	share in %
Coal	23.9%
Lignite	26.1%
Mineral oil	1.1%
Natural gas	12.3%
Nuclear energy	27.8%
Hydropower (not incl. pumped storage stations)	3.6%
Wind power	3.3%
Other	1.8%

Because of its minor importance, the contribution of mineral oil was ignored for the modelling of the average power generation. The contribution from waste incineration (figures under “other”, share of total approx. 0.9 %) was allocated to the waste disposal. Expenditure and emissions that would result from the provision of the infrastructure of plants were ignored because of their minor share of the total expenditure. As described in the aforementioned material recycling, the generated heat replaces process and district heat. The credit calculation was carried out on the basis of the mix of process heat generation as described above.

3 Results of the comparative ecological evaluation of disposal alternatives for plastics

The results relate to the disposal of one ton of PE-film and one ton of blends respectively.

Let us first of all have a look at the results for PE-films:

The results for the greenhouse effect (cf. Fig. 1) are determined by fossil carbon in all recycling options. Emissions result from the complete thermal oxidation of the PE-film in energy-related processes and in the blast furnace; during gasification emissions are released from the proportional oxidation of the PE-film and the proportional oxidation and provision of the coal used in the process. Compared to the aforementioned processes, the pollution is reduced by the share of carbon which is absorbed by the produced methanol.

The material-related recycling releases fossil carbon emissions due to the required energy. The credits from the equivalence processes of the energy- and raw material-related recycling are due to the energy efficiency of the processes or the replaced raw material and its, as to the energy content, specific carbon content.

From the point of view of a potential contribution to acidification, the highest credit is calculated for recycling materials into regranulate for the production of films. It is determined by NO_x and SO_2-emissions from the primary PE production, accounting for one half each. For the recycling of material into mouldings, too, the credit is defined by one half NO_x and one half SO_2-emissions, which mainly result from the cement clinker production, although this credit is comparatively small. For the use in blast furnaces, gasification and cement plants, credits are mainly determined by avoided SO_2-emissions, in power plants this mainly applies to NO_x-emissions, for the incineration in waste incineration plants SO_2 and NO_x-emissions are considered.

