CE Delft
Solutions for environment, economy and technology

Oude Delft 180
2611 HH Delft
The Netherlands
tel: +31 15 2 150 150
fax: +31 15 2 150 151
e-mail: ce@ce.nl
website: www.ce.nl
KvK 27251086

Future Dutch waste policy: priorities and leverage points

Report

Delft, April 2008

Authors: Maartje Sevenster
Geert Bergsma
Derk Hueting
Lonneke Wielders
Femke Brouwer

Publication Data

Bibliographic data:
Maartje Sevenster, Geert Bergsma, Derk Hueting, Lonneke Wielders, Femke Brouwer
Future Dutch waste policy: Priorities and leverage points
Delft, CE, 2008

Policy planning / Waste / Lifecycle management / Environmental impact / Environmental burden / Waste disposal / Analysis

Report code: 08.3515.10

CE Delft publications are available via www.ce.nl

Commissioned by: Netherlands Ministry of Housing, Spatial Planning and the Environment (VROM)

For further information on this study, contact project leader Maartje Sevenster at CE Delft.

CE Delft
Solutions for environment, economy and technology

CE Delft is an independent research and consultancy organisation specialised in developing structural and innovative solutions to environmental problems. CE Delfts solutions are characterised in being politically feasible, technologically sound, economically prudent and socially equitable.

For the latest information on CE check out our website: www.ce.nl.

This report is printed on 100% recycled paper.

Contents

Summary

In 2008 the Netherlands is drawing up a new National Waste Management Plan (Dutch abbreviation: LAP). Historically, waste policy in the Netherlands has always been based on a sectoral strategy focusing mainly on the waste disposal phase, but in the new LAP consideration is also to be given to the entire supply chains of wastes and products. In the present study the lifecycle environmental impact of a number of waste categories has been assessed, from raw materials production all the way through to waste disposal. The study represents one part of a two-pronged effort: in parallel with this analytical study, a series of concrete pilot projects on individual supply chains have also been started. The project as a whole, addresses the following research questions:

> *Based on the environmental impact associated with waste disposal (relative to the overall environmental impact of the material/product supply chain) and considerations of cost efficiency, to which waste streams should policy priority be given in the coming LAP planning period, what kind of targets can be formulated and what leverage points are available for (lifecycle-oriented) policy?*

The waste streams identified in this study as deserving policy priority are characterised in having a substantial lifecycle environmental impact, a substantial environmental impact associated with waste disposal and/or high costs. It is on these grounds that these streams merit extra attention in the new LAP. To judge whether improvements are indeed possible and practically feasible will require further study, however, as the analyses provided in this report permit no conclusions on these issues.

Lifecycle environmental impact

In track A1 of the study a quantitative assessment was made of the lifecycle environmental impact of 22 waste streams, including residual household waste and commercial and institutional residual waste. These 22 streams were selected from the over 110 streams cited in the LAP 'sectoral plans' on the basis of policy considerations. The environmental assessments ('quick-scan LCAs') were performed for a wide-ranging set of environmental themes, with results subsequently aggregated using six different procedures (weighting methods). When it comes to a 'top 10' ranking of priority waste categories, these methods all yield approximately the same picture.

Table 1 Waste streams featuring in at least one of the 'top 10' rankings for lifecycle environmental impact (track A1) obtained using six different weighting methods (average order)

Category code	No. of times in top 10 with the 6 weighting methods	Category name
1	6	Residual household waste (bulk-collected)
28	6	End-of-life vehicles
4	6	Commercial and institutional residual waste
29	6	End-of-life tyres
63	5	Separately collected paper and board
68	6	Metal waste, general
21	6	Gas-discharge lamps
88	6	Animal waste, SRM/HRM
37	6	Stony materials
67	6	Separately collected textiles
22	1	Household organic waste

Alongside a number of waste streams that have always featured prominently in Dutch waste policy, from this lifecycle perspective there also emerge several streams with high levels of energy consumption during the use phase (end-of-life vehicles, end-of-life tyres and gas-discharge lamps). Waste streams with a relatively high environmental impact in the production phase also rank high (animal waste, textiles and metals).

Environmental impact of waste disposal

In track A2 of the study an assessment was made of the environmental impact associated with waste disposal for a total of 38 waste streams: all those from track A1, supplemented by those for which impact data had already been calculated as part of the Environmental Impact Assessment conducted for the LAP. In this case there is greater variation in the top 10s obtained with the different weighting methods than on track A1, with a number of waste categories featuring in the top 10 of one or two weighting methods only.

Table 2 Waste streams featuring in 'top 10' rankings for environmental impact of waste disposal (track A2) using different weighting methods (order based on highest position recorded)

Ranking	Category code	No. of times in top 10	Category name
1	1	5	Residual household waste (bulk-collected)
2	63	4	Separately collected paper and board
3	37	6	Stony materials
4	2	4	Bulky household waste (carpeting only)
5	6	6	Water treatment sludge
6	4	5	Commercial and institutional residual waste
7	38	6	Gypsum
8	9	6	Waste incinerator fly ash
9	88	3	Animal waste, SRM/HRM
10	22	4	Household biowaste
11	84	2	Shredder waste
12	91	2	Batteries (zinc-carbon & alkaline)

Share of waste disposal in lifecycle impact

In track A0 of the study the share of the waste disposal phase in overall lifecycle environmental impact was determined, i.e. the score on track A2 divided by that on track A1. The resultant rankings are in virtually complete agreement with those for track A2. The only potentially problematical categories to emerge are oil/water/sludge mixtures and similar wastes.

Waste disposal costs

In track A3 of the study, the approximate costs of waste disposal were calculated. Many of the categories ranking high on this criterion also feature in the environmental impact rankings. To an extent, this is due to the volume of the waste streams concerned.

Table 3 ‘Top 10’ ranking on waste disposal costs (track A3)

Ranking	Cost (million €)	Code	Category name
1	2,348	37	Stony materials
2	471	1	Residual household waste (bulk-collected)
3	220	4	Commercial and institutional residual waste
4	188	44	Waste wood, A- and B-grade
5	150	6	Water treatment sludge
6	117	48	Tar-containing asphalt
7	87	2	Bulky household waste (total)
8	55	25	Separately collected garden waste
9	50	39	Screened sand
10	45	5	Waste from public spaces

Comparison

The relatively large overlap between the various lists is striking, with a number of waste streams featuring in the rankings on all three main tracks: lifecycle environmental impact (A1), waste disposal impact (A2) and costs (A3). Most of these streams are characterised by low separate collection or recycling rates or low-grade applications, but there are also several biotic streams, viz. paper and board, animal waste and household organic waste. It should be noted that although the results of the various weighting methods are generally in good agreement, when it comes to biotic materials there are substantial differences among the rankings. Whether or not land use is included as a factor and what weight is assigned to it are of crucial importance here.

A number of streams scoring high on the lifecycle impact track do not feature at all on the waste disposal track, however. Among these are several streams characterised by high energy consumption in the use phase. For these particular categories there needs to be permanent and renewed focus in energy policy, taking due care to ensure that energy-saving measures do not lead to extra impacts in the waste phase. Several other streams are environmentally intensive materials with a reasonably high recycling rate. Despite this recycling these still feature high on the ranking for lifecycle impact, but at the same time score very modestly when it comes to waste disposal; in most cases the impact of waste disposal is in fact ‘negative’. This holds for metal and textiles waste, for example.

If a lifecycle perspective had not been included, these would not have featured in the ranking.

Conclusions

Combining all three tracks - lifecycle environmental impact, waste disposal impact and waste disposal costs - yields the following combined list (Table 4).

Table 4 'Top 17' ranking for waste and recycling policy, based on lifecycle environmental impact, waste disposal impact and waste disposal costs combined

Ranking	Code	Category name
1	37	Stony materials (construction and demolition waste)
2	1	Residual household waste (bulk-collected)
3	63	Separately collected paper and board
4	2	Bulky household waste (total, plus carpeting fraction in particular)
5	6	Water treatment sludge
6	4	Commercial and institutional residual waste
7	38	Gypsum (construction and demolition waste)
8	9	Waste incinerator fly ash
9	84	Shredder waste
10	91	Batteries (incl. cat. 90)
11	88	Animal waste (incl. cat. 89)
12	22	Organic waste (incl. cat. 23 and bulk-collected)
13	68	Metal waste, general
14	67	Separately collected textiles
15	44	Waste wood, A- and B-grade (construction and demolition waste)
16	25	Separately collected garden waste
17	76	Oil/water/sludge mixtures (plus SP12 and similar)

No. 1 on this combined list, stony construction and demolition waste, features high in both the environmental rankings (A1, A2) and is a very convincing no. 1 in the cost ranking (A3). Nos. 2 through 12 rank high on waste disposal impact (A2) and, in part, on lifecycle impact (A1). Nos. 13 and 14 are from the lifecycle ranking (A1), nos. 15 and 16 from the cost ranking (A3), with no. 17, finally, added because of the relative prominence of the waste phase (A0) in the overall lifecycle. For these 17 categories of waste, and the 'allied' streams cited in the table, it is recommended to review the concrete policy options available for reducing environmental impacts and compare these for efficacy and cost effectiveness.

From the rankings for the various tracks a number of clear priorities emerge:

- High-volume streams with low separation or recycling rates or low-grade applications (viz. bulky and non-bulky) household residual waste, commercial and institutional residual waste, stony construction and demolition waste (CDW)): policy emphasis on prevention, at-source separation and higher-grade applications, with focus on specific substreams of the 'residual waste'.
- Streams involving high-priority 'material chains' emerging from the CE/CML materials study (CE/CML, 2004) (viz. metals, animal wastes, stony CDW, paper/board and household biowaste): lifecycle policies and recycling are important here, but consumption volume reduction and/or material substitution can also serve as leverage points.

- Streams involving high levels of energy consumption in the use phase (viz. end-of-life vehicles and tyres, and similarly white and brown goods, gas-discharge lamps, textiles and carpeting) whereby traditional waste policy has little influence on lifecycle impact: improving the efficiency of energy-consuming appliances offers the best leverage here, but there also needs to be focus on synergies between waste disposal and energy efficiency.
- Streams whereby waste disposal itself is the main contributor to (toxic) emissions (viz. water treatment sludge, gypsum CDW, waste incinerator fly ash, shredder waste and batteries): in this case technical waste disposal measures (in part already scheduled) may improve the situation, but the composition of the residual waste going into incinerators also provides leverage for tackling the final waste resulting from waste disposal itself.

Much of the suggested leverage goes beyond what is traditionally understood under the term 'waste policy' - as is indeed to be expected if a lifecycle approach to the issue is adopted. At the same time, though, there are obviously synergies between the waste phase and the rest of the lifecycle, as embodied in 'design-for-recycling' and more focus on materials selection when designing energy-efficiency measures. Some of these leverage points can be elaborated in the Netherlands' new waste policy, others are already being exploited in other policy areas.

1 Introduction

1.1 Background

In 2008 the Netherlands is drawing up a new National Waste Management Plan (Dutch abbreviation: LAP) to serve as a framework for waste policy for the next five-year planning period, as required by statute. Historically, waste policy in the Netherlands has always been based on a sectoral strategy focusing mainly on the waste disposal phase, with recycling rates, volume reduction and the 'waste hierarchy' all playing a major role. Although this strategy has been largely successful, it has become clear that it does not always automatically lead to the right priorities being set when it comes to reducing lifecycle environmental burdens.

Thus, the 'dematerialisation' study carried out by CE Delft and the Leiden Institute of Environmental Science (CE/CML, 2004) makes clear that policies based solely on considerations of volume have little bearing on the relative environmental impact of the materials concerned. Although sand is by far the most widely used material in volume terms, for example, the environmental impact due to the quarrying and use of all the sand consumed in the Netherlands pales into insignificance when compared with the impact associated with all the country's aluminium consumption. Over their entire lifecycle, it is animal products that have the greatest environmental impact of all.

Against this background, in the new LAP existing Dutch waste strategy is to be augmented by an integrated, lifecycle-oriented strategy. In its waste management policy for the coming planning period, the main aspiration of the environment ministry (VROM) is to tackle those waste streams that have the greatest environmental impact and/or are currently least cost-effective and for which there are measures at hand to improve the situation.

In the present study the lifecycle environmental impact of a number of waste categories has been assessed, from raw materials production all the way through to waste disposal. In many cases the environmental impact is due largely to the 'pre-waste phase', over which traditional waste policy has little influence. How this is to be tackled is consequently one of the key questions addressed in this study. The study represents one part of a two-pronged effort: in parallel with this analytical study ('prong A'), a series of concrete pilot projects on individual supply chains have also been started ('prong B'). The project as a whole addresses the following research questions:

> *Based on the environmental impact associated with waste disposal (relative to the overall environmental impact of the material/product supply chain) and considerations of cost efficiency, to which waste streams should policy priority be given in the coming LAP planning period, what kind of targets can be formulated and what leverage points are available for (lifecycle-oriented) policy?*

For ‘prong A’ a supervisory committee was set up comprising the following persons:

- Arjen Kapteijns (VROM).
- Robbert Thijssen (VROM).
- Anne-Marie Bor (SenterNovem).
- Marco Kraakman (SenterNovem).
- Loek Bergman (VROM).
- Joost Lommelaars (SenterNovem).

1.2 Scope and basic analytical procedure

As it is unfeasible to carry out a full lifecycle assessment (LCA) of all 100-plus waste categories defined in the LAP sectoral plans (see Appendix A), the focus of this study is on drawing up ‘top 10’ or ‘top 20’ rankings, based on the following four criteria:

1 Share of waste disposal in lifecycle environmental impact.
2 Lifecycle environmental impact.
3 Environmental impact of waste disposal.
4 Cost of waste disposal.

This meant that a large number of waste streams were rejected as being less relevant on the basis of qualitative considerations. In the quantitative analyses that followed, ‘quick-scan LCAs’ were performed for 22 waste categories, with reasonable assumptions and estimates having to be made for missing data (cf. Section 2.5). The resultant dataset cannot therefore be used for detailed analyses or conclusions. Similarly, the cost figures used for drawing up the fourth ranking, above, are intended as ‘ballpark’ values and are not built up in the same way for all waste streams. For example, in some cases waste disposal fees were used as an approximation.

To determine the cost effectiveness of a particular waste disposal method requires its costs and environmental benefits to be compared with those of potential alternatives. In the present project there was no scope for such an exercise. The waste streams identified in this study as deserving policy priority are characterised in having a substantial lifecycle environmental impact, a substantial environmental impact associated with waste disposal and/or high costs. It is on these grounds that these streams merit extra attention in the new LAP. To judge whether improvements are indeed possible and practically feasible will require further study, however.

It should be noted that the analyses presented here involve various kinds of double-counting, because of the (partial) overlap in the chains of certain waste streams. As an example, the category ‘Shredder waste’ forms part of the chains for ‘End-of-life vehicles’ and ‘White and brown goods’, while the ‘Metal waste from metal-working’ covered by Sectoral Plan 21 is also part of the ‘End-of-life vehicles’ chain, for the ‘material losses’ occurring at this stage will also already have been incorporated in the environmental impact of vehicle manufacture. The waste categories are thus not disjunct, i.e. mutually independent, and individual results cannot simply be summed.

2 Methodology

2.1 Classification and selection of waste materials

In the National Waste Management Plan (LAP) 34 Sectoral Plans are defined[1]. These can be further subdivided into just over 110 waste streams. The full classification employed in the present project is detailed in Appendix A. From these 110+ waste categories, a number of streams were selected for quantitative assessment of:

- Share of waste disposal in lifecycle environmental impact (track A0).
- Lifecycle environmental impact (track A1).
- Environmental impact of waste disposal (track A2).
- Cost of waste disposal (track A3).

The precise choices are described in Appendix A. All categories were assessed with respect to waste disposal costs, with the exception of several minor streams on which no precise volume and/or cost data could be found. It should be noted that the waste disposal cost data presented here are intended as 'ballpark' figures only.

For qualitative reasons, many categories were already rejected for track A1 assessment (LCA) at an early stage. Among these are waste streams that are already very much on the decline, owing to technological developments or policy efforts (asbestos, mercury-containing waste, photographic waste). In the case of certain other streams a lifecycle-based strategy is altogether less relevant; this holds for the wastes and residues associated with waste incineration and power generation, medical waste, shipping cargo residues and suchlike. The waste categories selected for track A1 assessment are automatically included in track A2 assessment (impact of waste disposal only). Additionally, though, all the waste streams covered by the Environmental Impact Assessment conducted for the LAP are also included in track A2.

The selection for track A1 comprises 22 waste streams, including Residual household waste and commercial and institutional residual waste. The supply chains considered yield sufficient information to pronounce qualitatively on other waste streams too, however. For example, the results of the LCA for the category 'Metal waste, general' will also hold largely for categories like gas cylinders and LPG tanks. The selection for track A2 assessment comprises 38 waste streams.

The A1 and A2 analyses were then combined to create a ranking based on the *share* of the impact of waste disposal in overall lifecycle environmental impact (i.e. the A2 score divided by the A1 score). Naturally, this 'track A0' ranking comprises the same 22 waste streams as track A1.

---

[1] In addition, there is a 'policy framework' covering waste streams not addressed in the present study, most of which relate to minor volumes of hazardous waste.

2.2 Environmental themes

For assessing the environmental impact (lifecycle or waste disposal only) of the various waste streams, a set of environmental themes first had to be selected. In this, we sought maximum congruence with those employed in the Environmental Impact Assessment (EIA) conducted for the 2002-2012 LAP. Most of our set of environmental themes are widely used (including in the policy context) and correspond with those used in the ‘CML methodology’, recognised worldwide as a standard in the field of Life Cycle Assessment (LCA).

The EIA for the LAP (hereafter: LAP-EIA) also included several less commonly used environmental themes, however, which until now have only been implemented in the ‘IVAM methodology’, viz.:
- Loss of biodiversity.
- Loss of life support functions.

These impact themes both derive from the LCA intervention ‘land use’. Instead of using the two impacts cited we therefore took ‘land use’ as a ‘main impact’ for inclusion in the weighting procedure along with the other more familiar themes (cf. Section 2.3). This is line with the approach adopted in the major ‘materials study’ carried out several years ago for VROM (CE/CML, 2004). The other three ‘intervention-oriented’ themes are energy consumption, water consumption and final waste. This is in line with the approach adopted in LAP-EIA.

Another deviation from standard procedure in LAP-EIA was its use of GWP500 as a measure of climate change. For this purpose GWP100 is generally used, as is indeed the case in most other policy areas in the Netherlands. In this study GWP100 has likewise been taken, even in cases where LAP-EIA results were adopted unchanged (waste disposal phase of several streams). The difference between these two indicators amounts to no more than a few percent, however.

Table 5 Environmental themes employed for impact assessment

Theme	Remarks	Abbreviation and unit
Abiotic depletion	Also in LAP-EIA	ADP, kg Sb eq.
Climate change (GWP100)	In LAP-EIA, GWP500	GWP, kg CO_2 eq.
Ozone layer depletion	Also in LAP-EIA	ODP, kg CFC-11 eq.
Human toxicity	Also in LAP-EIA	HTP, kg 1,4-DB eq.
Ecotoxicity (freshwater)	Also in LAP-EIA	FAETP, kg 1,4-DB eq.
Ecotoxicity (terrestrial)	Also in LAP-EIA	TETP, kg 1,4-DB eq.
Smog formation		POCP, kg C_2H_4
Acidification		AP, kg SO_2 eq.
Eutrophication	In LAP-EIA, two themes[2]	EP, kg PO_4 eq.
Land use	In LAP-EIA, 'intervention-oriented', here as a proxy for biodiversity impacts	m^2a
Water consumption	Intervention (not included in weighting)	m^3
Energy consumption	Intervention (not included in weighting)	MJ
Final waste	Intervention (included in weighting in CE, 2002)	kg

2.3 Weighting

In order to arrive at a priority list of waste categories, i.e. a ranking, the scores on the selected environmental themes (with the exception of the intervention-oriented themes) were next aggregated to a single score using a number of different weighting methods. For this purpose, weighting sets were taken that cover as many themes as possible; however, none of the available sets include abiotic (i.e. mineral resource) depletion - or, rather, most weighting schemes adopt a value of zero for this theme. For this reason, a weighting variant was also considered in which each normalised score is assigned an equal weight. This can be regarded as a weighting based simply on share in aggregate global impact.

The other four weighting sets are as follows:

- The **'NOGEPA** panel' weighting factors (Huppes et al., 2003), applied to normalised scores[3]. This weighting set was developed in a series of sessions in which the various environmental themes were assigned a weight by a panel of experts. The final score is dimensionless.
- The **'distance-to-target'** method used in **LAP-EIA** (background document A02), again applied to normalised scores. These weighting factors are derived from Dutch national policy targets, with impacts being assigned a greater weight the further the current emission or impact is from the relevant target. The final score is dimensionless.
- The **Greencalc** 'green' prevention cost method (Greencalc, 2002), which calculates the cost of reducing impacts to a 'sustainable' level. The final score is expressed in monetary terms (million Euros). Practical application shows that land use carries considerable weight in this method.
- The prevention cost method indexed to the Dutch policy setting (**CE, 2002**), which calculates the cost of reducing impacts to the level embodied in national targets. The final score is again expressed in million Euros.

2 In convertling the LAP-EIA data, an equivalence factor of 0.13 was used for soil eutrophication (from kg NO_x equivalent to kg PO_4^3 equivalent).

3 NOGEPA is the acronym of The Netherlands Oil and Gas Exploration and Production Association.

Application shows that climate change carries considerable weight in this method. Note that final waste is also factored in here.

Table 6 Normalisation and weighting methods used

		Weighting of normalised scores			Shadow price of impacts	
Theme	**Normalisation[a] (global, 2000)**	**Equal weighting**	**NOGEPA**	**Distance-to-target**	**Green-calc (€)**	**CE, 2002 (€)**
Abiotic depletion	5.47E-12	1				0
Climate change (GWP100)	2.43E-14	1	0.35	1.17	0.091	0.05
Ozone layer depletion	5.21E-09	1	0.05	6	5,724.69	30
Human toxicity	2.80E-14	1	0.18	2	0.048	
Ecotoxicity (freshwater)	3.05E-13	1	0.07	2	0.048	
Ecotoxicity (terrestrial)	9.48E-13	1	0.05	2	0.048	
Smog formation	2.50E-11	1	0.09	2	4.402	2
Acidification	4.19E-12	1	0.07	2.9	2.723	4
Eutrophication	3.26E-11	1	0.14	3.6	54.454	9
Land use	8.06E-15	1			0.205	
Final waste				[b]		0.185

a Unity divided by total global impact for the theme in question.

b In LAP-EIA final waste was factored in, too, but because there are no normalisation data for final waste this has not been done here (in LAP-EIA normalisation was indexed to the Dutch situation).

Besides these weighting methods, by way of extra comparison consideration was also given to two other impact methods that yield a single-figure, weighted, aggregate score: Eco-indicator99 and EPS, both of which were also used in the VROM materials study (CE/CML, 2004) as an additional weighting procedure.

In the Ecoindicator99 method (Goedkoop & Spriensma, 1999) each impact is assigned in its entirety to one of three categories of damage: to natural resources, ecosystem quality and human health. These are then weighted on the basis of scores assigned by a panel of experts. This method also gives due consideration to biodiversity issues. For the LAP-EIA data adopted in the present study a version of the Ecoindicator had to be used that predates the latest version used with the Ecoinvent data. The effect of this on the weighted score for waste disposal is likely to be minor, though.

A key feature of the EPS 2000 method (Steen, 1999) is that abiotic depletion is factored in, which means this method, too, adds to the picture provided by the other weighting methods used. It should be noted, though, that this method is not really equipped to handle the Ecoinvent data and that the scores consequently need to be interpreted with due caution. In addition, this method could not be applied to the LAP-EIS data on waste disposal. For this reason the EPS scores were not used in drawing up the rankings, but only (where feasible) for comparing alternative processing options in Chapter 3.

2.4 Process data and allocation

The majority of the impact data used in this study have been taken from the Ecoinvent database (version 1.3) and the analyses of LAP-EIA (AOO, 2002 and background documents), though some are from the Idemat (2001) and LCAFOOD[4] databases. For data on the composition of waste categories, energy consumption of disposal options and so on, a range of recent sources were additionally used.

Wherever possible the same standard LCA assessment procedure was adopted, i.e. in line with current general practice, characterised as follows:

1 In all cases the product lifecycle was broken down into the production phase (resource recovery and production of intermediates and/or product), use phase (where applicable: see below) and waste disposal phase.
2 The production phase of biotic materials was modelled as involving carbon uptake. When these materials are incinerated or otherwise disposed of at the end of their lifecycle this carbon is released back to the environment as CO_2 emissions. Although the net effect over the entire lifecycle is zero, in this way short-cycle CO_2 is also explicitly tracked. This means the impact of the production phase may sometimes be negative. Compared with earlier practice, in which this short-cycle CO_2 was ignored entirely, this leads to a different breakdown of environmental impact over the lifecycle. Although the total net lifecycle impact remains unchanged (track A1), this is not the case for waste disposal (A2) and its share in that impact (A0), which will be higher than in the old approach.
3 Materials recycling was allocated to the waste disposal phase; in other words, our calculations are based on savings on primary resources[5] rather than on recycled content. The only exception here was for steel, for which the European average for recycled content was taken, with only part of the percentage recycled being allocated to the waste phase. The reason for this is that in the case of steel there is no such thing as '100% virgin material', with primary and secondary steel in principle entirely equivalent. This differs from the situation for paper, which is of course likewise characterised by a high average recycling rate, but where there is a clear distinction between the market for primary and secondary material. For steel, then, the environmental gains accruing from recycling have been allocated across the various phases of the lifecycle, while with the other materials they accrue entirely to waste disposal. This leads to a relatively low score for waste disposal (track A2) and its share in lifecycle impact (A0) for materials with a high recycling rate (except for waste streams involving CO_2 uptake; see point 2 above). The scores for lifecycle impact (A1) remain unaffected. For the categories of final waste for which there are no recycling provisions in place, however, it means

4 www.lcafood.dk.

5 The material saved depends on the situation, of course. In the case of useful application of stony construction and demolition waste, for example, savings will be on virgin gravel or sand.

a higher lifecycle score than if calculations were based on recycled content, so that the contribution of waste disposal to lifecycle impact is then lower.

4 In the case of waste used as an energy source, i.e. as an ancillary fuel in a cement kiln or power station, savings on the Dutch hard coal supply mix have been taken in proportion to the lower heating value. The assumption is thus that there is no difference in the emissions of hard coal and the waste in question per MJ combusted material. This is a fairly rough-and-ready approach.

5 In the case of waste burned in municipal incinerators, emission and energy output data for the (Swiss) processes concerned have been adopted from the Ecoinvent database[6], unless the waste category was included in LAP-EIA and the data could be lifted from there. Where applicable, energy output was corrected for the Dutch electricity mix.

The use phase was included for energy-consuming products (gas-discharge lamps and cars) and for car tyres, carpeting and textiles. In the case of car tyres the type of tyre affects vehicle energy consumption and so part of this must be allocated to the tyre. With carpeting and textiles, maintenance - vacuuming and other forms of cleaning - may be a major contributor to lifecycle impacts.

For batteries and accumulators, the use phase was not included, though similar arguments could be cited as for tyres. In this case, though, the use phase is likely to have a far smaller share in lifecycle impact (cf. Matheys et al., 2006), because the embodied materials are in themselves very ‘environment-intensive’.

In the case of household organic waste, too, consumer energy use has been left out of the equation. The same applies to a number of steps in the production phase, it may be added, because for this category use was made of ‘cradle-to-gate’ environmental data, i.e. with the materials largely unprocessed. The processes involved in foodstuff chains are so diverse that they have been ignored here. Even so, for household organic waste, the pre-waste phase still predominates (cf. Section 3.3) and this category also features in the ‘top 10’ for overall lifecycle impact (cf. Section 4.2).

2.5 Uncertainties

The aim of the present study was to investigate whether Dutch waste policy can be dovetailed into lifecycle management and to identify waste categories potentially deserving priority focus in the country’s waste policy from 2009 onwards from several different perspectives. For a total of 22 waste categories ‘quick-scan LCAs’ were performed, with reasonable assumptions and estimates having to be made where data was lacking. The resultant data cannot therefore be used for detailed analyses or conclusions.

[6] In the case of metals, incinerator emissions have not been included, because these relate mainly to the leaching of bottom ash, an aspect not well modelled by the Swiss data for the Dutch situation.

The uncertainties in the environmental impact data are given by the sum of the uncertainties arising in the three stages of analysis:

1 Volume of individual waste categories: different sources report different data and the variation from year to year is sometimes marked. Discrepancies between sources are often around 15%, even for fairly well monitored streams like residual household waste[7]. Year-to-year differences are often greater still. As volume is one of the codeterminants of a waste stream's overall impact, this may mean different sampling years lead to differences in ranking.
2 Composition of waste categories: most categories comprise a range of different materials. In the case of end-of-life vehicles, for example, product composition is a fairly complex issue, but at the same time reasonably well understood. With the category 'Metal waste, general', in contrast, the main components are known, but data on their respective shares are hard to come by. In the case of household waste, different sources report different compositions, with figures for individual fractions sometimes 10% higher or lower[8].
3 Environmental data on individual processes: once the material composition of the waste stream had been satisfactorily established, the relevant environmental impact data were transferred from standard databases (generally Ecoinvent v1.3). Although these data have been compiled with the greatest care, because uncertainties nevertheless accumulate in the more complex process trees, for some environmental themes the effective uncertainties are substantial[9]. Most of the data are European or Swiss averages, moreover, and are based on assumptions that do not always match the Dutch situation, with no allowance being made for reprocessing of incinerator bottom ash, for example (cf. Section 2.4). This reservation holds mainly for waste disposal, though, because for the pre-waste phase (in particular, production of primary materials and intermediates) use of European averages is fairly well in line with reality. Finally, there were certain processes for which environmental data were lacking entirely, so that a rough-and-ready approach had to be adopted. Thus, tyre retreading was considered equivalent to materials recycling.

All the various choices made in modelling the respective lifecycles lead to uncertainties in the final result. Although the relative errors in the three steps outlined are not all defined in the same way, they appear to be of the same order of magnitude. The error in the final result is likely to be at least around 50%. The influence of this on rankings is discussed in Chapter 4. Its influence on the relative merits of waste disposal options (Chapter 3) is less pronounced, as these are less affected by uncertainties in volumes.

7 Although for this category of 'Household residual waste' the CBS statistics on total volume can be reliably adopted, the component fractions reported in certain sources are inconsistent with these data.
8 This means the relative shares reported by individual sources may sometimes be radically different.
9 The uncertainties in the process data used in this study are generally at least 20% (standard deviation from median). For the various processes, the main uncertainties relate to different environmental themes.

Costs, too, are plagued by a certain amount of uncertainty, because of gaps in the relevant literature. Processors are not always willing or able to report openly on costs, and returns on secondary materials are often far from clear. The cost data used in this study are therefore not built up in the same way for all the waste streams reviewed and should be seen as ‘ballpark’ figures. The influence of this on the rankings is discussed in Chapter 4.

3 Analysis of individual waste streams

3.1 Introduction

In this chapter, for a set of selected waste streams (cf. Appendix A) we review the quantitative environmental impact of the respective lifecycle phases and the estimated costs of waste disposal. In each case, several waste disposal options are compared: in principle, the current disposal strategy plus one or more alternatives that give a good idea of possibilities and choices. It may be an improvement of recycling rate that is involved, but for certain materials energy-from-waste may well be the environmentally preferable option. In the case of separately collected paper, for example, 100% recycling (current situation) is compared with 100% incineration, even though according to the 'waste hierarchy' this does not qualify as an improvement. For residual waste (household and commercial/institutional) no alternative was considered, because almost by definition this will be burned in municipal incinerators. When it comes to the constituent fractions of this residual waste, it can be deduced from data on other waste streams whether the policy aim should be increased separation to reduce the volume of this waste category.

In the following sections the methodology and results for each of the selected waste streams are reported and discussed. The numbered LAP sectoral plans are referred to as 'SP8', etc.

3.2 Gas-discharge lamps (#21)

Gas-discharge lamps (including tube lights and compact fluorescent lamps), which come under SP8, constitute waste stream #21. This waste stream was included in the 2002 LAP-EIA (Background document A12) and those data on average composition have been adopted here. The main component materials are glass, steel, brass, copper, aluminium and paper. Manganese and mercury have also been specifically included, with other constituents being subsumed under the heading 'inorganic chemicals'. For all these materials, production chain data were taken from Ecoinvent.

With lamps, the use phase is obviously important. Based on 8,000 burning hours, 50 W nominal output (SenterNovem, 1996) and 190 gram per lamp (LAP-EIA) as good averages, energy consumption in the use phase comes to 7,580 MJ_e/kg.

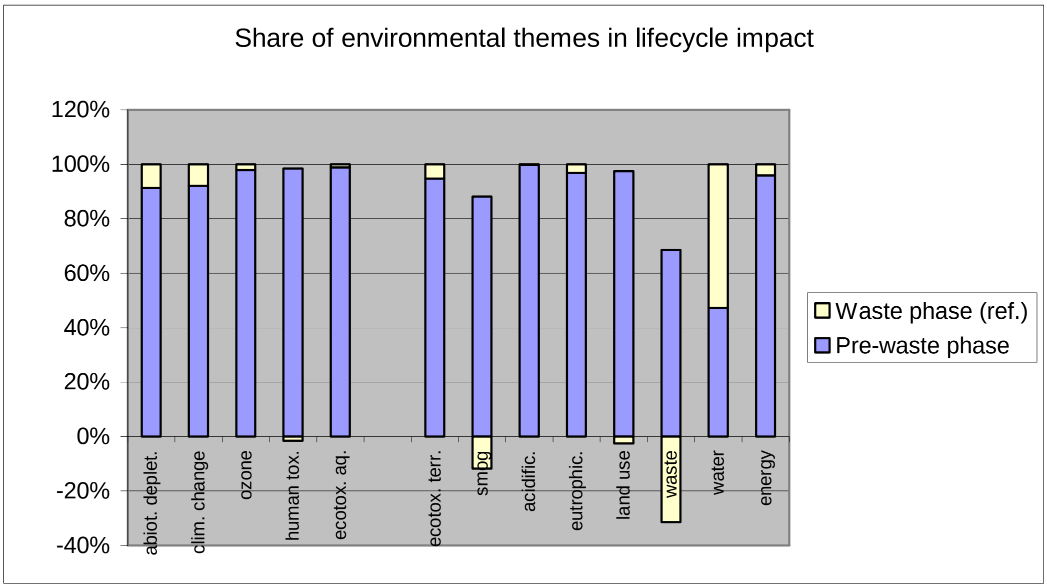
As in LAP-EIA, a 50-50 split of colour-80 lamps and standard lamps was taken. In both cases the LCA assessed disposal via shredding and via 'end-cut/air-push' (cf. LAP-EIA), with recycling of materials. Both routes satisfy the minimum standard for waste disposal in force in the Netherlands according to the LAP sectoral plan. Their impacts were taken directly from LAP-EIA.

The following waste disposal scenarios were thus assessed:
1 100% shredder.
2 100% end-cut/air-push.

The lifecycle scores per environmental theme are reported in Appendix B.1.

From a lifecyle perspective there is virtually no difference between these disposal scenarios. This is because the lifecycle impact is dominated entirely by the use phase (at least 98% of the impact on each theme). Even if the use phase is not included, waste disposal is of only limited influence on lifecycle impacts, as Figure 1 and Figure 2 show. Only if the Ecoindicator weighting method is used does waste disposal lead to environmental gains (negative impact).

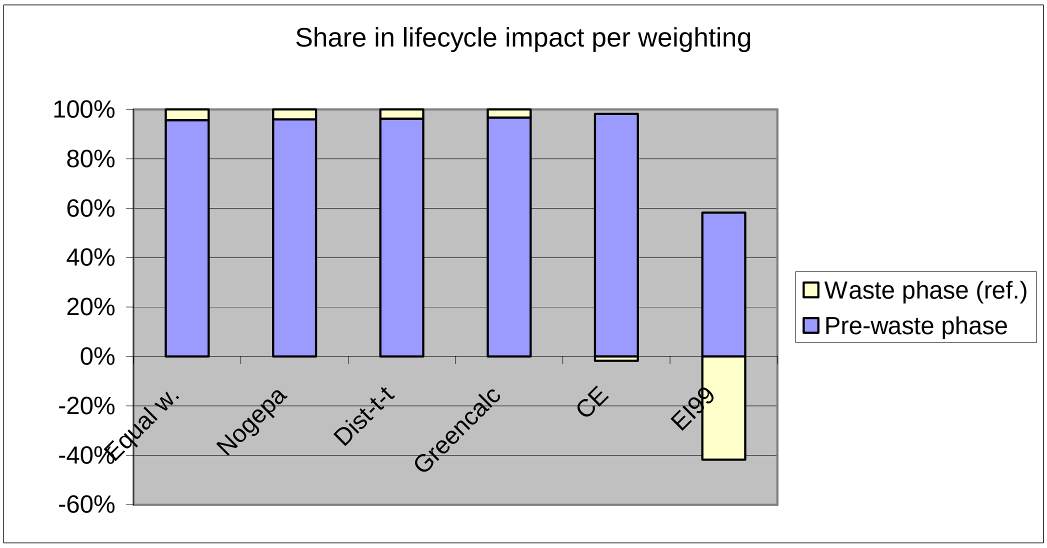
Figure 1 Contribution of pre-waste and waste phase to lifecycle impact, by environmental theme, scenario 1 (ref.) (use phase not included here, as share is almost 100%)



Explanation of figures and tables in Chapter 3
The lifecycle environmental impacts of all the waste streams reviewed in this chapter are presented in a uniform manner. For each of the nine emission-related impacts and four intervention-related impacts (cf. Section 2.2) the contribution of the production phase, waste phase and, where applicable, use phase to the total of 100% is given. In a second figure the same is done for the weighted aggregate impact, according to the various weighting methods (cf. Section 2.3). The effect of the waste phase may be 'negative', though (it may have a positive net environmental impact because of savings on primary resources, say) and in such cases this is indicated as a negative share. See the bar for 'EI99' in Figure 2, for example. In this case the pre-waste phase counts for +60% and the waste phase for -40%. This means that if the actual impact of the pre-waste phase were 150 'eco-points', the impact of the waste phase would be -50 'eco-points', yielding 100 when summed. The length of the bars is thus 100% in all cases.
The theme 'waste' (cf. Figure 1) stands for 'final waste' (cf. Table 6). The reference is to materials emerging at some point in the lifecycle as 'waste for landfill'. If the waste phase impacts 'negatively' on this (i.e. contributes positively to reducing lifecycle final waste), it will be mainly via savings on primary resources. In the lifecycle of metals, for example, a great deal of final waste is created at

the mining stage and recycling will therefore prevent much of this waste, thus making a 'negative' contribution to this theme.
While the figures show the split of environmental impacts across the phases of the lifecycle, the two tables for each of the waste streams report the *absolute* impacts over the entire lifecycle and for the waste disposal phase alone. In addition, the tables report on each of the disposal scenarios considered, while the figures relate solely to the reference (i.e. current in most cases) situation. The interventions (cf. Section 2.2) 'final waste', 'water consumption' and 'energy consumption' are also reported along with the weighted impacts (cf. Section 2.3). With the weighted data, the differences between the various disposal scenarios can be assessed. This difference is indicated by the percentages in the right-hand column, which in each case indicate by how much the scenario with the lowest impact differs from that with the highest. If one of the scenarios leads to a 'negative' impact (as explained above), this kind of comparison can give apparently confusing results, with variations of over 100%. A few examples by way of illustration: • Scenario 1 scores 80, scenario 2 scores 100 : variation is 20%. • Scenario 1 scores -80, scenario 2 scores -100 : variation is -25%. • Scenario 1 scores -80, scenario 2 scores 100 : variation is 180%. • Scenario 1 scores 80, scenario 2 scores -100 : variation is 225%.

Figure 2 Contribution of pre-waste and waste phase to weighted lifecycle impact, scenario 1 (ref.) (use phase not included)



The LAP-EIA data already include the avoided emissions due to savings on virgin resources. In LAP-EIA these appear to be generally on the low side, probably due to minor differences in assumptions compared with the present study[10].

Final scores on tracks A1 and A2

As described in Section 2.3, the environmental impact scores can be weighted to arrive at a single-figure final score. In Table 7 and Table 8 these final scores are reported for the entire waste stream, for both lifecycle impact and the impact of waste disposal alone.

[10] When it comes to the use of secondary steel, for example, LAP-EIA proceeds from savings on oxysteel but using the emissions of electrosteel production. Here we base ourselves on savings on pig iron.

Table 7 Final scores for lifecycle impact (weighted) for entire waste stream (3.6 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	5.1E+07	5.1E+07	0.207%
Water consumption (m^3)	4.4E+09	4.4E+09	0.047%
Energy consumption (MJprim)	9.6E+10	9.6E+10	0.002%
Ecoindicator99 (E,E)	2.8E+08	2.8E+08	0.004%
EPS (pre-waste phase only)	3.1E+09	3.1E+09	0%
Equal weighting	6.06E-04	6.06E-04	0.004%
Nogepa	7.05E-05	7.06E-05	0.007%
Distance-to-target	7.03E-04	7.04E-04	0.008%
Greencalc prevention costs	7.14E+02	7.14E+02	0.007%
CE prevention costs	3.49E+02	3.49E+02	0.004%

Table 8 Final scores for waste disposal (weighted) for entire waste stream (3.6 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	-1.3E+05	-2.4E+05	80.52%
Water consumption (m^3)	1.4E+07	1.2E+07	15.08%
Energy consumption (MJprim)	2.2E+06	6.8E+05	69.39%
Ecoindicator99 (E,E)	-2.4E+05	-2.5E+05	5.06%
EPS			
Equal weighting	8.77E-08	1.14E-07	23.21%
Nogepa	6.04E-09	1.10E-08	44.84%
Distance-to-target	1.51E-07	2.07E-07	27.39%
Greencalc prevention costs	3.21E-02	8.23E-02	60.98%
CE prevention costs	-7.17E-03	-2.27E-02	216.77%

According to most of the weighting methods, shredder processing is the best option, the exception being the CE method, because of the contribution of final waste. Waste disposal has virtually no influence on overall ifecycle impact, however, and measures to reduce materials usage and, more importantly, the lamps' energy consumption are the more obvious course of action from a lifecycle perspective.