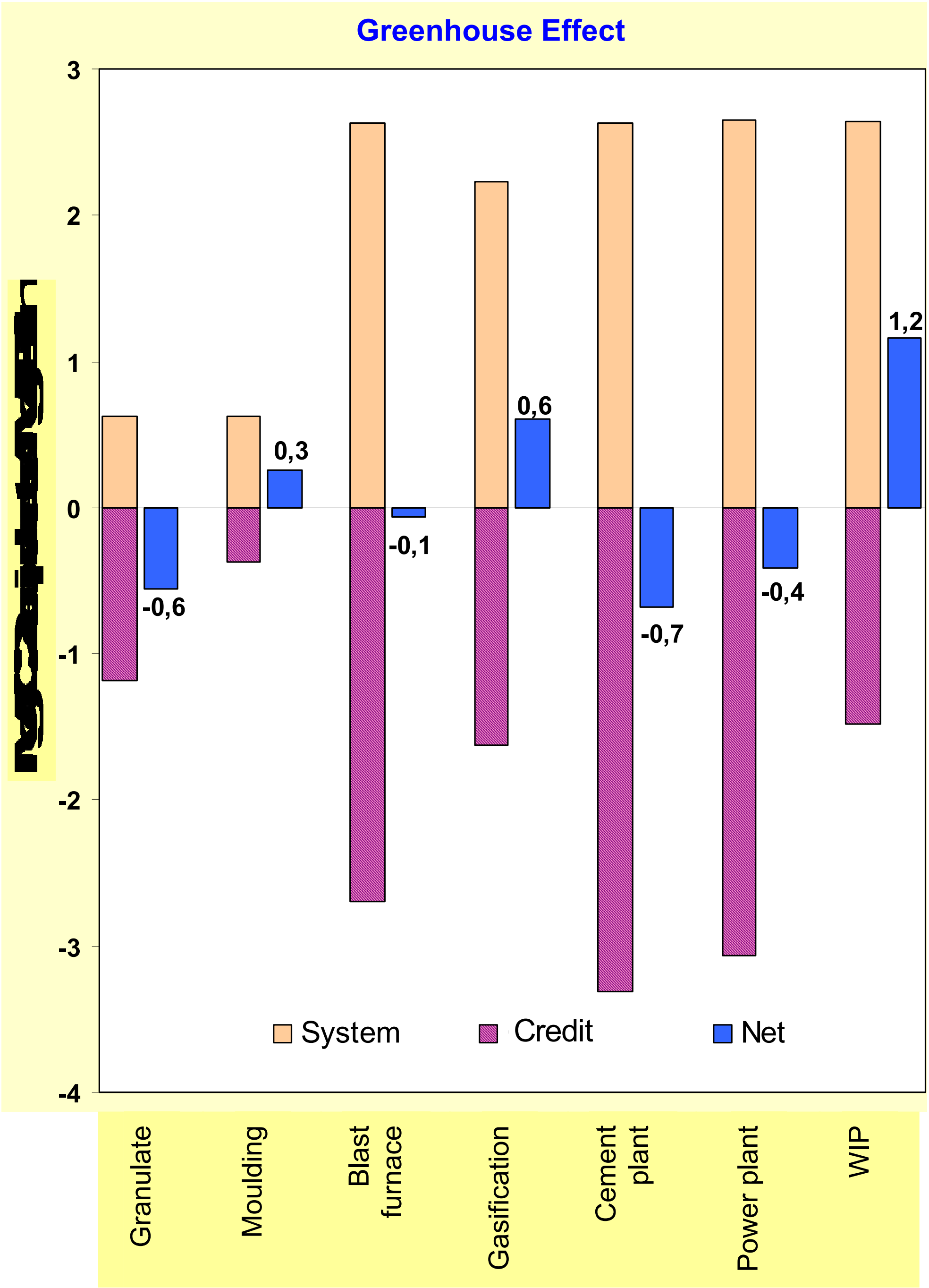

Fig. 1 Results of the comparative evaluation of the recycling of PE-film – greenhouse effect

The comparatively high credits for the cancer risk from the equivalence processes of gasification and incineration in WIPs result in both cases from the substitution of heat, in WIPs almost completely, in gasification of approx. 65 % (rest due to emissions of methanol production). Regarding the heat substitution it must be said that in this case mainly the substitution of fuel oil in decentral heating systems avoids environmental impacts.