Waste disposal costs

According to LAP-EIA, shredding costs between 450 and 1,100 € per tonne. The figure for end-cut/air-push is somewhat lower: 450-700 €/t. The total cost of disposing of this waste stream is thus around € 2.8 million (€ 2.1 million for end-cut/air-push).

3.3 Household and other organic waste (SP9)

Waste streams #22 (Household organic waste) and #23 (Separately collected commercial and institutional organic waste) have been taken together here, as they are largely equivalent in terms of both composition and disposal strategy. In addition, within these categories only the fraction of ‘avoidable product wastage’ has been included[11], the volume of which was calculated as follows. The volume of separately collected household organic waste is 1,362 kt (2005), the amount of separately collected organic waste from commercial and institutional sources 71 kt (2005) (UA, 2006). In the former category, though, around 80% is garden waste[12] and therefore does not count as product waste. Of the remaining 272 kt, we assumed that 50% is avoidable wastage (i.e. not peelings, fruit stones and suchlike) and the same holds for the 71 kt from commercial and institutional sources. For the present analysis the relevant figure is therefore 172 kt.

The composition of organic waste varies very widely and in many cases also involves supply chains that are not well covered by standard databases. Here we took an average of a selection of the available plant(-based) materials from Ecoinvent, such as wheat, rye, potatoes, corn, corn flour, potato starch, peas and oilseed rape. The data relate mainly to the cultivation phase rather than to subsequent processing (except in the case of corn flour and starch). Studies have shown that the share of fish and meat in the food waste arising in the catering industry is probably around 15%. Although this is hard to substantiate, this figure is likely to be lower for households. Because the environmental data on animal products are from a different database from that used for plant products (cf. Section 3.17), in this study we opted to base calculations on an assumption of 100% plant products in the waste. The impacts of the pre-waste phase may therefore be somewhat on the low side, but they predominate nonetheless (Figure 1 and Figure 2). The 5% contamination included in waste disposal in LAP-EIA A14 was ignored in the pre-waste phase.

The following waste disposal scenarios were assessed:

1 95% composting, 5% digestion.
2 100% bulk collection and incinerator disposal.
3 100% gasification and co-firing in power station.

The lifecycle scores per environmental theme are reported in Appendix B.2.

The impacts of waste disposal were taken from LAP-EIA (A14). Because the Ecoinvent data are based on short-cycle CO_2 uptake at the beginning of the cycle and release at the end, the short-cycle emissions had to be added to the LAP-EIA data. In the case of composting, moreover, methane and nitrous oxide emissions were adjusted to accommodate the latest findings of Tauw (2007). Details are provided in Appendix B.2.

---

[11] This is because food is unique in the sense that, on consumption, the portion eaten vanishes entirely, leaving only the natural ‘packaging’. The lifecycle environmental impact must be allocated entirely to the portion eaten, however.

[12] www.minvrom.nl.

In LAP-EIA the impacts reported are for organic waste in its entirety, including garden waste, peelings and so on. This probably means the impact of waste disposal has been assessed too favourably (i.e. overly optimistic environmental gains) compared with the pre-waste phase. However, the latter impacts are possibly on the low side because of the non-inclusion of animal waste. As Figure 3 and Figure 4 show, the pre-waste phase generally predominates, except in the case of the CE weighting method, where climate and final waste are significant factors.

Figure 3 Contribution of pre-waste and waste phase to lifecycle impact, by environmental theme, scenario 1 (ref.)

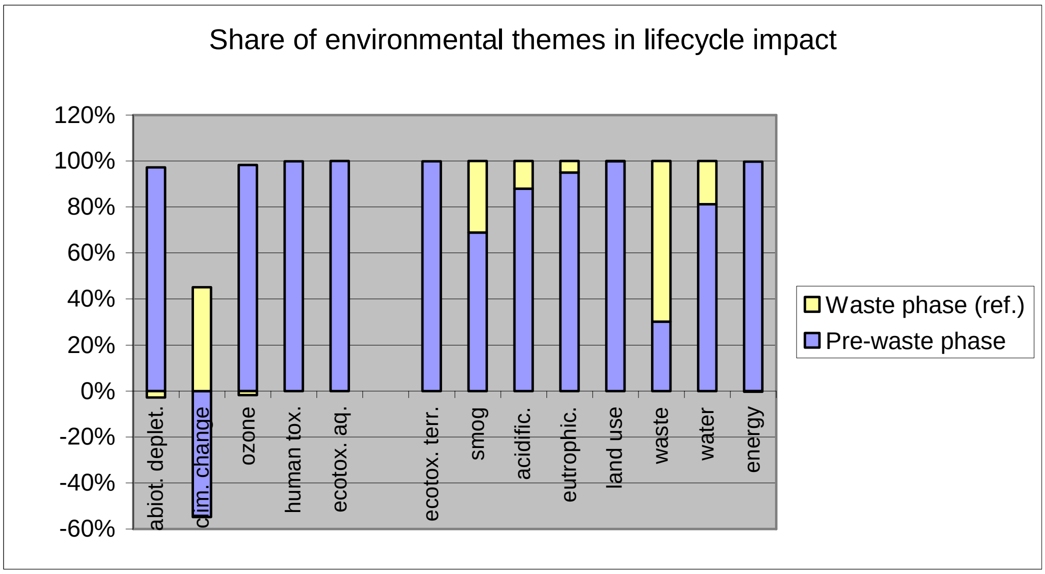
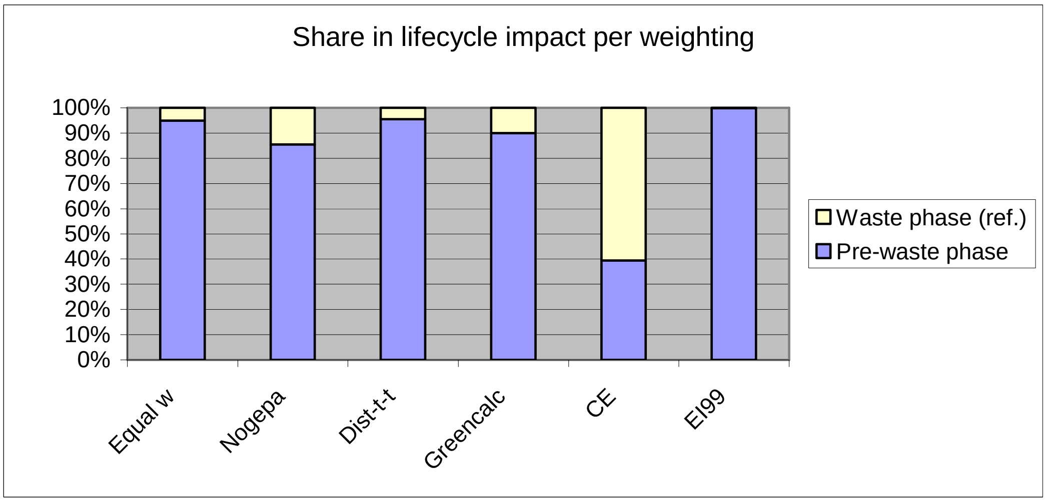


Figure 4 Contribution of pre-waste and waste phase to weighted lifecycle impact, scenario 1 (ref.)



Final scores on tracks A1 and A2

The scores can be weighted to arrive at a single-figure final score, as described in Section 2.3. In Table 9 and Table 10 these final scores are reported for the entire waste stream, for both lifecycle impact and the impact of waste disposal alone.

Table 9 Final scores for lifecycle impact (weighted) for entire waste stream (172 kt)

	Scenario 1	Scenario 2	Scenario 3	Variation
Final waste (kg)	1.87E+07	8.87E+06	-5.79E+06	131%
Water consumption (m^3)	2.20E+08	2.74E+08	-2.05E+09	849%
Energy consumption (MJprim)	1.99E+09	2.09E+09	1.33E+09	36%
Ecoindicator99 (E,E)	2.15E+07	2.20E+07	1.48E+07	33%
EPS (pre-waste phase only)		2.82E+07		0%
Equal weighting	4.48E-05	4.55E-05	3.85E-05	15%
Nogepa	3.89E-06	4.08E-06	3.28E-06	20%
Distance-to-target	1.12E-04	1.11E-04	1.02E-04	8%
Greencalc prevention costs	6.16E+01	6.36E+01	5.51E+01	13%
CE prevention costs	8.94E+00	8.43E+00	1.31E+00	85%

Table 10 Final scores for waste disposal (weighted) for entire waste stream (172 kt)

	Scenario 1	Scenario 2	Scenario 3	Variation
Final waste (kg)	1.31E+07	3.23E+06	-1.14E+07	187%
Water consumption (m^3)	4.14E+07	9.55E+07	-2.23E+09	2,438%
Energy consumption (MJprim)	-6.13E+06	1.03E+08	-6.59E+08	741%
Ecoindicator99 (E,E)	3.12E+04	4.84E+05	-6.69E+06	1.481%
EPS				
Equal weighting	2.25E-06	2.97E-06	-4.03E-06	236%
Nogepa	5.65E-07	7.62E-07	-4.49E-08	106%
Distance-to-target	4.96E-06	4.30E-06	-4.29E-06	187%
Greencalc prevention costs	6.15E+00	8.19E+00	-3.39E-01	104%
CE prevention costs	5.41E+00	4.90E+00	-2.22E+00	141%

From a lifecycle perspective, composting/digestion (1) and incinerator disposal (2) score roughly the same on many themes. The greatest difference is for climate change. Gasification and power plant co-combustion is the most attractive option with respect to all themes, though, with the greatest difference observed for water consumption. This is an expensive disposal route, however, and will not therefore be used on any great scale. Another possible high-energy route for organic waste might be hydrothermal upgrading (HTU; cf. Section 4.5).

The category 'Bulk-collected commercial and institutional organic waste' (#24) comprises around 80 kt, about half of which is likewise avoidable. This stream falls under SP3 (commercial and institutional) and will be returned to later in Section 3.22, but in principle the same conclusions hold as for #22 and #23.

Waste disposal costs
The costs of composting and digestion are 45 €/t and 55 €/t, respectively (LAP-EIA, A14). For the total volume this gives a figure of € 7.8 million.

3.4 End-of-life vehicles (#28)

End-of-life vehicles constitute waste stream #28, which comes under SP11. Calculation of lifecycle environmental impacts was based on the 'average European car' used in Ecoinvent (v1.3)[13]. Although this average car differs slightly in composition from the average Dutch end-of-life vehicle, the differences are small. The percentage of steel is almost exactly the same, while the share of other materials varies by no more than about 1%. The category 'End-of-life vehicles' consists largely of passenger cars.

At the moment 83% of these materials are recycled and 2% used for energy recovery, leaving 15% as final waste (ARN, 2006 data). Recycling rates were assumed to be greatest for the metals (via shredding) and lowest for the plastics. Recycling was valued via savings on primary resources, with upgrading processes also being factored in using an approach based on climate impact data. Of the 15% final waste, two-thirds is shredder waste. The impacts of disposing of this final waste were adopted from LAP-EIA calculations. The remaining 5% final waste was not modelled, nor the 2% energy recovery.

For lack of data, no allowance could be made for new 'post-shredder technology' with which the bulk of the shredder waste (around 75%) can be usefully applied or burned. The remainder (around 25%) would be landfilled for the time being. In response to this new technology, a landfill ban is to be introduced as of 1 January, 2009.

For the use phase we also based ourselves on Ecoinvent, viz. 150,000 km per vehicle and average European emission data.

The following waste disposal scenarios were assessed:
1 83% materials recycling, 10% shredder waste to landfill.
2 83% materials recycling, 10% shredder waste to pyrolysis.
3 95% materials recycling, 5% shredder waste to landfill.

The lifecycle scores per environmental theme are reported in Appendix B.3.

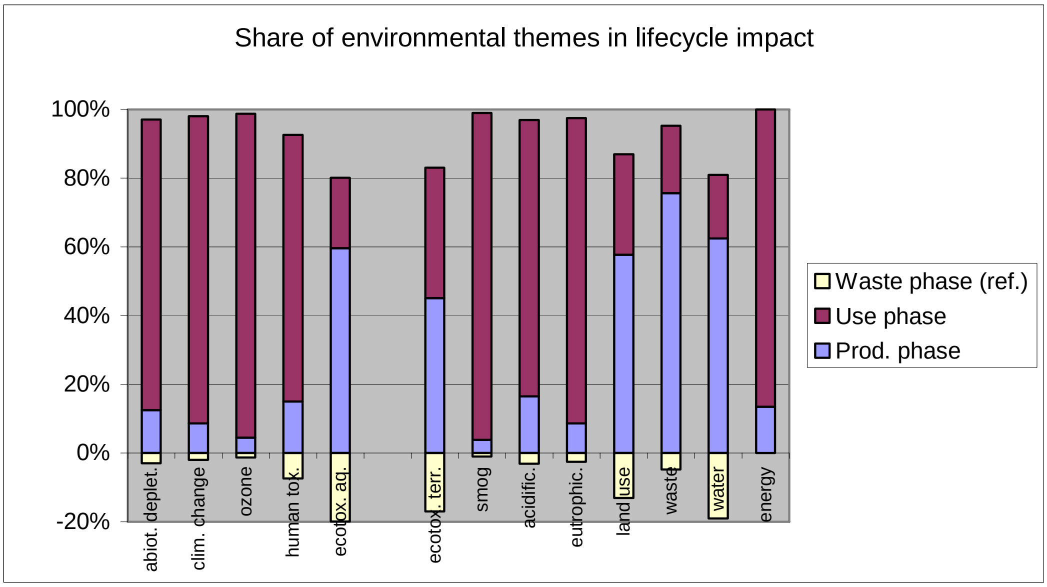
Over the whole lifecycle there is little difference between the waste scenarios, but in all cases waste disposal has negative impacts[14] (Figure 5 and Figure 6). On the environmental themes most closely associated with fuel consumption it is the use phase that predominates, but this does not hold for all the themes.

---

13 Note that this deviates slightly from the standard procedure set out in Section 2.4, as this car consists partly of secondary aluminium and thus has 'recycled content'. As this represents only 1% of the total weight, though, the impact on the results will be insignificant.

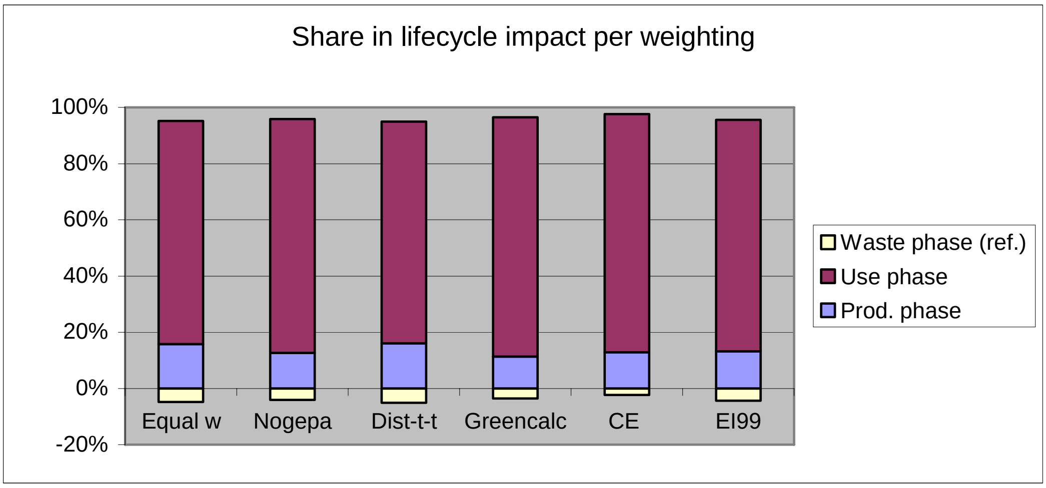
14 It is hereby assumed that a proportion of some materials moves in a closed cycle, with only the additional recycling percentage over and above the employed European averages being factored in (cf. Section 2.4).

Figure 5 Contribution of production phase, use phase and waste phase to lifecycle impact, by environmental theme, scenario 1 (ref.)



The various weighting methods all give roughly the same picture of lifecycle impacts.

Figure 6 Contribution of production phase, use phase and waste phase to weighted lifecycle impact, scenario 1 (ref.)



Final scores on tracks A1 and A2

The scores can be weighted to arrive at a single-figure final score, as described in Section 2.3. In Table 11 and Table 12 these final scores are reported for the entire waste stream, for both lifecycle impact and the impact of waste disposal alone.

Table 11 Final scores for lifecycle impact (weighted) for entire waste stream (276 kt)

	Scenario 1	Scenario 2	Scenario 3	Variation
Final waste (kg)	1.5E+08	1.1E+08	1.3E+08	26%
Water consumption (m^3)	6.9E+09	6.9E+09	6.9E+09	0%
Energy consumption (MJprim)	1.3E+11	1.3E+11	1.3E+11	2%
Ecoindicator99 (E,E)	5.6E+08	5.6E+08	5.5E+08	1%
EPS	8.8E+09	8.8E+09	8.7E+09	0%
Equal weighting	1.43E-03	1.43E-03	1.42E-03	1%
Nogepa	1.76E-04	1.76E-04	1.75E-04	1%
Distance-to-target	2.52E-03	2.52E-03	2.50E-03	1%
Greencalc prevention costs	1.61E+03	1.60E+03	1.60E+03	1%
CE prevention costs	7.10E+02	7.01E+02	7.01E+02	1%

Table 12 Final scores for waste disposal (weighted) for entire waste stream (276 kt)

	Scenario 1	Scenario 2	Scenario 3	Variation
Final waste (kg)	-7.7E+06	-4.5E+07	-2.23E+07	-482%
Water consumption (m^3)	-2.1E+09	-2.1E+09	-2.13E+09	-1%
Energy consumption (MJprim)	-3.8E+09	-4.2E+09	-6.08E+09	-59%
Ecoindicator99 (E,E)	-2.6E+07	-2.7E+07	-3.4E+07	-31%
EPS	-2.2E+09	-2.2E+09	-2.2E+09	-2%
Equal weighting	-7.65E-05	-7.94E-05	-8.94E-05	-17%
Nogepa	-7.84E-06	-8.15E-06	-8.95E-06	-14%
Distance-to-target	-1.42E-04	-1.46E-04	-1.61E-04	-13%
Greencalc prevention costs	-6.11E+01	-6.43E+01	-7.20E+01	-18%
CE prevention costs	-1.76E+01	-2.61E+01	-2.62E+01	-48%

Increasing the recycling rate from 83% (current situation, scenario 1) to 95% (target, scenario 3) leads to a lifecycle improvement of around 1%. As the results for scenario 2 show, this kind of improvement can also be achieved through more efficient processing of the shredder waste. From a lifecycle perspective, the energy consumed during the product's lifetime is obviously of prime importance.

Waste disposal costs

The fee paid for end-of-life vehicle disposal is € 15, with an average weight of 936 kg (ARN, 2007). This gives a price of 16 €/t, which is probably on the high side as an estimate of the total net cost of waste disposal. For the waste stream as a whole this gives a figure of € 4.53 million.

3.5 End-of-life tyres (#29)

End-of-life tyres constitute waste stream #29, which comes under SP11. These are the tyres replaced in the course of a vehicle's lifetime. Composition data were taken from Spriensma et al. (2001) and are for an 'average European' car tyre. These tyres (weight: 8.7 kg) consist almost entirely of rubber[15], steel and fillers (carbon black and silica). In Spriensma et al. (2001) a certain fraction of the energy consumed in motoring is allocated to the tyres, because their composition has an impact on rolling resistance. Their share in energy consumption is around 4% per tyre (lifetime: 40,000 km). As Figure 7 shows, this means the use phase predominates in total lifecycle impact. However, the materials production phase also contributes substantially more than waste disposal (Figure 8), so from a lifecycle perspective, at any rate, the role of waste disposal is fairly negligible.

According to BEM[16] end-of-life tyre disposal is by way of product recycling (retreading, 35%), materials recycling (10%), incineration with energy recovery (30%) and 'other methods' (25%). No reliable data on retreading were available, however, and in the reference scenario this fraction was therefore taken equal to that for materials recycling. Because useful application is the minimum standard for car tyres, the fraction disposed of by 'other methods' was also assumed to be incinerated with energy recovery (cement kiln).

The following two waste disposal scenarios were thus assessed:

1 45% materials recycling and 55% incineration with energy recovery.
2 100% materials recycling.

The lifecycle scores per environmental theme are reported in Appendix B.4.

The picture to emerge from Figure 7 and Figure 8 is very similar to that for the lifecycle of end-of-life vehicles. In both cases it is the use phase and production phase that predominate in lifecycle impacts.

[15] Ecoinvent data on synthetic rubber were used, as data on natural rubber were lacking.
[16] www.bandenmilieu.nl.