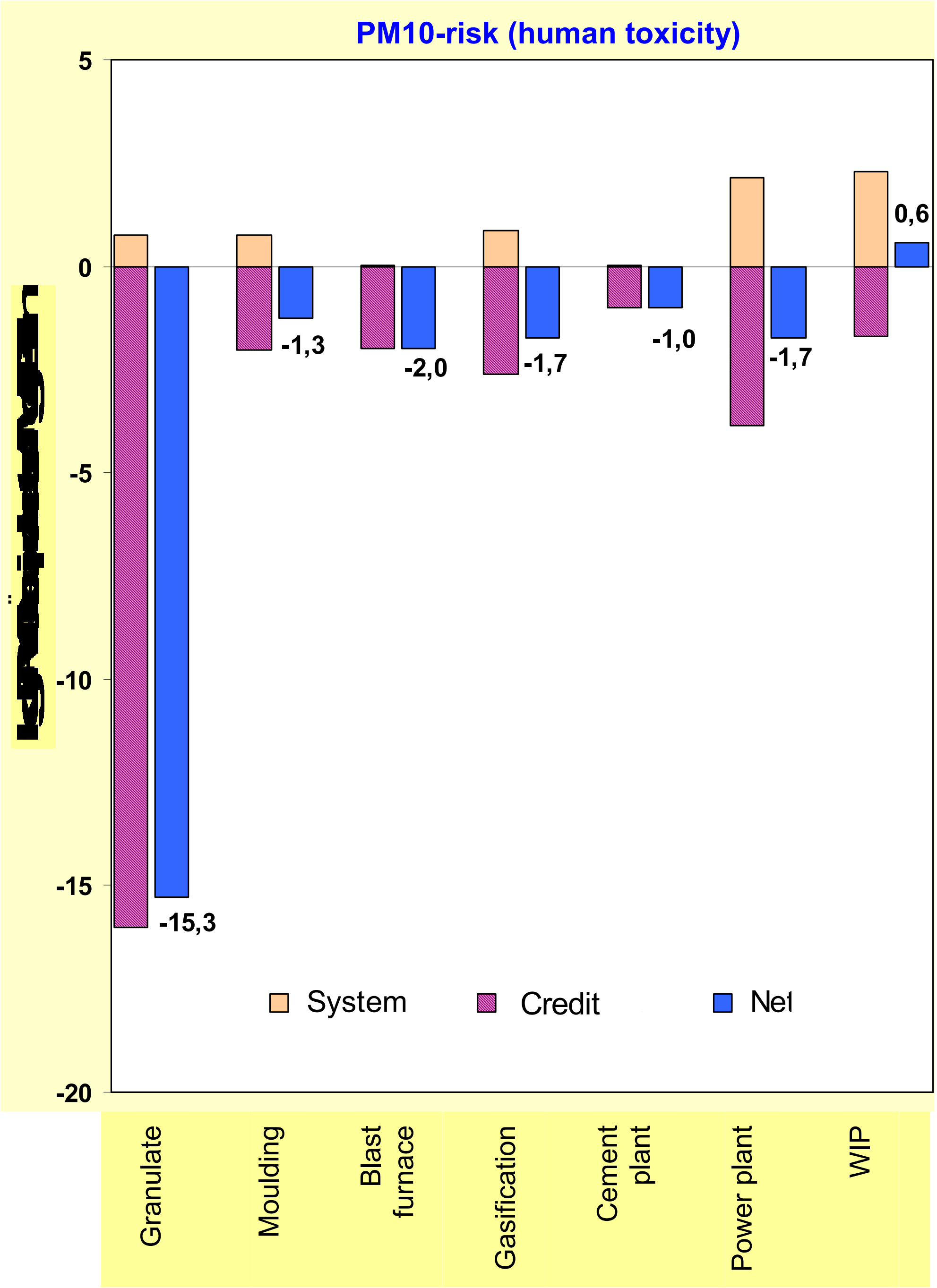

Fig. 2 Results of the comparative evaluation of the recycling of PE-film – human toxicity

The basic tendency of the results for the impact categories ‘human toxicity risk due to particulate matter (PM10)’ (cf. Fig. 2) and ‘terrestrial eutrophication’ corresponds to the tendency presented for the results for the acidification potential. Regarding the terrestrial eutrophication they are almost entirely determined by the substitution of nitrogen oxides emissions. It is only for the scenario 'use in power plants' that the substitution of ammonia plays a certain role. For particulate matter, substitution effects for dust and sulphur dioxide have to be considered, too.