Figure 7 Contribution of production phase, use phase and waste phase to lifecycle impact, by environmental theme, scenario 1 (ref.)

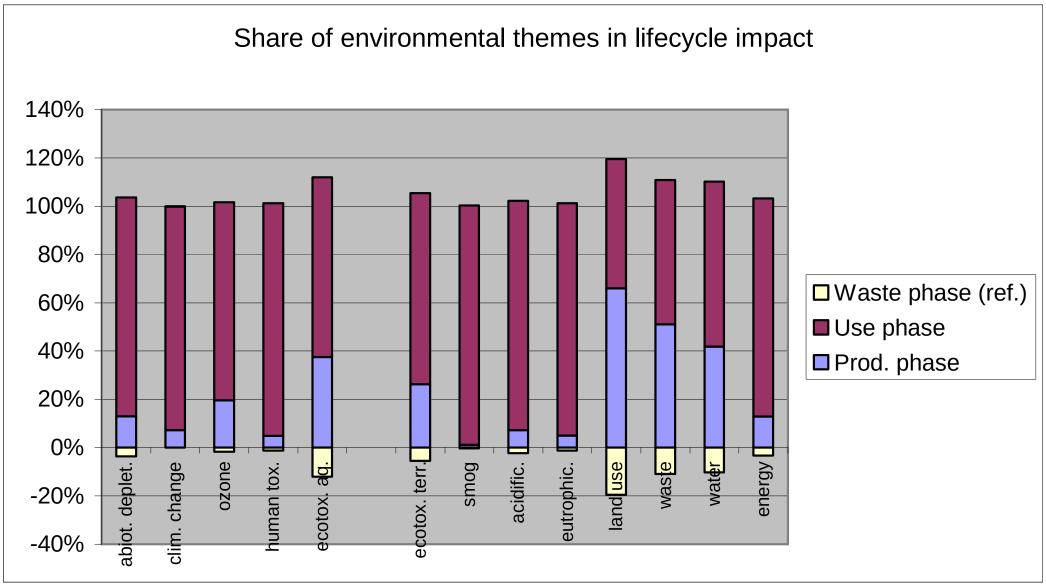
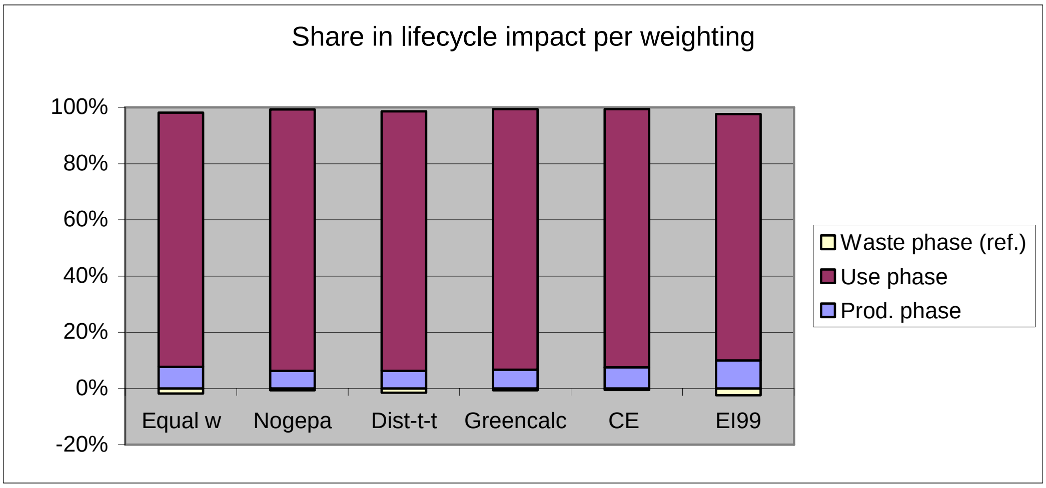


Figure 8 Contribution of production phase, use phase and waste phase to weighted lifecycle impact, scenario 1 (ref.)



Final scores on tracks A1 and A2

The scores can be weighted to arrive at a single-figure final score, as described in Section 2.3. In Table 13 and Table 14 these final scores are reported for the entire waste stream, for both lifecycle impact and the impact of waste disposal alone.

Table 13 Final scores for lifecycle impact (weighted) for entire waste stream (100 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	3.3E+07	2.5E+07	24%
Water consumption (m^3)	1.9E+09	1.7E+09	11%
Energy consumption (MJprim)	8.3E+10	8.1E+10	2%
Ecoindicator99 (E,E)	3.5E+08	3.4E+08	2%
EPS	3.3E+09	3.0E+09	10%
Equal weighting	8.46E-04	8.30E-04	2%
Nogepa	1.07E-04	1.04E-04	2%
Distance-to-target	1.47E-03	1.44E-03	2%
Greencalc prevention costs	9.89E+02	9.69E+02	2%
CE prevention costs	4.28E+02	4.18E+02	2%

Table 14 Final scores for waste disposal (weighted) for entire waste stream (100 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	-3.2E+07	-1.0E+08	-222%
Water consumption (m^3)	-1.7E+09	-3.6E+09	-111%
Energy consumption (MJprim)	-2.4E+10	-3.8E+10	-61%
Ecoindicator99 (E,E)	-7.7E+07	-1.4E+08	-78%
EPS	-2.2E+09	-4.9E+09	-125%
Equal weighting	-1.39E-04	-2.80E-04	-102%
Nogepa	-6.71E-06	-2.54E-05	-278%
Distance-to-target	-1.91E-04	-4.44E-04	-133%
Greencalc prevention costs	-5.75E+01	-2.34E+02	-307%
CE prevention costs	-2.32E+01	-1.15E+02	-396%

In terms of lifecycle impact, increasing the recycling rate leads to an improvement of around 2%. If we ignore the use phase, the effect will be greater, though, and for waste disposal itself the improvement is significant. In the case of reuse (retreading) due allowance must certainly be made for the impact on energy consumption during the product's service life. If 'second-hand' tyres lead to greater fuel consumption, this will soon knock on in a negative net environmental impact.

Waste disposal costs

A reasonably large fraction of end-of-use tyres have a positive economic value (according to the Car Tyre Management Decree/*Besluit Beheer Autobanden, BBA*). We assumed this holds for the fraction that is retreaded (35%). For the remaining fraction the costs will amount to about 0.10 €/kg (*BBA*). The net costs taken here for tyre disposal are 70 €/t, or € 7 million for the entire waste stream.

3.6 Stony materials (#37)

'Stony materials' form waste stream #37, part of SP13 (construction and demolition waste). At 22,580 kt, this is by far the largest category of waste in the Netherlands. It consists mainly of mixed rubble, concrete rubble and masonry rubble (UA/Rense, 2007). On this basis the respective shares of bricks and concrete can be estimated as 35% and 50%. The remainder is mortar and asphalt (share 11%).

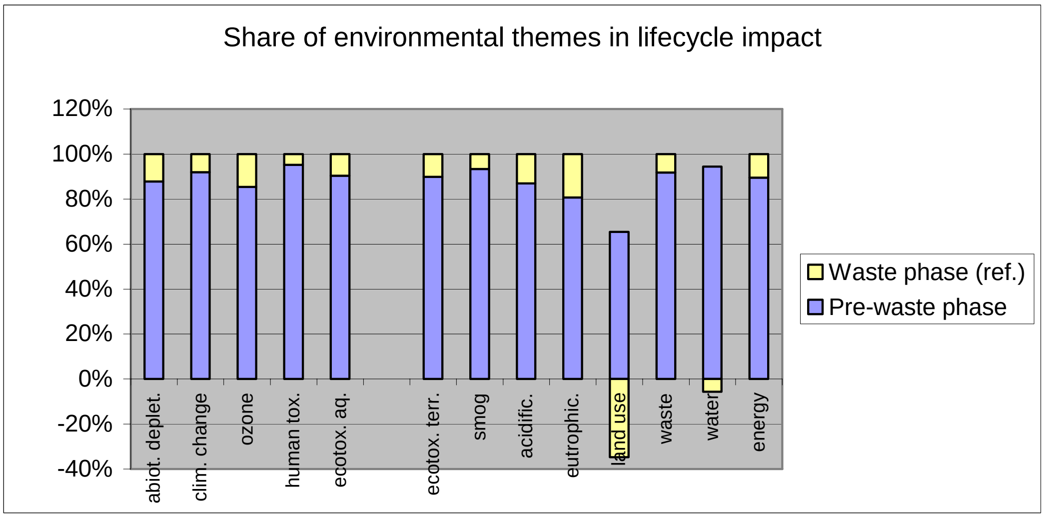
The current waste disposal strategy is to crush the waste and use it in road foundations (96%) or as a concrete filler (4%) (BRBS, 2007). This means, on the one hand, transport and electricity consumption and, on the other, savings on sand and gravel, respectively[17]. There is scope for increasing the percentage used as concrete filler, but this holds only for the share of concrete granulate (i.e concrete rubble). That share is presently 16% (UA/Rense, 2007), but given the possibility of this rising in the future (BRBS, 2007), alternative calculations were also run with 20% used as a filler.
The following two waste disposal scenarios were thus assessed:
1 96% road foundations and 4% concrete filler (reference).
2 80% road foundations and 20% concrete filler.

The lifecycle scores per environmental theme are reported in Appendix B.5.

The differences between the two scenarios are minor; only on land use does the reference scenario score slightly better. This is because the savings on land use due to substitution of sand (in road foundations) are greater than those due to substitution of gravel (concrete). As Figure 9 shows, relative to the pre-waste phase, too, useful application of the granulate has the greatest (i.e. restrictive) effect on land use. On all the other themes, the extra energy consumption associated with transport and crushing outweighs the savings on sand and gravel. This is not unexpected, as these surface-quarried minerals are not themselves associated with any major environmental burdens.

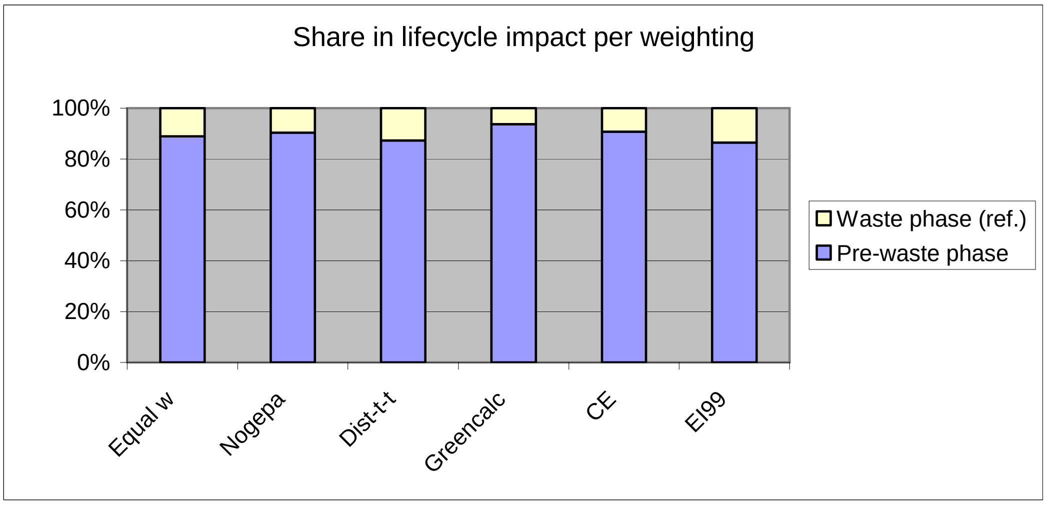
[17] The assumption here is that a given weight of granulate replaces the same weight of sand or gravel. This is probably an underestimate, as the granulate is generally less dense, but exact densities can vary widely.

Figure 9 Contribution of pre-waste and waste phase to lifecycle impact, by environmental theme, scenario 1 (ref.)



As Figure 9 shows, all weighting methods give around 10% additional environmental impact for waste disposal relative to the pre-waste phase.

Figure 10 Contribution of pre-waste and waste phase to weighted lifecycle impact, scenario 1 (ref.)



Final scores on tracks A1 and A2

The scores can be weighted to arrive at a single-figure final score, as described in Section 2.3. In Table 15 and Table 16 these final scores are reported for the entire waste stream, for both lifecycle impact and the impact of waste disposal alone.

Table 15 Final scores for lifecycle impact (weighted) for entire waste stream (22,580 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	1.86E+08	1.78E+08	4,6%
Water consumption (m^3)	5.76E+09	5.51E+09	4,3%
Energy consumption (MJprim)	4.50E+10	4.47E+10	0,6%
Ecoindicator99 (E,E)	1.58E+08	1.58E+08	0,1%
EPS	1.57E+09	1.54E+09	1,5%
Equal weighting	3.34E-04	3.32E-04	0,4%
Nogepa	4.67E-05	4.66E-05	0,3%
Distance-to-target	4.96E-04	4.94E-04	0,5%
Greencalc prevention costs	4.90E+02	4.90E+02	0,2%
CE prevention costs	2.72E+02	2.69E+02	0,8%

Table 16 Final scores for waste disposal (weighted) for entire waste stream (22,580 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	1.52E+07	6.66E+06	56%
Water consumption (m^3)	-3.63E+08	-6.12E+08	-69%
Energy consumption (MJprim)	4.72E+09	4.45E+09	6%
Ecoindicator99 (E,E)	2.13E+07	2.11E+07	1%
EPS	5.24E+07	2.91E+07	44%
Equal weighting	3.69E-05	3.57E-05	3%
Nogepa	4.49E-06	4.34E-06	3%
Distance-to-target	6.27E-05	6.03E-05	4%
Greencalc prevention costs	3.10E+01	3.18E+01	3%
CE prevention costs	2.52E+01	2.31E+01	8%

The forms of useful application considered here have hardly any effect on environmental impact, whether it is the lifecycle as a whole that is under review or waste disposal only. This is because the materials substituted are far less environmentally intensive than the construction materials themselves. What needs to be found is a higher-quality use for these materials, with the materials substituted more environmentally intensive, too. This holds all the more as the volume of this waste stream is truly enormous and features in virtually all the ‘top 10’ rankings (cf. Chapter 4). At the moment, though, there appear to be no obvious options available.

Waste disposal costs

The net costs of disposing of stony construction and demolition waste are around 104 €/t, deriving mainly from rubble crushing. The costs associated with the entire waste stream are thus € 2.35 billion.

3.7 Gypsum (#38)

Waste stream #38 is ‘Gypsum’, also part of SP13 (construction and demolition waste). Its total annual volume is 200 kt (TNO, 2004).

In the Netherlands there is massive reuse of FGD (Flue Gas Desulphurisation) gypsum. According to UA (2006) around 236 kt FGD-gypsum is freed up each year and all the gypsum currently used in this country is of this variety. The basic Ecoinvent dataset does not include this kind of gypsum, however, and for the pre-waste phase ‘normal’ gypsum was therefore taken. The category was broken down into plaster blocks, plasterboard and ‘invisible’ gypsum such as plasterwork (about 50%) (TNO, 2004).

The reference situation taken for waste disposal was ‘Versatzbau’[18]. As various LAP-EIA calculations show (incl. those on flue-gas treatment residues), Versatzbau has a greater environmental impact than normal landfill. This is due largely to the longer transport distances involved. Here we adopted the transport assumptions of LAP-EIA (distance: 600 km plus return trip). The attendant impacts were taken from Ecoinvent, as were those for landfill, corrected for the fact that Versatzbau itself does not involve any land use. The sum of these impacts was therefore taken for Versatzbau.

The following waste disposal scenarios were assessed:
1 100% Versatzbau.
2 50% material recycling, 50% Versatzbau.

The lifecycle scores per environmental theme are reported in Appendix B.6.

With these waste flows, the waste disposal phase is of major influence. The reference, Versatzbau, performs poorly in environmental terms. Recycling, calculated on the basis of savings on wall plaster and Portland cement, scores significantly better, but ‘negative’ scores for waste disposal (i.e. net savings) occur only on a small a number of themes.

In this case the contribution of the pre-waste phase has even been somewhat overestimated, it may be added, as the use of FGD-gypsum was not factored in. Being a useful by-product from a different process, FGD-gypsum will have less environmental impact than ‘normal’ gypsum. This means that gypsum should perhaps feature slightly higher in the ranking for the share of waste disposal in overall lifecycle impact (A0) and slightly lower in the lifecycle ranking (A1). We return to this issue in Chapter 4.

---

18 That is, use in German mines to prevent to prevent shaft collapse.

Figure 11 Contribution of pre-waste and waste phase to lifecycle impact, by environmental theme, scenario 1 (ref.)

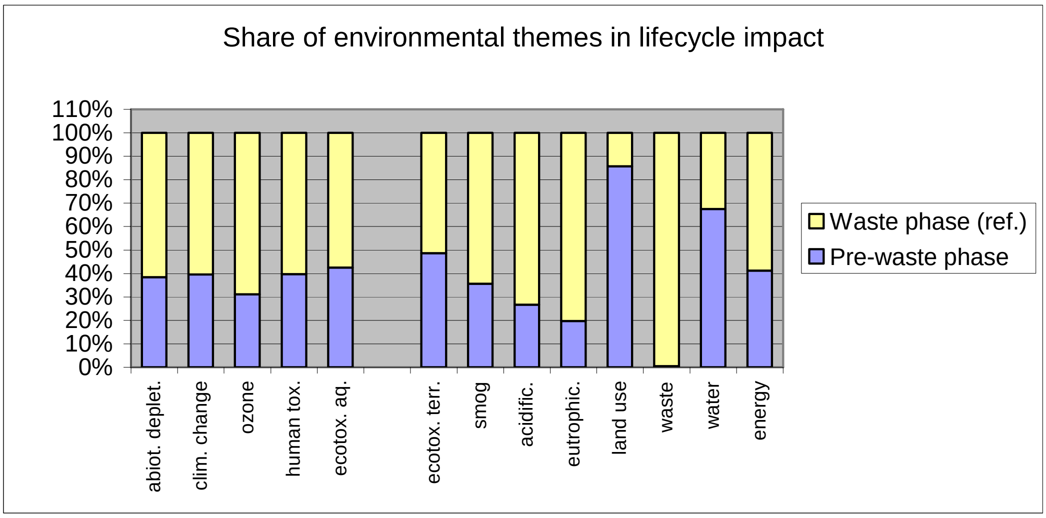
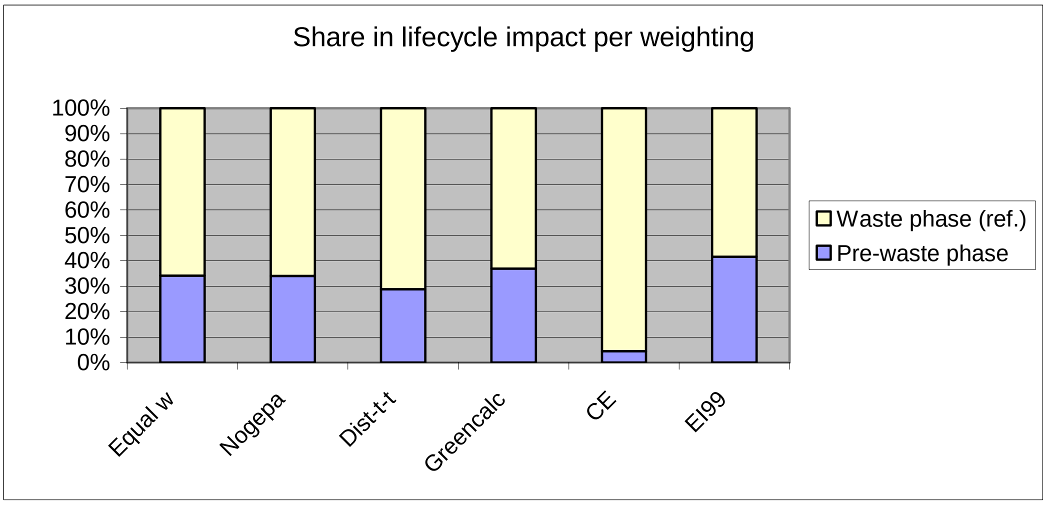


Figure 12 Contribution of pre-waste and waste phase to weighted lifecycle impact, scenario 1 (ref.)



Final scores on tracks A1 and A2

The scores can be weighted to arrive at a single-figure final score, as described in Section 2.3. In Table 17 and Table 18 these final scores are reported for the entire waste stream, for both lifecycle impact and the impact of waste disposal alone.

Table 17 Final scores for lifecycle impact (weighted) for entire waste stream (200 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	2.01E+08	1.01E+08	50%
Water consumption (m^3)	1.70E+08	1.23E+08	27%
Energy consumption (MJprim)	1.27E+09	8.17E+08	36%
Ecoindicator99 (E,E)	1.18E+07	6.70E+06	43%
EPS	6.67E+07	3.98E+07	40%
Equal weighting	4.46E-05	2.36E-05	47%
Nogepa	4.04E-06	2.17E-06	46%
Distance-to-target	1.08E-04	5.59E-05	48%
Greencalc prevention costs	3.45E+01	1.90E+01	45%
CE prevention costs	6.57E+01	3.36E+01	49%

Table 18 Final scores for waste disposal (weighted) for entire waste stream (200 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	2.00E+08	1.00E+08	50%
Water consumption (m^3)	6.14E+07	1.48E+07	76%
Energy consumption (MJprim)	7.60E+08	3.07E+08	60%
Ecoindicator99 (E,E)	9.50E+06	4.37E+06	54%
EPS	4.66E+07	1.97E+07	58%
Equal weighting	4.14E-05	2.03E-05	51%
Nogepa	3.66E-06	1.79E-06	51%
Distance-to-target	1.03E-04	5.13E-05	50%
Greencalc prevention costs	3.01E+01	1.46E+01	51%
CE prevention costs	6.38E+01	3.17E+01	50%

At the moment waste gypsum is disposed of in German mines (Versatzbau). Although this can be designated a ‘useful application’, it is still relatively low-grade, partly because in practice the only ‘savings’ achieved are on other kinds of waste, with there consequently being no savings on primary resources. The scenario with 50% recycling therefore scores considerably higher with respect to both lifecycle and waste disposal alone. Current efforts in this area therefore deserve extra attention and should if possible be stepped up.

Waste disposal costs

The reference taken was 100% Versatzbau, which costs 13 €/t (BRBS data). The costs for the entire waste stream are thus € 2.6 million.

3.8 Plate glass (#50)

Plate glass is waste stream #50, again part of SP13 (construction and demolition waste, CDW). The annual volume is 74 kt (VRN, Vlakglas Recycling Nederland[19]). It should be noted that the bulk of this does not feature in the usual CDW monitoring reports, as it generally arises between the construction and demolition phase.

For the pre-waste phase Ecoinvent data on plate glass were used (50% uncoated, 50% coated). For this waste stream we assumed 100% useful application. According to VRN statistics (VRN, 2006), separately collected glass is used in the production of plate glass (13%), glasswool (37%), packaging (39%) and glass beads (11%). For want of specific data, the glass bead fraction was included as ‘plate glass’.

Data on energy consumption and transport were taken from Flanagan et al. (2003), impact data for production processes and savings on glassfibre from Ecoinvent. As specific data are lacking, for recycling to plate glass we assumed the same relative energy savings (25% relative to primary) as hold for secondary glassfibre (Flanagan et al., 2003) and secondary packaging glass (CE, 2007). Other data on packaging glass were adopted from Ecoinvent and CE (2007).
As an alternative disposal method, we also considered the impacts associated with glass sent to landfill. A small portion of the glass collected by VRN (around 1.5%; VRN, 2006) has to be landfilled because it is contaminated in some way. Another small fraction of waste plate glass arises as CDW, ending up ultimately (via a crushing plant) in road foundations. This volume is even smaller, though, and here landfilling was therefore assumed[20].

The following waste disposal scenarios were assessed:
1 100% useful application as packaging (39%), glasswool (37%) and plate glass (24%).
2 100% landfill.

The lifecycle scores per environmental theme are reported in Appendix B.7.

In this case the difference between useful application and landfill is enormous, even when the comparison is for the lifecycle as a whole. As can be seen from Figure 13, application as glassfibre offsets the impacts of the pre-waste phase entirely or may even lead to net ‘negative’ lifecycle impacts.

---

19 www.vlakglasrecycling.nl, data for 2007.

20 In the case of glass, the difference in impact between landfill and use in road foundations is also marginal, it may be added, and the influence of this minor volume is therefore negligible.

Figure 13 Contribution of pre-waste and waste phase to lifecycle impact, by environmental theme, scenario 1 (ref.)

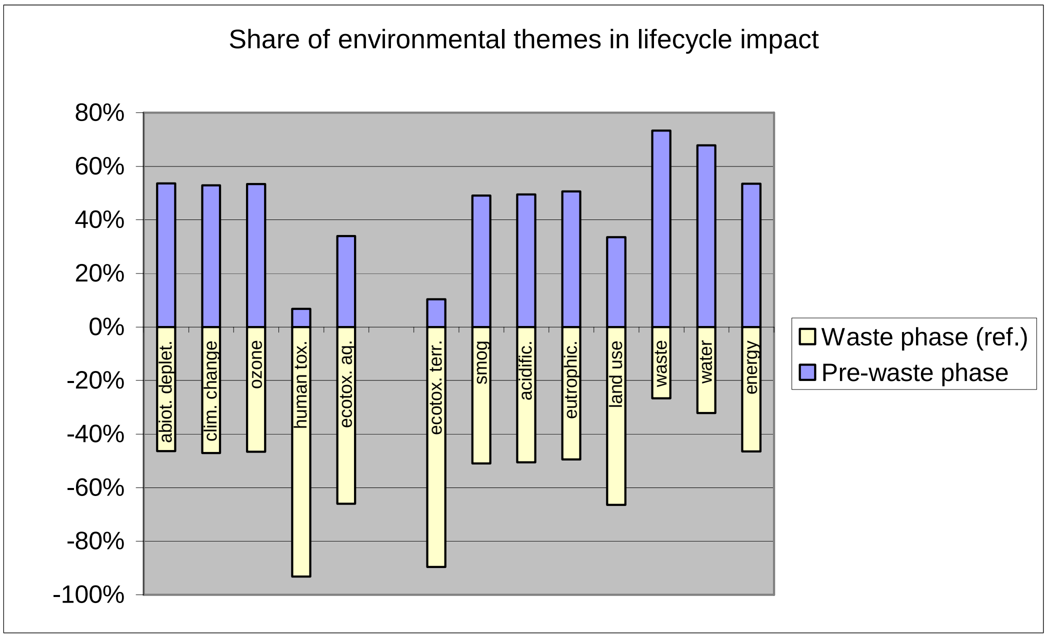
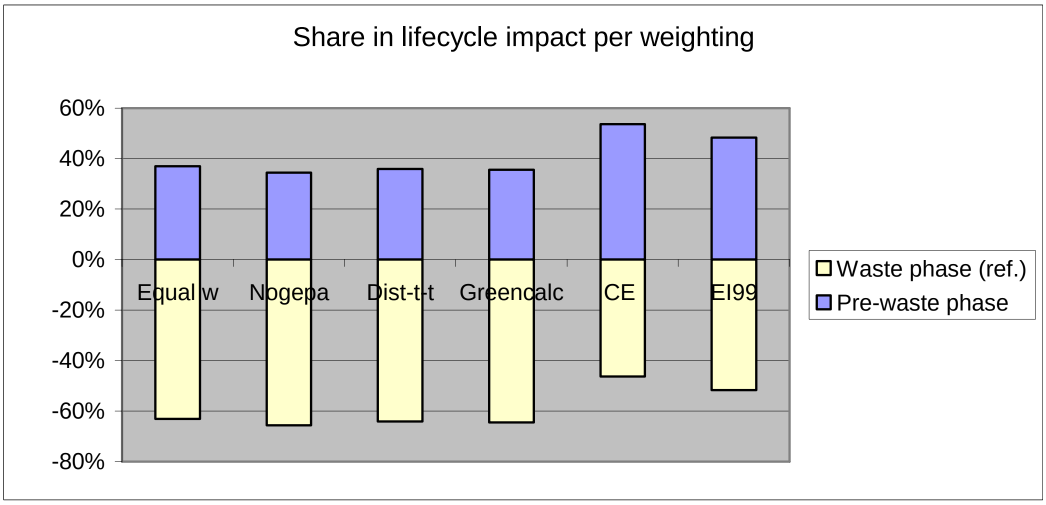


Figure 14 Contribution of pre-waste and waste phase to weighted lifecycle impact, scenario 1 (ref.)



In a certain sense what we have here is ‘upcycling’, because the glassfibre that has been saved out on is more energy-intensive than the material’s original application as plate glass. Even with 100% recycling as plate glass, though, savings in the waste phase are still substantial.

Final scores on tracks A1 and A2

The scores can be weighted to arrive at a single-figure final score, as described in Section 2.3. In Table 19 and Table 20 these final scores are reported for the entire waste stream, for both lifecycle impact and the impact of waste disposal alone.

Table 19 Final scores for lifecycle impact (weighted) for entire waste stream (74 kton)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	4.13E+06	8.04E+07	95%
Water consumption (m^3)	6.99E+07	1.34E+08	48%
Energy consumption (MJprim)	1.35E+08	1.05E+09	87%
Ecoindicator99 (E,E)	-3.83E+05	5.76E+06	107%
EPS	1.64E+07	5.91E+07	72%
Equal weighting	-7.61E-06	1.09E-05	170%
Nogepa	-1.17E-06	1.30E-06	190%
Distance-to-target	-1.60E-05	2.05E-05	178%
Greencalc prevention costs	-1.11E+01	1.39E+01	180%
CE prevention costs	1.14E+00	2.20E+01	95%

Table 20 Final scores for waste disposal (weighted) for entire waste stream (74 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	-2.36E+06	7.40E+07	103%
Water consumption (m^3)	-6.30E+07	7.28E+05	8758%
Energy consumption (MJprim)	-8.98E+08	1.52E+07	6006%
Ecoindicator99 (E,E)	-6.08E+06	5.59E+04	10980%
EPS	-4.22E+07	4.77E+05	8951%
Equal weighting	-1.84E-05	1.03E-07	17892%
Nogepa	-2.46E-06	1.06E-08	23266%
Distance-to-target	-3.63E-05	1.73E-07	21028%
Greencalc prevention costs	-2.49E+01	1.33E-01	18782%
CE prevention costs	-7.14E+00	1.37E+01	152%

Whether the lifecycle as a whole is considered or waste disposal alone, the difference in impact between recycling and landfill is very substantial. Collection and recycling of plate glass is thus highly beneficial. The greatest savings are achieved if the secondary material is used for glasswool production. These conclusions hold to a large extent for other kinds of glass, too. Packaging glass, in particular, has a fairly sizeable waste stream, a large fraction of which is collected and recycled, most of it once more as packaging glass. Although this means a considerable reduction in lifecycle environmental impact, there is no flipover to the ‘negative’ side, as in the case of recycling of plate glass to glasswool.

Waste disposal costs

Based on the current waste disposal fee of 0.50 €/m^2 we arrive at a figure of 35 €/t for the disposal costs of plate glass, giving a total figure of € 2.6 million for the waste stream as a whole.

3.9 Paper and board (separately collected)

Separately collected paper and board is waste stream #63 and comes under SP18. Packaging paper and board are part of SP14. With paper, the key question is whether recycling should be included in the waste phase or allocated to the upstream steps of the material cycle (i.e. via recycled content). Although this makes no difference to overall lifecycle impact, this is obviously not the case for the impact of the waste disposal phase alone.

As the underlying issue here is to formulate a new national waste policy, we have opted to allocate the savings accruing from recycling to the waste disposal phase (cf. Section 2.4). This means we have calculated with paper grades having a high primary fibre content (average of LWC and SC paper[21]).

The following waste disposal scenarios were assessed:

1 100% recycling (current situation).
2 100% disposal in waste incinerator.

The lifecycle scores per environmental theme are reported in Appendix B.8.

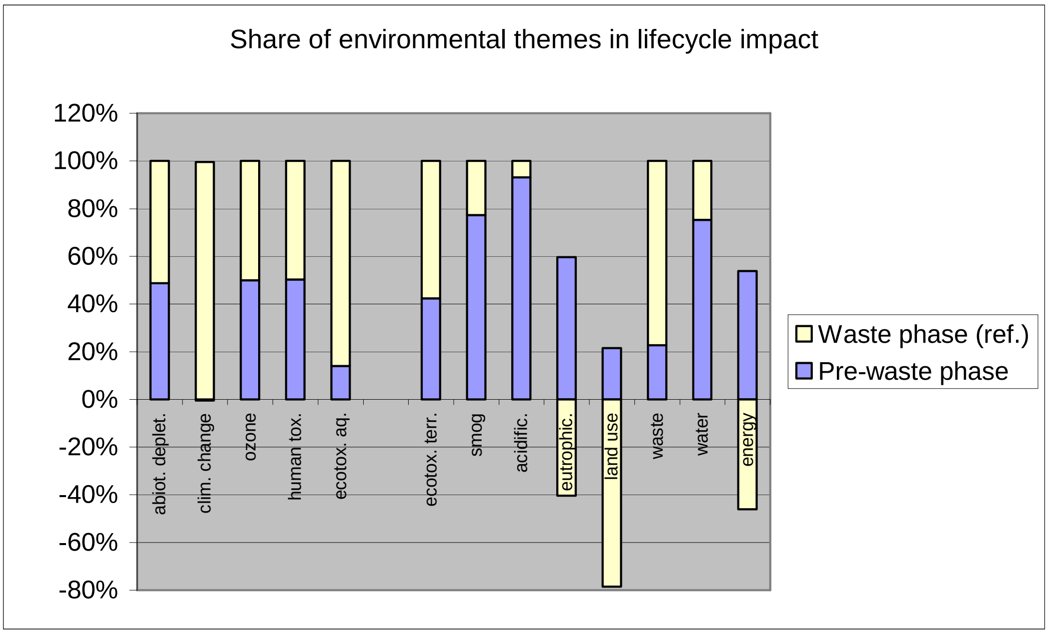
For recycling we assumed collection schemes as per Ecoinvent and avoided emissions due to substitution of sulphate pulp. The emissions associated with incinerator disposal of paper were also taken from Ecoinvent. Note that separately collected paper does not currently end up being incinerated. However, it can be queried whether separate collection and recycling in fact has any environmental benefits and, in addition, the variant with incinerator disposal was also modelled for the paper fraction of household residual waste and commercial and institutional residual waste (cf. Sections 3.21 and 3.22).

As Figure 15 shows, recycling is associated with a (substantially) greater impact on various environmental themes, with eutrophication, land use and energy consumption forming the only exceptions. On these themes recycling also scores better than incinerator disposal (cf. Appendix B.8).

---

[21] Light-weight coated (Ecoinvent: Paper, wood-containing, LWC, at regional storage) and Supercalendred (Paper, wood-containing, supercalendred (SC), at regional storage).

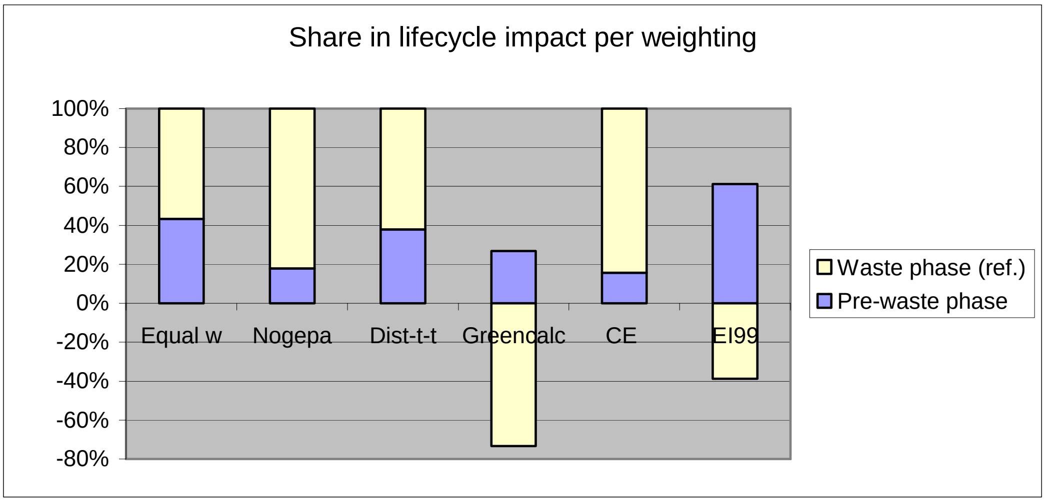
Figure 15 Contribution of pre-waste and waste phase to lifecycle impact, by environmental theme, scenario 1 (ref.)



The various weighting methods give varying pictures (Figure 16). Methods that factor in land use conclude that the current waste disposal method (i.e. recycling) leads to considerable environmental gains, while the others point to extra environmental impact in the waste disposal phase[22]. The ratio between the waste and pre-waste phase found here is due partly to our standard approach for dealing with short-cycle carbon (uptake and emissions), as set out in Section 2.4. As a 'biotic' material, paper involves removal of CO_2 from the atmosphere in the raw materials phase (forestry). This means that any CO_2 emissions due to energy consumption in the pre-waste phase are to some extent offset by this 'negative' climate impact of CO_2 removal. In the case under review, the pre-waste phase even has a net 'negative' climate impact. With incineration the carbon is released once more, while with recycling there are savings on primary resources. In the latter case there is therefore no carbon removal, in the same way that savings on primary resources in other production chains mean emissions avoidance. From a climate perspective this may make recycling unattractive. It should be noted, though, that the paper should in all cases be sourced from permanent production forests, with extraction in equilibrium with replanting.

22 Note in Figure 15 that waste disposal also brings with it major gains on the theme 'energy consumption'. This also includes use of biomass for energy generation (and as a feedstock).

Figure 16 Contribution of pre-waste and waste phase to weighted lifecycle impact, scenario 1 (ref.)



This approach leads to the waste disposal phase accounting for a greater share and the pre-waste phase for a smaller share than in the old method, where short-cycle CO_2 was ignored altogether. This makes no difference to the overall lifecyle score, though.

Finally, it should be noted that in calculating lifecycle CO_2 emissions we made no allowance for indirect emissions, in line with standard methodology. These are the emissions associated with land use (area and type) and are referred to in climate policy as LULUCF emissions[23]. Expansion of primary paper production may for example mean that wild nature, with high volumes of sequestered carbon, is converted to production forests, with far less, extending the 'system boundaries', it can also be argued that paper recycling reduces pressure on land, freeing up a greater area for bio-energy crops, implying avoided carbon emissions with this route. Although this indirect land use impact is not factored in explicitly in any of the weighting methods used, those that do include land use (Ecoindicator99 and Greencalc) are probably nearest the mark (cf. Figure 16).

23 Land use, land use change and forestry.

Final scores on tracks A1 and A2

The scores can be weighted to arrive at a single-figure final score, as described in Section 2.3. In Table 21 and Table 22 these final scores are reported for the entire waste stream, for both lifecycle impact and the impact of waste disposal alone.

Table 21 Final scores for lifecycle impact (weighted) for entire waste stream (2,461 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	6.25E+08	4.03E+08	35%
Water consumption (m^3)	2.07E+10	1.52E+10	27%
Energy consumption (MJprim)	1.06E+10	5.37E+10	80%
Ecoindicator99 (E,E)	6.81E+07	1.49E+08	54%
EPS	2.12E+09	8.70E+08	59%
Equal weighting	6.82E-04	4.80E-04	30%
Nogepa	9.54E-05	5.43E-05	43%
Distance-to-target	1.22E-03	9.11E-04	25%
Greencalc prevention costs	-2.22E+03	1.58E+03	240%
CE prevention costs	5.00E+02	2.43E+02	51%

Table 22 Final scores for waste disposal (weighted) for entire waste stream (2,461 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	4.83E+08	2.61E+08	46%
Water consumption (m^3)	5.12E+09	-4.40E+08	109%
Energy consumption (MJprim)	-6.37E+10	-2.06E+10	-209%
Ecoindicator99 (E,E)	-1.16E+08	-3.60E+07	-223%
EPS	1.03E+09	-2.23E+08	122%
Equal weighting	3.86E-04	1.84E-04	52%
Nogepa	7.83E-05	3.72E-05	53%
Distance-to-target	7.54E-04	4.50E-04	40%
Greencalc prevention costs	-3.49E+03	3.09E+02	1.231%
CE prevention costs	4.22E+02	1.65E+02	61%

As a consequence of the issues discussed above, for this waste stream the choice of weighting method is absolutely crucial for results. Table 21 and Table 22, like the figures preceding them, show that it is only with weighting methods emphasising land use (Ecoindicator and Greencalc, as mentioned earlier) that recycling scores better than incineration. Against the yardstick of energy consumption, too, recycling scores more favourably. These issues are being explored in greater depth in an ongoing project (CE, 2008a) in the context of the Dutch packaging tax (CE, 2007a).

Waste disposal costs
On average, the direct costs of waste paper collection are 42 €/t (UA, 2005). As the secondary resource also has a market value, though, the net cost will be lower. In fact, net returns (after deduction of sorting and transport costs) are likewise around 40 €/t, at a minimum, making the net costs of waste disposal zero or negative (vaop.nl).

3.10 Separately collected plastics (#65)

The waste stream 'Separately collected plastics' is part of SP19. Bulk-collected plastics come under SP3, waste packaging plastics under SP14 and process-dependent industrial plastics waste under SP2. This gives a figure of 151 kt for this waste stream.

With respect to composition, we assumed an array of common, representative plastics covered by the Ecoinvent database (including waste disposal)[24]. Based on European data and materials sourcing, we took the following breakdown: PP (20%), HDPE (18%), LDPE (44%) and PVC (18%).

The impacts of incinerator disposal of plastics were taken from Ecoinvent. For recycling, the data of Pré consultants on the energy consumption and avoided emissions associated with collection and processing (as included in Ecoinvent/Simapro) were adopted. The assumption here is that recycling (of PP, PE and/or PVC) leads to 100% substitution of the primary material concerned. This should be seen as an approximation, as plastics recycling often leads to a loss of quality.