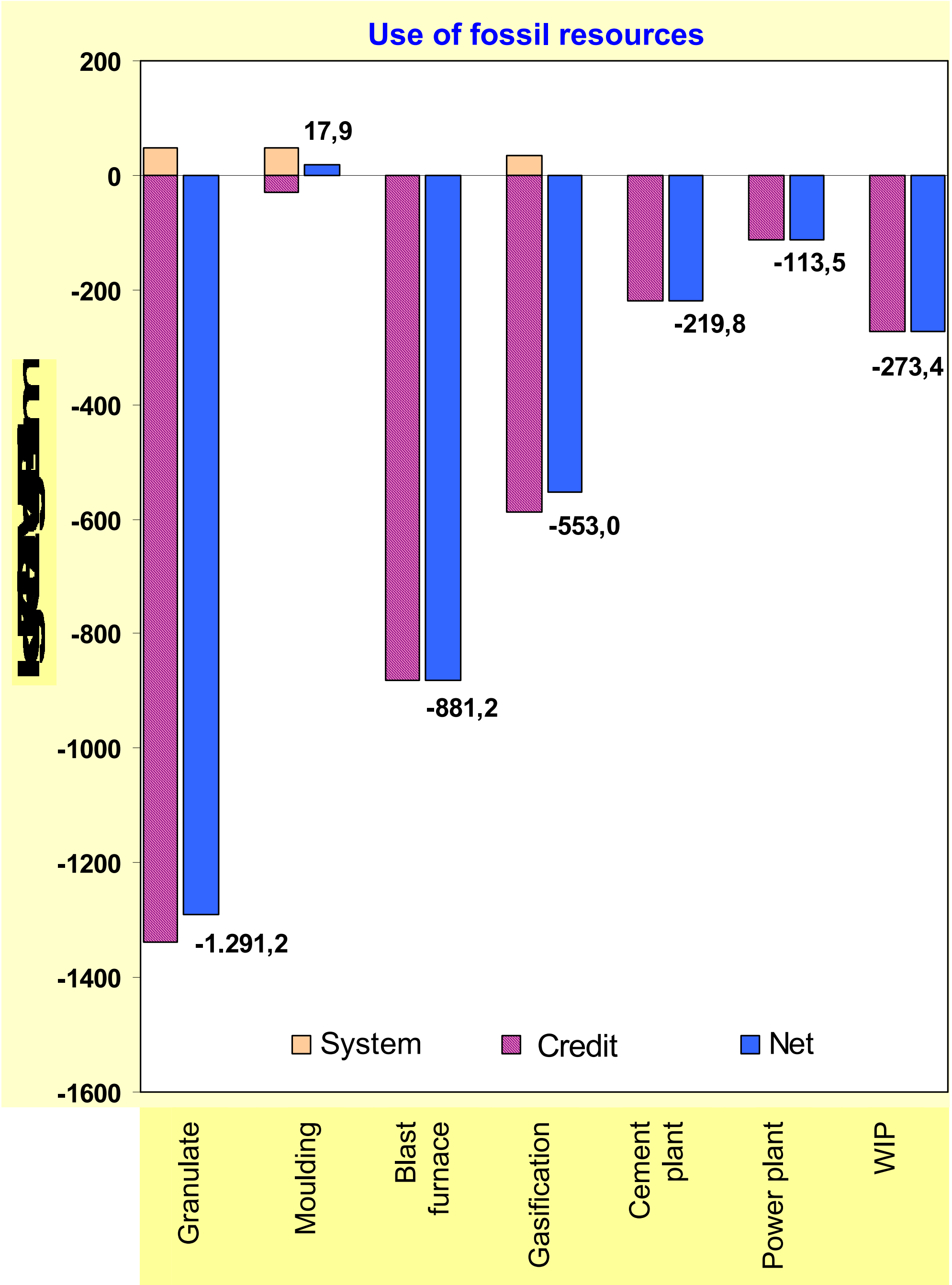

Fig. 3 Results of the comparative evaluation of the recycling of PE-film – use of fossil resources

When evaluating the use of fossil resources (cf. Fig. 3), the question of the finiteness of deposits of the individual resources must be considered as well. Consequently, the substitution of raw oil is more important, especially compared with coal.

The order of the results is different according to each impact category. The material reuse of PE-film in regranulate has the least environmental impacts regarding the use of fossil energy sources and acidification, eutrophication and PM10-risk, and is therefore clearly more favourable than the discussed disposal alternatives. This also applies to the greenhouse effect. Again, material recycling has the biggest advantages over almost all other options. However, the energy recovery via co-incineration in cement plants constitutes an exception because the assumed substitution of coal results in an even bigger relief for the environment. As regards the cancer risk, material reuse in the form of new films is significantly exceeded by the recovery in gasification und thermal treatment in WIPs. This result, however, is only due to the fact that generated district heat currently replaces fuel oil in decentral heating systems; in the medium and long term these substitution gains will lose their importance.

Let us now of have a look at the evaluation results for blends:

As almost the same recycling processes apply to both the recovery of PE-film and the recycling of blends, the explanations of the results for PE-film can in large parts be translated to those of blends. The results for the greenhouse effect for example are described the same way as those for PE-films, they are determined by fossil carbon emissions. The net result for the material recovery of blends is positive, i.e. the substitution effects exceed the environmental impact resulting from disposal. The use as a substitute fuel is slightly more favourable compared to a material-related recycling.

As regards acidification, eutrophication and the PM10-risk (cf. Fig. 4), the lack of a possibility of a reuse of the material in the form of regranulate does not result in significantly differing credits due to the equivalence processes. However, basically the same remarks as mentioned for PE-films apply to the examined options. Deviating from that, the pollution occurring in the raw material-related recycling options are proportionally slightly higher than in PE-film processing. This can partly be explained by the necessary processing of blends into agglomerate. Furthermore, due to the higher chlorine content of blends, more hydrogen chloride emissions are released in the blast furnace than in the use of PE-film.

Regarding the cancer risk, the large credits for the gasification and WIPs can mainly be explained by the substituted room heat. The in comparison to PE-film again slightly increased pollution from the blast furnace process results from the higher cadmium emissions released in the use of blends and is caused by the higher cadmium content of these plastics.

As heavy fuel is substituted in the blast furnace process, this recycling option shows the best result regarding the conservation of fossil resources.

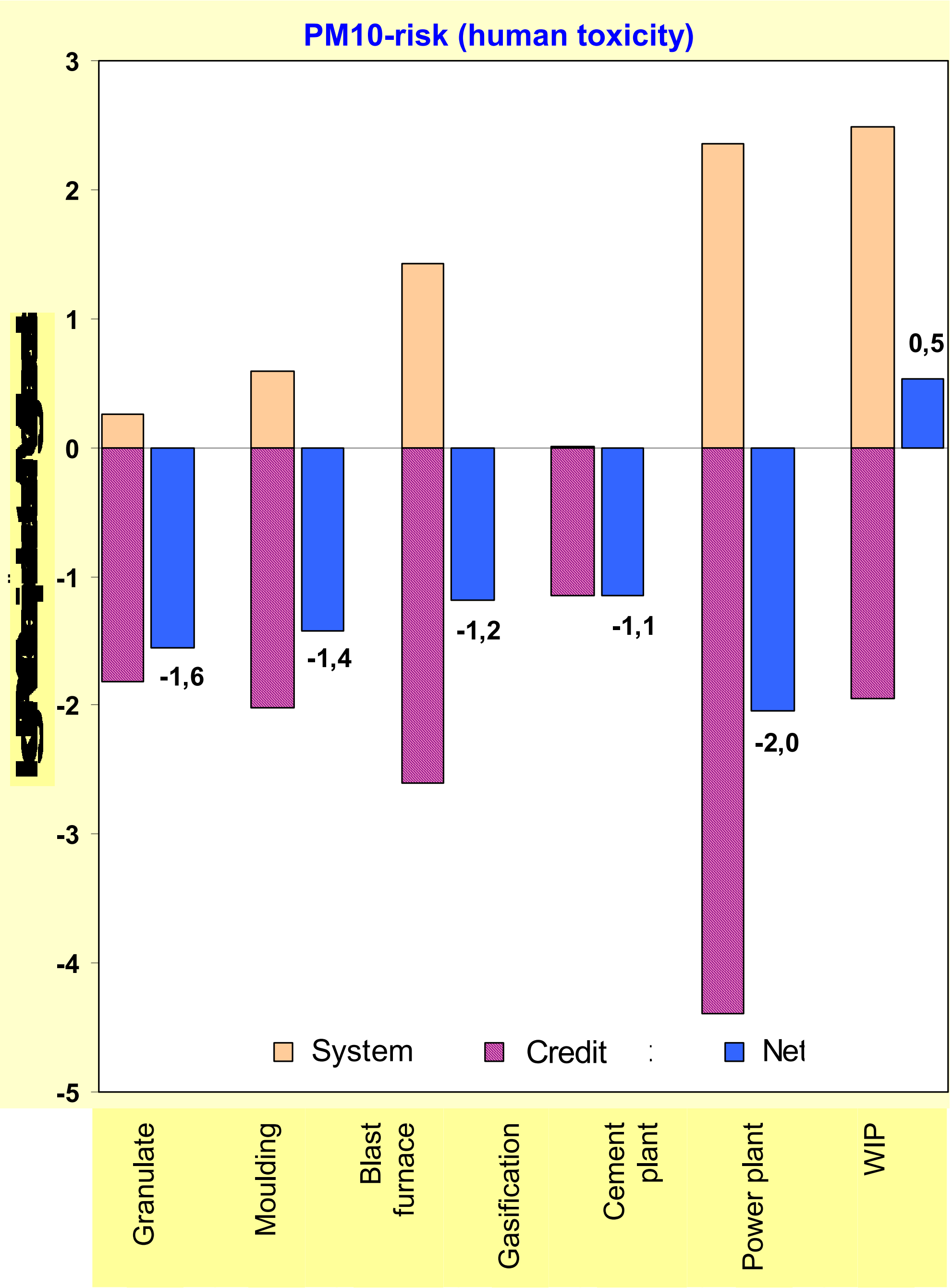

Fig. 4 Results of the comparative evaluation of the recycling of blends – PM10-risk

4 Conclusion

For most waste components a material reuse is more favourable from an ecological point of view than pure energy recovery. This also applies to plastics that have a high calorific value and therefore favourable characteristics for an energy-related use. In case commercial wastes are sorted according to kinds of plastic, the resulting sorting fractions consequently can be used in the plastic industry as a high-quality intermediate product in the form of regranulate. The example of PE-film was used to show the ecological advantages. They can be translated to all other kinds of plastic that can be produced in sorting plants.

In case a type-specific separation of plastics is impossible, a material reuse does not prove fundamentally favourable in comparison to disposal alternatives. However, if energy recovery is carried out in refuse derived fuel power plants which exclusively generate power and if they have an energy efficiency comparable to common waste incineration plants due to the chlorine content of commercial wastes (SCHU 2007), in this case, too, the material recycling remains favourable. In case these mixed plastics are used as fuels in a highly efficient way, this usually results in slight ecological advantages.