The following waste disposal scenarios were assessed:
1 Recycling of all PE and PP, remainder incinerated.
2 Recycling of all PVC, remainder incinerated.
3 100% incineration.

At the moment a large fraction of collected plastics is recycled, most of which is probably PE and PP. There is little reliable information on PVC recycling rates. Based on European data (AJI, 2004) the fraction of PVC (mechanically) recycled seems to be around 10-15% (rough estimate). For the stream of separately collected material this percentage is probably higher. Here we consider a scenario with 100% recycling of PVC. Scenario 3 is incinerator disposal.

The lifecycle scores per environmental theme are reported in Appendix B.9.

On a number of themes, waste disposal is a major contributor to overall lifecycle impact and the differences between the scenarios are consequently considerable. Note that PVC recycling scores better on several themes than PE and PP recycling, even though PVC has only an 18% share. The relative benefits

[24] The data relate to production up to and including polymerisation, i.e. without the final step of product moulding.

of PE and PP recycling relative to incineration are less pronounced and on several themes incineration is in fact slightly preferable to recycling.

Figure 17 Contribution of pre-waste and waste phase to lifecycle impact, by environmental theme, scenario 1 (ref.)

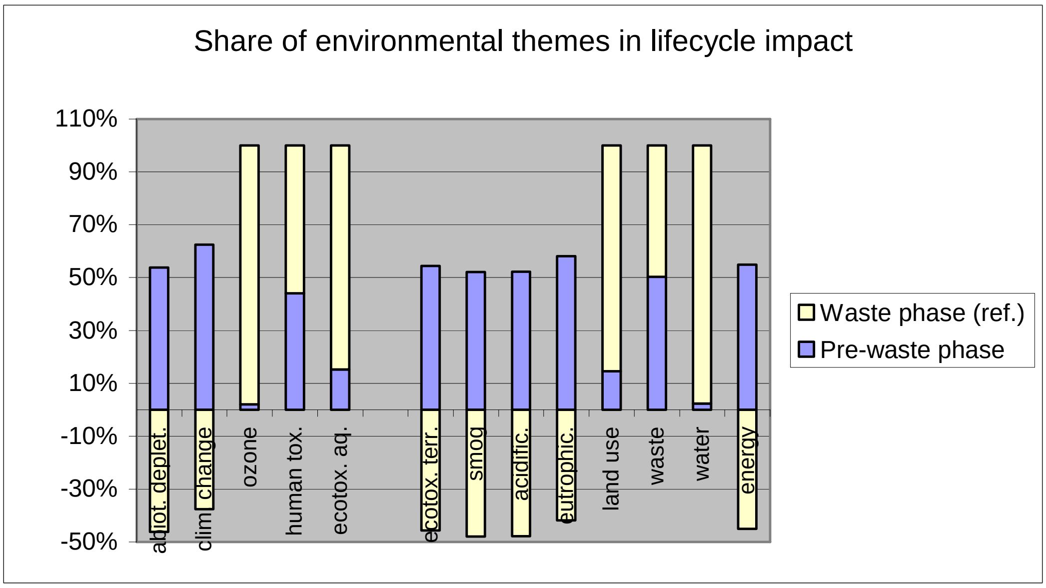
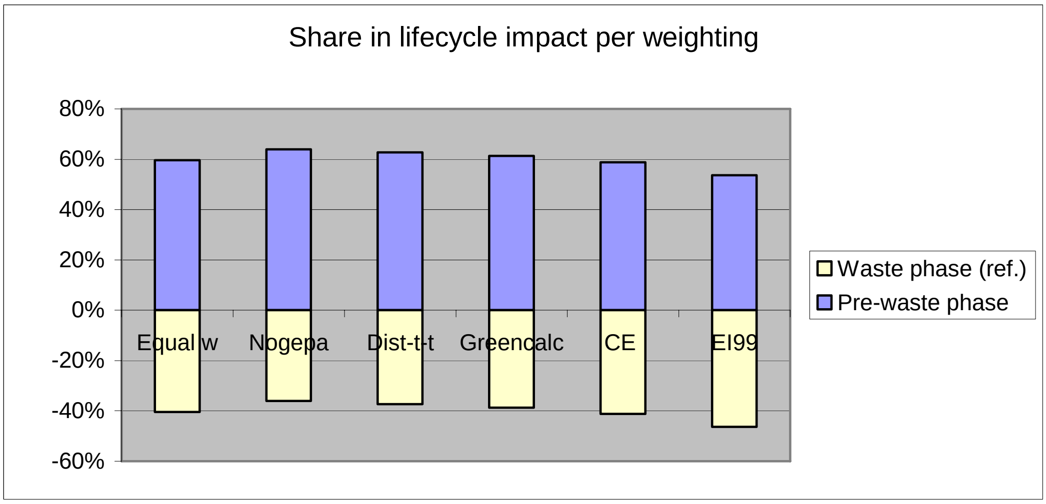


Figure 18 Contribution of pre-waste and waste phase to weighted lifecycle impact, scenario 1 (ref.)



This effect would be even more marked in the case of (co-)combustion in a power station or cement kiln (cf. CE, 2006b) and if the quality factors of the various recycling options were considered in more detail. For LDPE packaging, for example, a factor of 62% was taken (CE, 2007). In virtually all cases this relates to mechanical recycling, with second-generation applications of lower quality than those of the virgin material. This means that our analysis overestimates the environmental benefits of recycling.

Final scores on tracks A1 and A2

The scores can be weighted to arrive at a single-figure final score, as described in Section 2.3. In Table 23 and Table 24 these final scores are reported for the entire waste stream, for both lifecycle impact and the impact of waste disposal alone.

Note that scenarios 1 and 2 can best be compared with scenario 3, as the score of scenario 1 is influenced not only by PE and PP recycling but also by PVC incineration, and vice versa for scenario 2.

Table 23 Final scores for lifecycle impact (weighted) for entire waste stream (151 kt)

	Scenario 1	Scenario 2	Scenario 3	Variation
Final waste (kg)	5.45E+06	2.77E+06	9.31E+06	70%
Water consumption (m^3)	4.58E+08	-1.96E+08	3.90E+07	143%
Energy consumption (MJprim)	2.02E+09	3.79E+09	7.52E+09	73%
Ecoindicator99 (E,E)	4.92E+06	1.56E+07	2.66E+07	82%
EPS	4.68E+07	2.27E+07	1.43E+08	84%
Equal weighting	1.83E-05	1.54E-04	1.88E-04	90%
Nogepa	2.07E-06	1.27E-05	1.64E-05	87%
Distance-to-target	3.05E-05	3.03E-04	3.55E-04	91%
Greencalc prevention costs	1.77E+01	5.89E+01	9.22E+01	81%
CE prevention costs	8.54E+00	2.05E+01	3.68E+01	77%

Table 24 Final scores for waste disposal (weighted) for entire waste stream (151 kt)

	Scenario 1	Scenario 2	Scenario 3	Variation
Final waste (kg)	2.71E+06	3.51E+04	6.57E+06	99%
Water consumption (m^3)	4.48E+08	-2.06E+08	2.82E+07	146%
Energy consumption (MJprim)	-9.30E+09	-7.53E+09	-3.80E+09	-145%
Ecoindicator99 (E,E)	-3.11E+07	-2.05E+07	-9.46E+06	-229%
EPS	-1.66E+08	-1.90E+08	-6.93E+07	-174%
Equal weighting	-3.86E-05	9.73E-05	1.31E-04	129%
Nogepa	-2.69E-06	7.92E-06	1.16E-05	123%
Distance-to-target	-4.50E-05	2.27E-04	2.79E-04	116%
Greencalc prevention costs	-3.02E+01	1.11E+01	4.43E+01	168%
CE prevention costs	-1.99E+01	-7.91E+00	8.40E+00	337%

Scenario 1 clearly emerges the best, according to all five weighting methods. The difference between scenarios 1 and 3 is due entirely to the recycling of PE and PP (82% of total volume). Given the fairly minor share of PVC (18%), however, there is also a fair amount of difference between scenarios 2 and 3 and according to the EPS weighting method as well as in terms of final waste, PVC recycling even comes out best. Compared with incinerator disposal, then, recycling of both PE/PP and PVC is a good option environmentally. Energy recovery via use as a secondary fuel might also be an environmentally attractive option for PE and PP, however, certainly if recycling proves in practice to have a quality factor less than 100%. For PVC this is unlikely, because the heating value of PVC relative to the total amount of energy invested is considerably smaller than for PE/PP. This is also the reason why PVC recycling scores so well on final waste, in particular, as well as in the EPS weighting method.

Waste disposal costs

The costs of plastics collection and processing are unknown. In the case of plastics packaging (not part of this category) collection and processing costs are estimated to be € 266/t in the Belgian PMD system (Rense, 2005). For the waste stream under consideration here this is likely to be an upper bound. Including the portion disposed of in incinerators, we therefore estimate the total costs for the aggregate stream at € 36 million, as a maximum figure.

3.11 Carpeting (as part of Bulky household waste, #02)

Post-consumer carpeting waste is one component of 'Bulky household waste' (SP1). The fraction separately collected amounts to 11 kt (data: CBS, 2006). The total volume of carpeting waste - including that originating in offices and as offcuts in carpet production - is very hard to determine.

Based on data from studies on carpeting waste disposal (CE, 2003, 2008) we arrived at the following composition of this waste stream. The carpet fibre is predominantly polypropylene and nylon, with a very small share of polyester, while the backing contains a considerable amount of latex and chalk. Of the total weight, PP accounts for 35%, chalk for 37%. The impacts associated with use of these materials were taken from Ecoinvent. Energy consumption in the production phase was adopted from CE (2004) and energy consumption in the use phase (vacuuming and other kinds of cleaning) from Allwood et al. (2006).

The following waste disposal scenarios were assessed:

1 Incinerator disposal.
2 Co-combustion in a cement kiln.
3 Recycling of the polymers.

The lifecycle scores per environmental theme are reported in Appendix B.11.

For recycling we assumed complete substitution of primary materials by the polymer fraction of the carpeting waste. The energy consumed in recycling was taken from CE (2008); this is therefore mechanical recycling. Applications for this material are generally lower quality than the original application, which should be corrected for when calculating savings (cf. CE, 2008). In the present exercise, however, recycling was conceived of as an ideal process in which there is no loss of quality in the second-generation application. The data reported in Appendix B.11 show that a substantial reduction in lifecycle environmental impact might be achieved with this kind of optimum recycling, although on certain environmental themes option 3 scores much the same as option 2, or slightly worse. In the weighted scores, it is only Ecoindicator that gives a worse score for option 3 (Table 26).

In the incinerator disposal scenario it is the pre-waste phase that predominates, except in the case of toxicity impacts (Figure 19).

Figure 19 Contribution of production phase, use phase and waste phase to lifecycle impact, by environmental theme, scenario 1 (ref.)

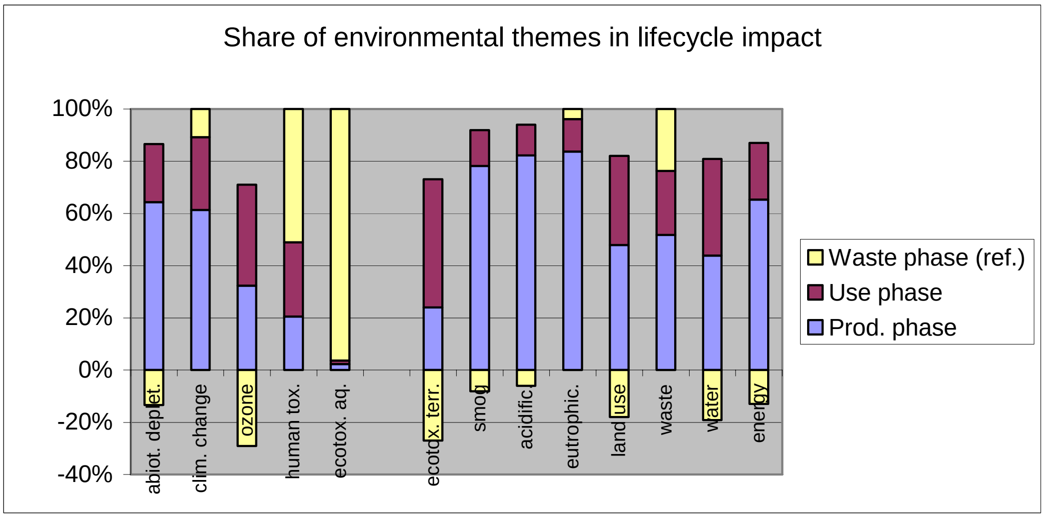
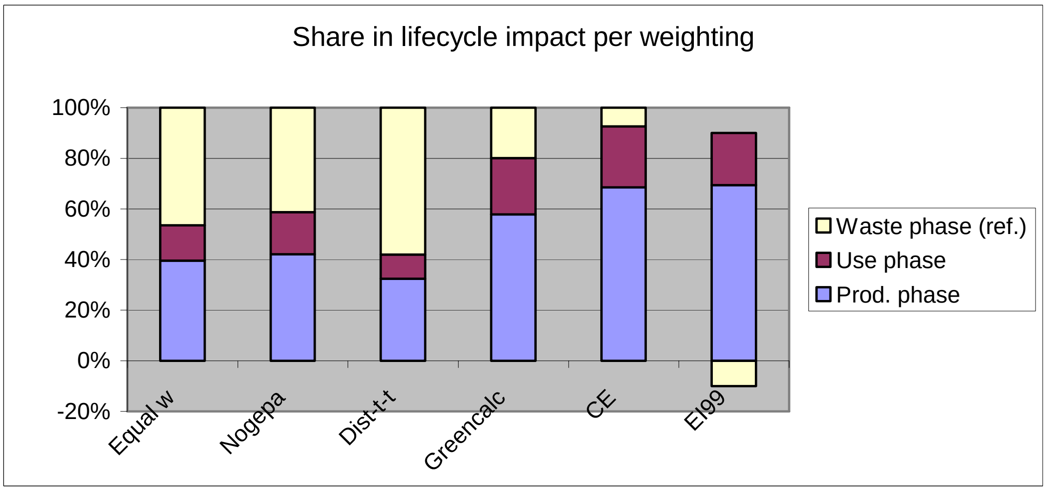


Figure 20 Contribution of production phase, use phase and waste phase to weighted lifecycle impact, scenario 1 (ref.)



Final scores on tracks A1 and A2

The scores can be weighted to arrive at a single-figure final score, as described in Section 2.3. In Table 25 and Table 26 these final scores are reported for the entire waste stream, for both lifecycle impact and the impact of waste disposal alone.

Table 25 Final scores for lifecycle impact (weighted) for entire waste stream (11 kt)

	Scenario 1	Scenario 2	Scenario 3	Variation
Final waste (kg)	5.88E+05	4.75E+05	3.81E+05	35%
Water consumption (m^3)	2.09E+07	2.37E+07	3.08E+07	32%
Energy consumption (MJprim)	9.27E+08	8.68E+08	6.91E+08	25%
Ecoindicator99 (E,E)	3.05E+06	2.83E+06	2.00E+06	34%
EPS	2.29E+07	2.50E+07	1.82E+07	27%
Equal weighting	1.22E-05	5.44E-06	4.03E-06	67%
Nogepa	1.20E-06	6.70E-07	4.61E-07	62%
Distance-to-target	2.08E-05	7.94E-06	4.59E-06	78%
Greencalc prevention costs	9.11E+00	6.85E+00	4.80E+00	47%
CE prevention costs	4.12E+00	3.64E+00	2.40E+00	42%

Table 26 Final scores for waste disposal (weighted) for entire waste stream (11 kt)

	Scenario 1	Scenario 2	Scenario 3	Variation
Final waste (kg)	1.40E+05	2.62E+04	-6.81E+04	149%
Water consumption (m^3)	-6.47E+06	-3.76E+06	3.43E+06	289%
Energy consumption (MJprim)	-1.63E+08	-2.22E+08	-3.99E+08	-145%
Ecoindicator99 (E,E)	-3.81E+05	-6.01E+05	-1.43E+06	-275%
EPS	-3.45E+06	-1.33E+06	-8.14E+06	-511%
Equal weighting	5.68E-06	-1.12E-06	-2.53E-06	145%
Nogepa	4.96E-07	-3.56E-08	-2.45E-07	149%
Distance-to-target	1.21E-05	-7.92E-07	-4.15E-06	134%
Greencalc prevention costs	1.81E+00	-4.48E-01	-2.50E+00	238%
CE prevention costs	3.02E-01	-1.80E-01	-1.41E+00	568%

Useful application of carpeting waste, whether as a secondary fuel (2) or via materials recycling (3), leads to a major reduction in lifecycle environmental impact. In scenario 3, however, no allowance was made for the fact that secondary materials will probably be used in fairly low-grade applications, so that a quality factor below 100% should really be used. Even with a fairly low quality factor, though, with most weighting methods recycling would show environmental benefits over use as a secondary fuel.

Waste disposal costs
With an incinerator fee of € 119/t, the aggregate costs for this waste stream come to € 1.3 million. Note that the cost ranking (track A3; cf. Section 4.5) for the total waste stream also includes bulky household waste. The carpeting waste itself does not feature there, but would score about as low as the category 'Separately collected textiles' (cf. Appendix C4).

3.12 Textiles (#67)

Separately collected textiles come under SP20. The volume of this stream is around 71 kt. In terms of constituent materials it comprises roughly 50% synthetic and 50% natural fibres (estimate based on Allwood et al., 2006). The following figures were taken:
- Polyester 40%.
- Nylon 10%.
- Cotton 50%.

In practice, wool also features prominently in the natural fibres fraction; the associated impacts are likely to be far lower than those of cotton, because cotton cultivation is environmentally very intensive. The impacts of the pre-waste phase are therefore probably on the high side, all the more so because in this study the impacts of cotton were taken from Idemat (2001), a somewhat outdated source. The energy consumption involved in textile production and maintenance/cleaning (use phase) were taken from Allwood et al. (2006). In the case of cotton clothing, the energy expended on cleaning is extremely high. Assumptions on number of washes per 'product lifetime' and washing temperature are obviously of major influence here, but we worked on the assumption these parameters have been realistically estimated by Allwood et al. (2006).

Today, separately collected textile waste is disposed of via three routes: reuse (as second-hand clothing), use as cleaning rags and recycling of fibres, and incinerator disposal of the unusable remainder (UA, 2006). In the case of use as cleaning rags or other forms of materials recycling (other than reuse) a quality factor of 56% was taken[25].

The following waste disposal scenarios were thus assessed:
1 Reuse 23%, recycling/cleaning rags 61%, incineration 16%.
2 Reuse 100%.
3 Recycling/cleaning rags 100%.

The lifecycle scores per environmental theme are reported in Appendix B.10.

Useful application of the waste offsets a reasonable fraction of the impacts associated with the pre-waste phase, excluding use, but compared with the production plus use phase, there is only around 20% compensation.

[25] Derived from VT calculation example 3 for industrial wet-scrubbing in the MJA2 context (SenterNovem, http://www.senternovem.nl/mja/verbredingsthemes/Rekenvoorbeelden/natwasserijen/voorbeeld_3.asp).

Figure 21 Contribution of production phase, use phase and waste phase to lifecycle impact, by environmental theme, scenario 1 (ref.)

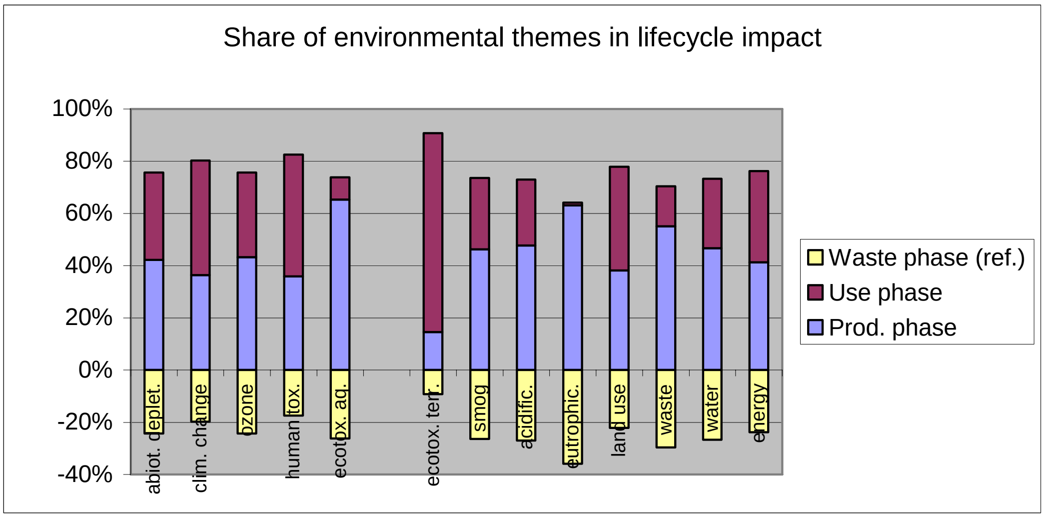
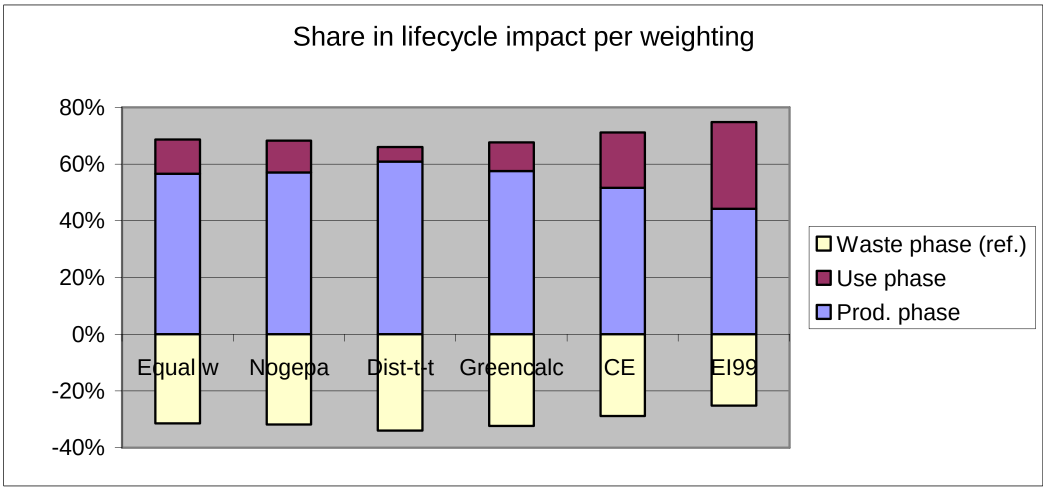


Figure 22 Contribution of production phase, use phase and waste phase to weighted lifecycle impact, scenario 1 (ref.)



Final scores on tracks A1 and A2

The scores can be weighted to arrive at a single-figure final score, as described in Section 2.3. In Table 27 and Table 28 these final scores are reported for the entire waste stream, for both lifecycle impact and the impact of waste disposal alone.

Table 27 Final scores for lifecycle impact (weighted) for entire waste stream (71 kt)

	Scenario 1	Scenario 2	Scenario 3	Variation
Final waste (kg)	1.45E+07	5.69E+06	1.44E+07	61%
Water consumption (m^3)	8.28E+08	4.78E+08	8.47E+08	43%
Energy consumption (MJprim)	1.54E+10	1.04E+10	1.57E+10	34%
Ecoindicator99 (E,E)	4.77E+07	2.99E+07	4.88E+07	39%
EPS	4.98E+08	3.38E+08	5.08E+08	33%
Equal weighting	2.00E-04	6.55E-05	2.01E-04	67%
Nogepa	2.46E-05	7.63E-06	2.47E-05	69%
Distance-to-target	4.71E-04	7.59E-05	4.74E-04	84%
Greencalc prevention costs	2.67E+02	7.73E+01	2.71E+02	71%
CE prevention costs	8.08E+01	3.79E+01	8.17E+01	54%

Table 28 Final scores for waste disposal (weighted) for entire waste stream (71 kt)

	Scenario 1	Scenario 2	Scenario 3	Variation
Final waste (kg)	-1.05E+07	-1.93E+07	-1.06E+07	-84%
Water consumption (m^3)	-4.74E+08	-8.23E+08	-4.55E+08	-81%
Energy consumption (MJprim)	-6.96E+09	-1.20E+10	-6.59E+09	-81%
Ecoindicator99 (E,E)	-2.43E+07	-4.21E+07	-2.32E+07	-81%
EPS	-2.18E+08	-3.78E+08	-2.08E+08	-82%
Equal weighting	-1.69E-04	-3.04E-04	-1.69E-04	-80%
Nogepa	-2.14E-05	-3.84E-05	-2.13E-05	-80%
Distance-to-target	-5.01E-04	-8.95E-04	-4.97E-04	-80%
Greencalc prevention costs	-2.45E+02	-4.35E+02	-2.41E+02	-80%
CE prevention costs	-5.52E+01	-9.81E+01	-5.43E+01	-81%

There is little difference in the scores for scenarios 1 and 3. In environmental terms, materials recycling lies somewhere between incinerator disposal and clothing reuse. To improve the environmental performance relative to the current mix of disposal routes (scenario 1), clothing reuse is thus the only option, or otherwise some form of high-value recycling whereby there are real savings on the use of primary fibre in new clothing.

Waste disposal costs

Disposal of separately collected textiles waste costs € 18/t (SenterNovem, 2004). For this waste stream as a whole, then, total disposal costs are € 1.3 million.

3.13 Metal waste, general (#68)

The category 'Metal waste, general' (part of SP21) comprises three more or less equal fractions: waste from metal working and surface treatment, metals contained in CDW and metals in municipal waste (including bulk-collected and packaging). The total volume is 1.98 kt. Of this, about 87% is ferro-metals and 13% non-ferro, with the latter consisting mainly of aluminium (8%) and copper (3%)[26].

[26] Shares estimated on the basis of European data and Euralcode notifications.

Impact data were taken from Ecoinvent. For steel and aluminium this means an 'average' mix containing 45% and 32% secondary material, respectively. The other metals are 100% primary material (cf. Section 2.4).

At the moment metals are characterised by a high recycling rate. Even the fraction ending up in municipal incinerators is partly recovered during slag reprocessing, using magnets and eddy-current separation. In the reference scenario we therefore assumed a 95% recycling rate for all metals except aluminium, for which a lower rate was taken: 72% (ECN, 2006). This recycling requires energy inputs (collection, sorting, processing) and these were included for aluminium and steel; for the other metals, general data are lacking. In calculating the savings on virgin materials, due allowance was made for the fact that part of the input already consists of secondary materials. For lack of data, waste disposal of the non-ferro metals other than aluminium was only approximately modelled; however, this represents only 5% of the total stream.

The following waste disposal scenarios were assessed:

1 72% recycling of aluminium, 95% recycling of other metals, rest to landfill.
2 80% recycling of aluminium, 100% recycling of other metals, rest to landfill.

The lifecycle scores per environmental theme are reported in Appendix B.12.

In the waste disposal phase around 20-30% of the impacts of the pre-waste phase are compensated (Figure 23 and Figure 24). The various weighting methods all give a similar picture.

Figure 23 Contribution of pre-waste and waste phase to lifecycle impact, by environmental theme, scenario 1 (ref.)

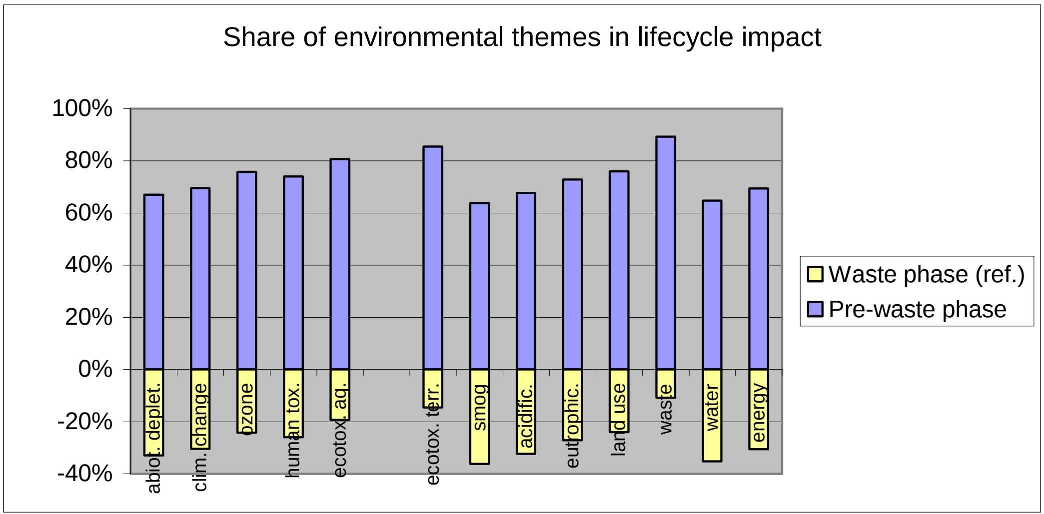
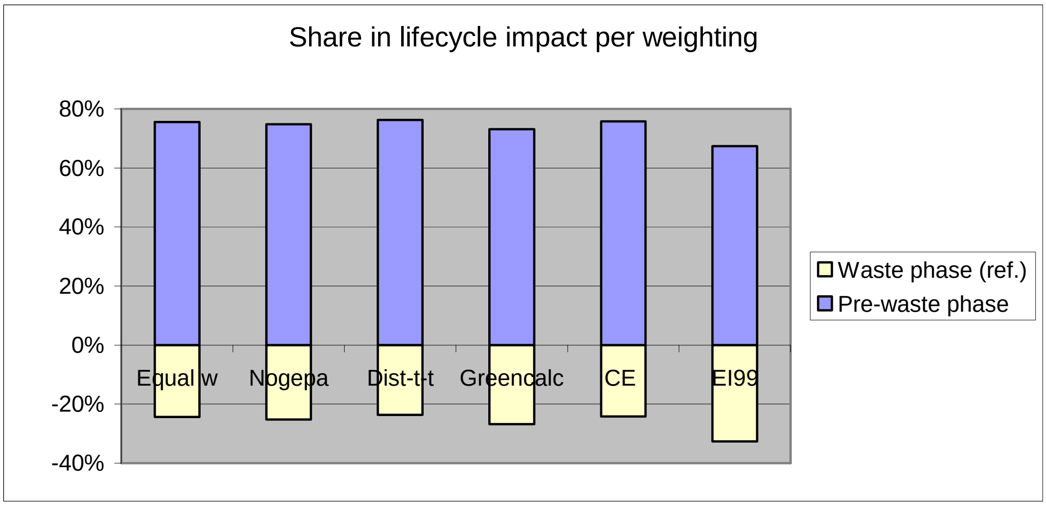


Figure 24 Contribution of pre-waste and waste phase to weighted lifecycle impact, scenario 1 (ref.)



Final scores on tracks A1 and A2

The scores can be weighted to arrive at a single-figure final score, as described in Section 2.3. In Table 29 and Table 30 these final scores are reported for the entire waste stream, for both lifecycle impact and the impact of waste disposal alone.

Table 29 Final scores for lifecycle impact (weighted) for entire waste stream (1,098 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	7.67E+08	6.97E+08	9%
Water consumption (m^3)	1.90E+10	1.66E+10	12%
Energy consumption (MJprim)	3.04E+10	2.80E+10	8%
Ecoindicator99 (E,E)	2.45E+08	2.28E+08	7%
EPS	3.52E+10	3.42E+10	3%
Equal weighting	1.08E-03	1.03E-03	5%
Nogepa	1.13E-04	1.07E-04	5%
Distance-to-target	2.11E-03	2.02E-03	4%
Greencalc prevention costs	8.12E+02	7.67E+02	6%
CE prevention costs	2.82E+02	2.58E+02	8%

Table 30 Final scores for waste disposal (weighted) for entire waste stream (1,098 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	-1.05E+08	-1.76E+08	-67%
Water consumption (m^3)	-2.27E+10	-2.50E+10	-10%
Energy consumption (MJprim)	-2.38E+10	-2.63E+10	-10%
Ecoindicator99 (E,E)	-2.31E+08	-2.48E+08	-8%
EPS	-1.83E+10	-1.93E+10	-6%
Equal weighting	-5.14E-04	-5.63E-04	-10%
Nogepa	-5.74E-05	-6.30E-05	-10%
Distance-to-target	-9.53E-04	-1.04E-03	-9%
Greencalc prevention costs	-4.70E+02	-5.15E+02	-10%
CE prevention costs	-1.32E+02	-1.56E+02	-18%

Increasing the recycling rates of the various metals leads to a 5-10% reduction in lifecycle impact. In terms of overall environmental benefits this is probably substantial compared with improvements in other streams, but it will not reduce the lifecycle impacts of this waste category to the extent that it no longer features on the track A1 ranking (cf. Chapter 4).

Waste disposal costs

For all the metals considered, the price paid for scrap is such as to more than offset the costs of collection and processing. Although there are probably net profits, however, in this study waste disposal costs were taken to be zero. For priority setting (track A3; cf. Section 4.5) and identification of the most expensive streams this makes no difference; in this context metal waste will not emerge as a priority item.

3.14 Spent oil, Category III (#75)

This stream comes under SP23. Category III oil is also referred to as 'halogenated oil'. In line with LAP-EIA (A03) we here assumed 1% water content and 0.5% chlorine content. The oil itself (98.5%) was modelled as heavy fuel oil. The water content was not included as a 'material chain' with environmental impacts. The volume of this stream is hard to determine; here we took a figure of 28 kt, half the aggregate volume of spent oil, categories I, II and III (56 kt) (UA, 2006).

The minimum standard for this stream is useful application, with fuel as the main use. The following waste disposal scenarios were therefore assessed:

1 Combustion in a cement kiln.
2 Combustion in a rotary furnace.

The lifecycle scores per environmental theme are reported in Appendix B.13.

Waste disposal has a major influence on the lifecycle score. Incineration in a cement kiln scores best on virtually every count. The pre-waste phase also makes a sizeable contribution to most environmental themes, however.

Figure 25 Contribution of pre-waste and waste phase to lifecycle impact, by environmental theme, scenario 1 (ref.)

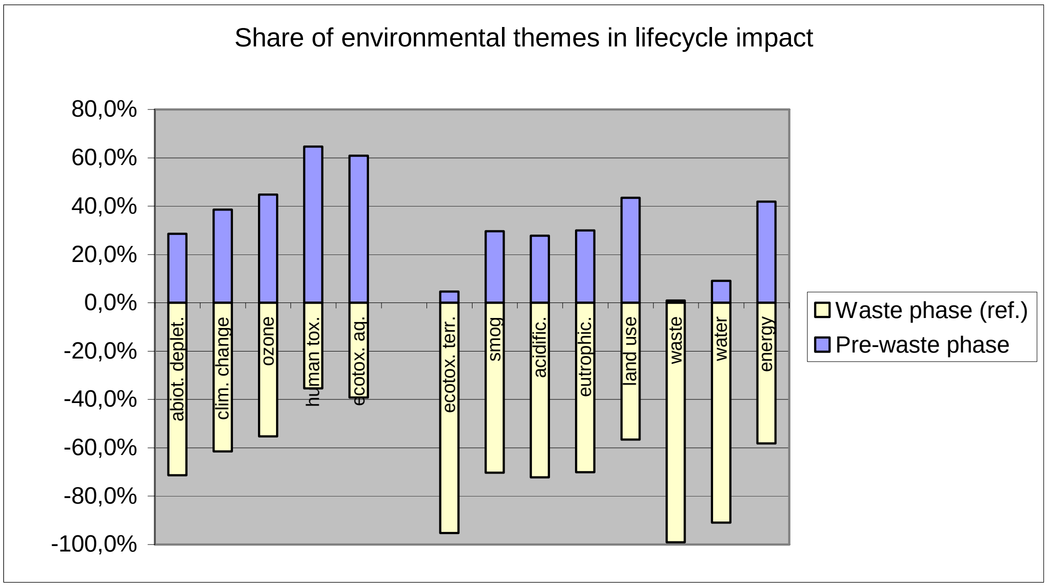
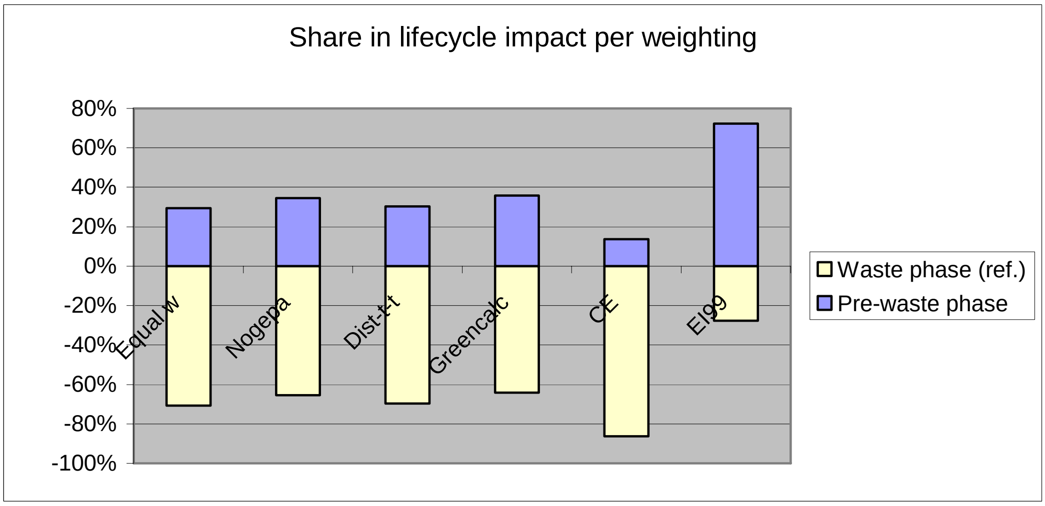


Figure 26 Contribution of pre-waste and waste phase to weighted lifecycle impact, scenario 1 (ref.)



Final scores on tracks A1 and A2

The scores can be weighted to arrive at a single-figure final score, as described in Section 2.3. In Table 31 and Table 32 these final scores are reported for the entire waste stream, for both lifecycle impact and the impact of waste disposal alone.

Table 31 Final scores for lifecycle impact (weighted) for entire waste stream (28 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	-3.3E+07	-7.0E+05	-4.592%
Water consumption (m^3)	-2.2E+08	-9.0E+08	-311%
Energy consumption (MJprim)	-5.8E+08	1.2E+09	148%
Ecoindicator99 (E,E)	2.7E+06	3.5E+06	23%
EPS (pre-waste phase only)	2.2E+07	2.2E+07	0%
Equal weighting	-8.32E-06	8.02E-06	204%
Nogepa	-2.85E-07	1.12E-06	125%
Distance-to-target	-8.09E-06	1.23E-05	166%
Greencalc prevention costs	-2.44E+00	1.12E+01	122%
CE prevention costs	-7.70E+00	5.55E+00	239%

Table 32 Final scores for waste disposal (weighted) for entire waste stream (28 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	-3.3E+07	-1.0E+06	-3.215%
Water consumption (m^3)	-2.4E+08	-9.3E+08	-280%
Energy consumption (MJprim)	-2.1E+09	-2.6E+08	-693%
Ecoindicator99 (E,E)	-1.7E+06	-8.4E+05	-96%
EPS			
Equal weighting	-1.42E-05	2.11E-06	775%
Nogepa	-6.03E-07	8.05E-07	175%
Distance-to-target	-1.43E-05	6.06E-06	336%
Greencalc prevention costs	-5.52E+00	8.14E+00	168%
CE prevention costs	-9.16E+00	4.09E+00	324%

Combustion in a rotary furnace scores considerably worse than combustion in a cement kiln, as also emerged in LAP-EIA. As combustion in a rotary furnace is probably more expensive, certainly now the Netherlands no longer has any such furnaces operating, it seems reasonable to assume that combustion in a cement kiln will now be the principal route.

Waste disposal costs

The cost of cement kiln combustion is 120 €/t (LAP-EIA A03), giving a total figure of € 3.4 million for the aggregate waste stream.

3.15 Oil/water/sludge mixtures (#76)

This stream is part of SP23. For disposing of oil/water/sludge mixtures the oil and sludge fractions are first separated and then processed separately. Water accounts for 67% of the overall stream, oil for 11% and sand (i.e. the solid sludge fraction) for 22% (LAP-EIA A19). During separation, however, only 2% of the oil is removed as such, with 8% remaining in the sand/sludge fraction (which thus makes up 30% of the stream) and 1% in the water fraction.

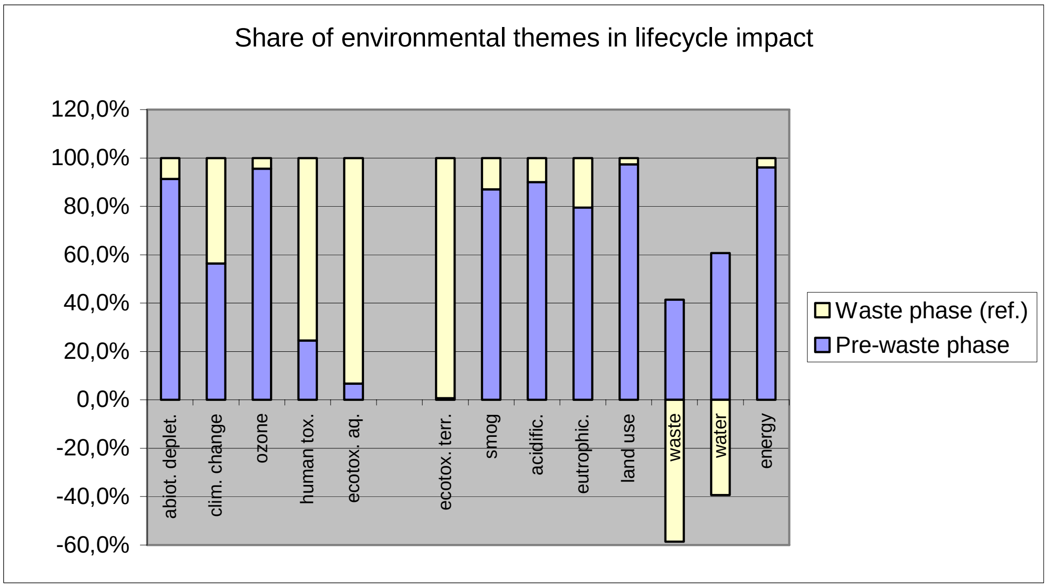
The minimum standard for this stream is useful application, with fuel constituting the main use. The following waste disposal scenarios were therefore assessed:

1 Minimum standard: sludge to TGI[27], oil fraction to cement kiln.
2 Sludge to cement kiln, oil fraction to power station.