This high-quality energy recovery requires the processing of commercial wastes into high-quality substitute fuels or at least a significant reduction of the PVC or chlorine content. This can only be guaranteed by the use of technical solutions such as NIR-devices. Sorting residuals from mixed building waste sorting plants, from packaging waste etc. have high chlorine contents. Furthermore, there are certain commercial wastes that may have an increased PVC content or include other chlorine-containing plastics. This means that especially potential raw material for refuse derived fuels may contain large amounts of chlorine. Because of an increasing use of PVC these amounts are even going to grow in the future.

If sorting plants are equipped for the treatment of commercial waste, only a comparatively small step must be taken to also separate other types of plastics and components of commercial waste such as paper and cardboard and reuse their material.

The discussed balances do not include the sorting. If we assume that the (energy) expenditure for the sorting and the linked environmental impact is only required for a material reuse and is therefore taken into account for the balancing, there would be no major consequences for the presented results. Investigations of the German ministry of environment into the question of collection systems for packaging waste (IFEU, INFA 2005) showed that expenditures for example regarding the greenhouse effect figure < 5 % of the total impact of the disposal system. It also becomes clear from the results presented above that for the most environmental impact categories the result becomes visible by the achievable substitution success. In comparison to that, the impact connected with the disposal is clearly smaller.

At the moment the waste disposal industry is insecure and fears excess capacities for substitute fuel recovery; long term fuel supply contracts under currently common market conditions are only entered reluctantly. Prices for the recycling of refuse derived fuel range between 75 €/t and 100 €/t according to (SCHU 2007). Due to the present demand for raw material, material recycling in contrast is more suitable for generating profits.

In view of the problems and/or bottlenecks regarding energy-related waste disposal capacities for commercial wastes, the time is right to think about alternatives. At the same time, medium-sized private waste disposal companies do not have the financial means to build and operate substitute fuel power plants themselves. It is also difficult to provide the required guarantees especially for the free commercial wastes, so that the only solution is the construction of sorting plants with the aim of separating recyclable fractions (Schu 2007).

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