The environmental impacts of these routes were taken from LAP-EIA (A19). The lifecycle scores per environmental theme are reported in Appendix B.14.

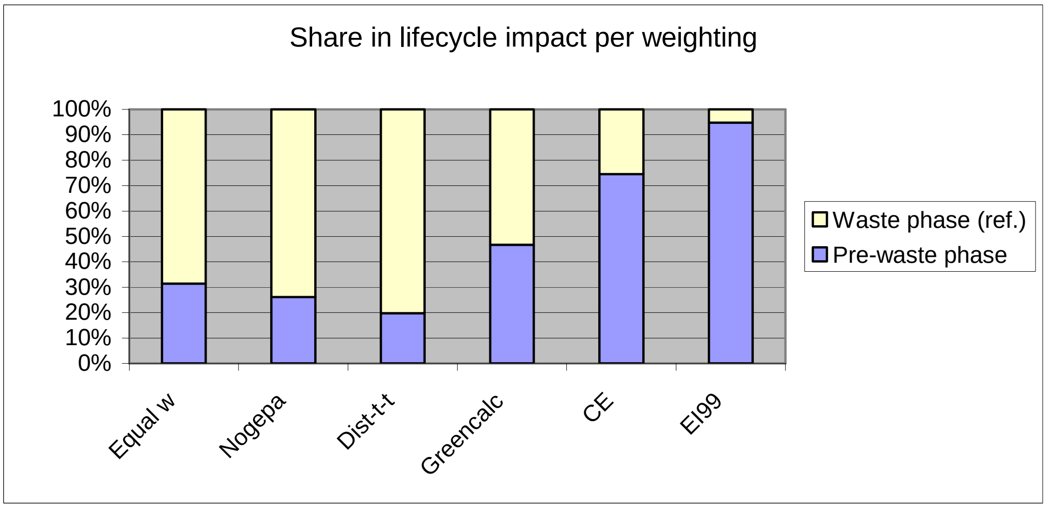
Waste disposal is of major influence on the score for lifecycle environmental impacts. The various weighting methods yield different pictures. In the Ecoindicator method the share of the waste disposal phase is fairly small.

Figure 27 Contribution of pre-waste and waste phase to lifecycle impact, by environmental theme, scenario 1 (ref.)



27 Tail gas incinerator.

Figure 28 Contribution of pre-waste and waste phase to weighted lifecycle impact, scenario 1 (ref.)



Final scores on tracks A1 and A2

The scores can be weighted to arrive at a single-figure final score, as described in Section 2.3. In Table 33 and Table 34 these final scores are reported for the entire waste stream, for both lifecycle impact and the impact of waste disposal alone.

Table 33 Final scores for lifecycle impact (weighted) for entire waste stream (180 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	-9.8E+04	-4.7E+06	-4.661%
Water consumption (m^3)	6.3E+06	-3.7E+07	685%
Energy consumption (MJprim)	1.1E+09	7.6E+08	31%
Ecoindicator99 (E,E)	3.3E+06	1.9E+06	41%
EPS (pre-waste phase only)	1.6E+07	1.6E+07	0%
Equal weighting	1.35E-05	2.65E-06	80%
Nogepa	8.77E-07	1.84E-07	79%
Distance-to-target	2.26E-05	3.64E-06	84%
Greencalc prevention costs	4.80E+00	1.80E+00	62%
CE prevention costs	1.41E+00	-1.22E-01	109%

Table 34 Final scores for waste disposal (weighted) for entire waste stream (180 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	-3.3E+05	-4.9E+06	-1.371%
Water consumption (m^3)	-1.2E+07	-5.4E+07	-370%
Energy consumption (MJprim)	4.3E+07	-3.0E+08	799%
Ecoindicator99 (E,E)	1.7E+05	-1.2E+06	788%
EPS			
Equal weighting	9.26E-06	-1.59E-06	117%
Nogepa	6.48E-07	-4.53E-08	107%
Distance-to-target	1.81E-05	-8.31E-07	105%
Greencalc prevention costs	2.56E+00	-4.41E-01	117%
CE prevention costs	3.59E-01	-1.18E+00	427%

In the case of the minimum standard, scenario 1, waste disposal makes a fairly solid contribution to lifecycle impact. The alternative scenario, 2, has considerably less overall impact, with all weighting methods even giving a 'negative' score when it comes to waste disposal. This disposal route is thus of major influence on the lifecycle impact score.

Waste disposal costs

The costs of TGI and power station combustion are 140 €/t, those for cement kiln combustion 120 €/t (LAP-EIA A19). Per tonne of waste, 20 kg oil fraction and 300 kg sludge fraction need to be processed. This increases the effective costs to around 44 €/t, or € 8 million for the aggregate waste stream. The costs associated with scenario 2 are slightly lower, with a better environmental score.

3.16 Metal-working oils (#80)

This stream is part of SP23. Water makes up 94% of the total stream, oil the remaining 6% (LAP-EIA A06). The pre-waste phase of water has been ignored, with that of the oil being modelled as heavy fuel oil.

After the oil and water have been separated by ultrafiltration, the oil fraction is sent for further disposal. The following scenarios were considered:
1 Minimum standard: use as a reducing agent.
2 Co-combustion in a cement kiln.

Environmental impacts were taken from LAP-EIA A06. The lifecycle scores per environmental theme are reported in Appendix B.15.

Waste disposal has a fairly substantial influence on the lifecycle score. The second option scores best on virtually every aspect. However, the minimum standard also leads to 'negative' impacts for the waste disposal phase on almost every theme (Figure 29).

Figure 29 Contribution of pre-waste and waste phase to lifecycle impact, by environmental theme, scenario 1 (ref.)

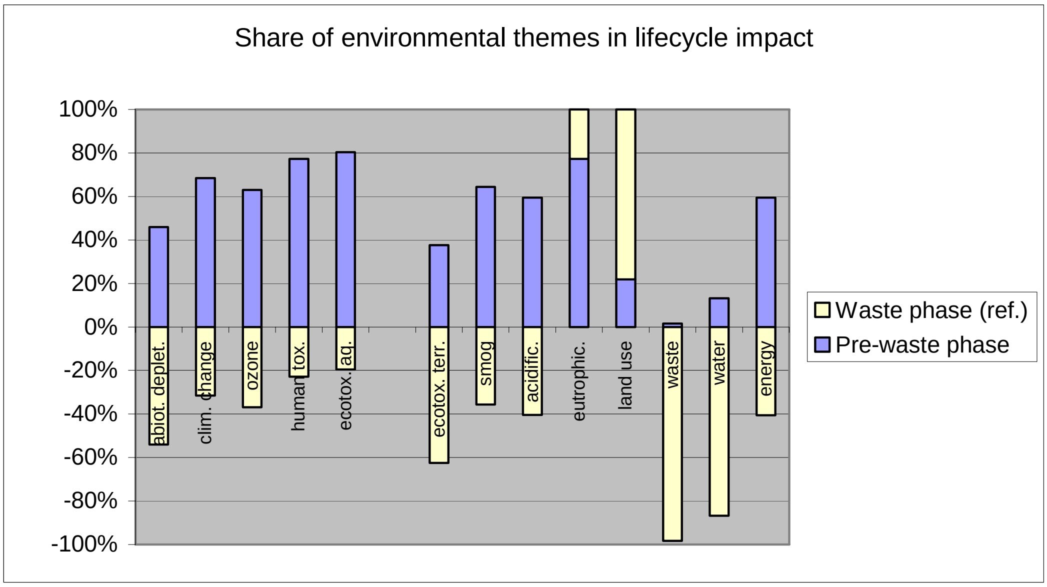
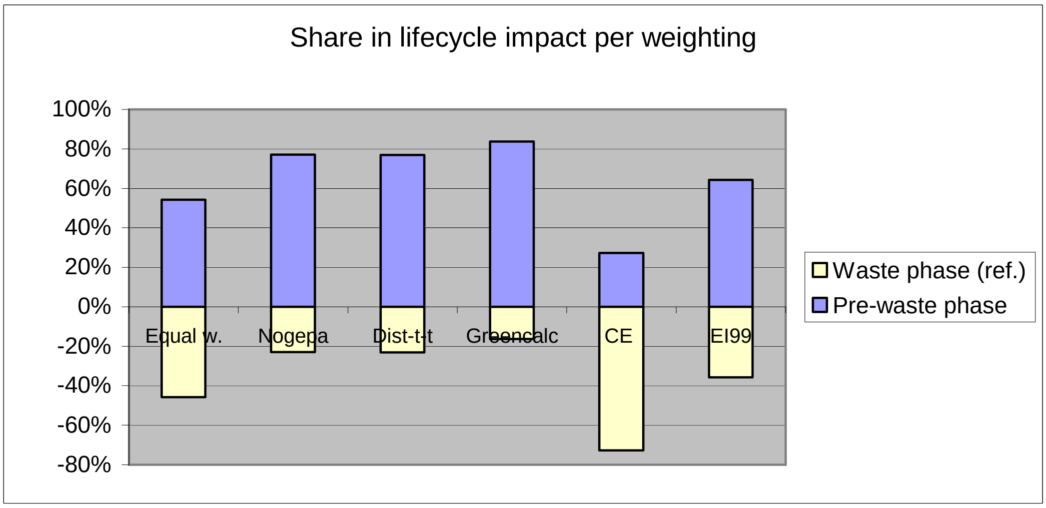


Figure 30 Contribution of pre-waste and waste phase to weighted lifecycle impact, scenario 1 (ref.)



Final scores on tracks A1 and A2

The scores can be weighted to arrive at a single-figure final score, as described in Section 2.3. In Table 35 and Table 36 these final scores are reported for the entire waste stream, for both lifecycle impact and the impact of waste disposal alone.

Table 35 Final scores for lifecycle impact (weighted) for entire waste stream (30 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	-1.1E+06	-2.2E+06	-101%
Water consumption (m^3)	-8.5E+06	-1.5E+07	-77%
Energy consumption (MJprim)	3.1E+07	-4.2E+07	238%
Ecoindicator99 (E,E)	1.3E+05	1.7E+05	25%
EPS (pre-waste phase only)	1.4E+06	1.4E+06	0%
Equal weighting	6.03E-08	-5.19E-07	962%
Nogepa	1.45E-08	-1.74E-08	220%
Distance-to-target	2.82E-07	-4.55E-07	261%
Greencalc prevention costs	1.60E-01	-1.70E-01	206%
CE prevention costs	-1.58E-01	-5.22E-01	-231%

Table 36 Final scores for waste disposal (weighted) for entire waste stream (30 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	-1.1E+06	-2.2E+06	-99%
Water consumption (m^3)	-1.0E+07	-1.6E+07	-65%
Energy consumption (MJprim)	-6.6E+07	-1.4E+08	-111%
Ecoindicator99 (E,E)	-1.6E+05	-1.1E+05	-36%
EPS			
Equal weighting	-3.24E-07	-9.04E-07	-179%
Nogepa	-6.12E-09	-3.80E-08	-521%
Distance-to-target	-1.21E-07	-8.58E-07	-611%
Greencalc prevention costs	-3.86E-02	-3.69E-01	-856%
CE prevention costs	-2.52E-01	-6.16E-01	-144%

There is a considerable difference between the two options, whichever weighting method is applied. Co-combustion in a cement kiln scores far better than the minimum standard. An option involving materials reuse (scenario 1) does not necessarily score better than an energy application.

Waste disposal costs

With the costs of use as a reducing agent taken as 70 €/t (LAP-EIA A06) and a 6% oil fraction per tonne of waste, the effective costs come to 4 €/t, or € 126,000 for the stream as a whole. Combustion in a cement kiln is twice as expensive.

3.17 Animal waste (#88)

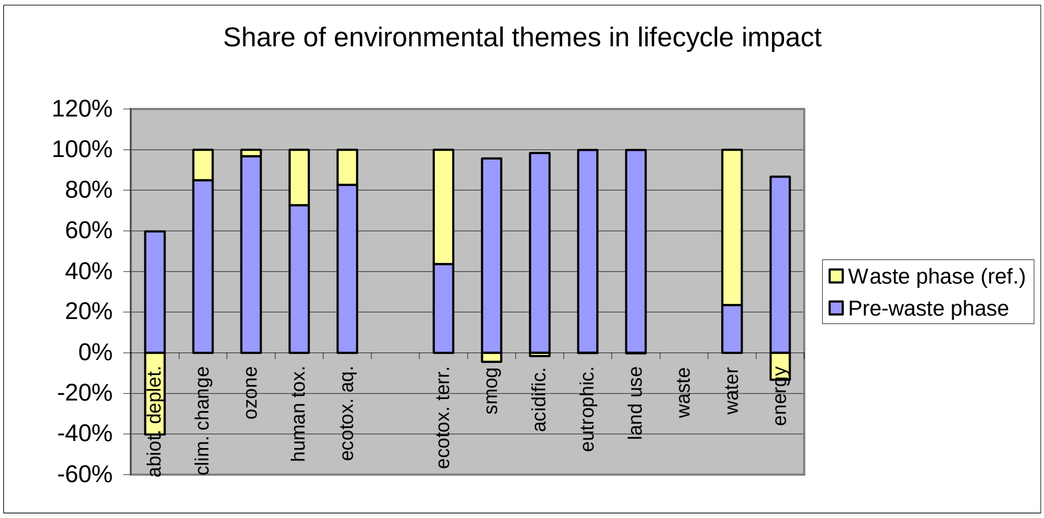
With 'Animal waste' (SP28) a distinction was traditionally made between 'specific-risk' and 'high-risk' material (SRM/HRM) and 'low-risk' material (LRM). Today, Category 1, 2 and 3 materials are distinguished, which run largely parallel. In the Netherlands Category 1 and 2 materials are processed by a single company, Rendac, and the annual volume is 138 kt (Rendac, 2007). This was the figure we took for waste stream #88. These materials may not be used as animal feed, but are usefully applied in the form of co-combustion in a cement kiln.

Impact data on the pre-waste phase were adopted from the Danish LCAFOOD database. Because this category of waste consists mainly of animal carcasses[28], lifecycle assessment covered 'cradle to farm'. The assumed mix is 40% cattle, 15% chicken and 45% pig (Rendac, 2007). Use of the Danish database means that for these production chains the impacts associated with final waste are unknown and that the impact data on other themes are probably incomplete (cf. Figure 31).

Data on energy consumption for the production of bone meal and animal fat, transportation and the energy 'savings' resulting from useful application of the material were taken from Rendac (2007). Process emissions were not included, but are probably modest. The eutrophying impact of wastewater discharge, for example, is only a few percent of the (absolute) eutrophying impact of waste disposal, including savings on fossil energy. As there is currently only one waste disposal option and possibilities are limited, for hygienic reasons (food chain), only the Rendac processing route was assessed.

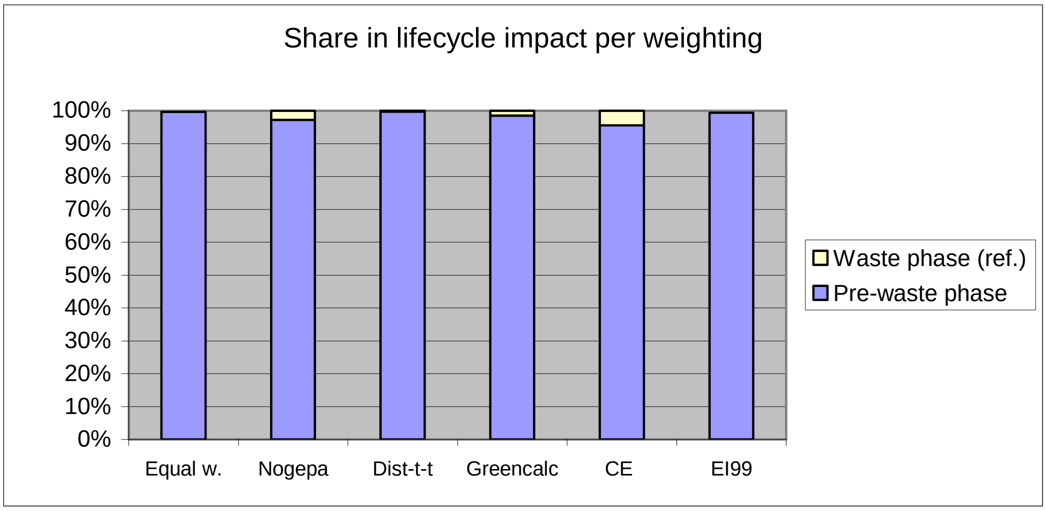
The lifecycle scores per environmental theme are reported in Appendix B.16.

Figure 31 Contribution of pre-waste and waste phase to lifecycle impact, by environmental theme, scenario 1 (ref.)



[28] Organs with a specific risk also come under this category, but here too there is little further processing beyond slaughter.

Figure 32 Contribution of pre-waste and waste phase to weighted lifecycle impact, scenario 1 (ref.)



With this category the pre-waste phase is clearly very predominant. It is only on the themes of water consumption and ecotoxicity (terrestrial) that the waste disposal phase appears to have any major impact. However, this is probably due to incompleteness of the Danish data set, which does not (fully) include the water consumption and pesticide use associated with production of animal feed.

On the theme of abiotic depletion and, to a lesser degree, primary energy consumption, waste disposal has a negative impact, as was to be expected.

Final scores on tracks A1 and A2

The scores can be weighted to arrive at a single-figure final score, as described in Section 2.3. In Table 37 and Table 38 these final scores are reported for the entire waste stream, for both lifecycle impact and the impact of waste disposal alone.

Table 37 Final scores for lifecycle impact (weighted) for entire waste stream (138 kt)

	Scenario 1	Remarks
Final waste (kg)		Unknown
Water consumption (m^3)	6.98E+07	Incomplete
Energy consumption (MJprim)	1.81E+09	Without biofeedstocks
Ecoindicator99 (E,E)	1.54E+08	
EPS	1.96E+08	
Equal weighting	2.79E-04	
Nogepa	3.90E-05	
Distance-to-target	8.75E-04	
Greencalc prevention costs	7.47E+02	
CE prevention costs	1.32E+02	

Table 38 Final scores for waste disposal (weighted) for entire waste stream (138 kt) (see remarks, Table 37)

	Scenario 1
Final waste (kg)	4.94E+05
Water consumption (m^3)	5.34E+07
Energy consumption (MJprim)	-3.27E+08
Ecoindicator99 (E,E)	-1.02E+06
EPS	3.41E+07
Equal weighting	-8.61E-07
Nogepa	1.10E-06
Distance-to-target	2.56E-06
Greencalc prevention costs	1.08E+01
CE prevention costs	5.90E+00

Little can be said about possible alternative disposal methods, because at the moment other applications of this waste are ruled out. Category 3 materials[29] may be used as animal feed (household pets, fur animals, fish farms, mixed feed) and indeed are so. There is also some production of gelatine, bone glue and fats for the oleochemical industry. With many of these applications there are no true 'savings' on other materials, because these are buoyed up entirely by the existence of slaughterhouse waste, as is often the case at mink farms and so on, due to price considerations. The same holds for gelatine production. A possible assumption would be that the fats and protein substitute for plant-based alternatives. A rough estimate based on palm oil and soy beans yields an overall lifecycle improvement of 5 to 10% (depending on weighting method). Given the priority position of animal waste in the rankings of Chapter 4 and the complexity of these production chains, a more detailed analysis would be desirable.

Waste disposal costs

Based on the Rendac (2007) data, waste disposal costs come to 164 €/t. Only part of this is paid by the supplier, with the government providing the rest. For the aggregate waste stream this gives a figure of € 22.6 million.

3.18 Batteries (#91)

Zinc-carbon and alkaline batteries constitute waste stream #91, part of SP29. As far as possible, data on the material composition of this stream were taken from LAP-EIA A05. This means that iron, zinc, manganese, mercury, lead, copper, nickel and 'inorganic chemicals' (other) are included in the pre-waste phase.

The following waste disposal scenarios were assessed:

1 Electric arc furnace.
2 Pyrometallurgical processing.

In both cases the metals fraction is (largely) recycled, as required for the minimum standard. The environmental impacts were taken from LAP-EIA A05,

[29] Largely equivalent in terms of both pre-waste and waste phase (animal/bone/feather meal production).

which already includes the avoided emissions due to savings primary materials (cf. footnote 2 on page 13).

The lifecycle scores per environmental theme are reported in Appendix B.17.

For most themes the waste disposal route is of only limited influence on the overall score. The greatest variation concerns smog formation and terrestrial ecotoxicity, where the pre-waste phase also make a limited contribution (Figure 33).

Figure 33 Contribution of pre-waste and waste phase to lifecycle impact, by environmental theme, scenario 1 (ref.)

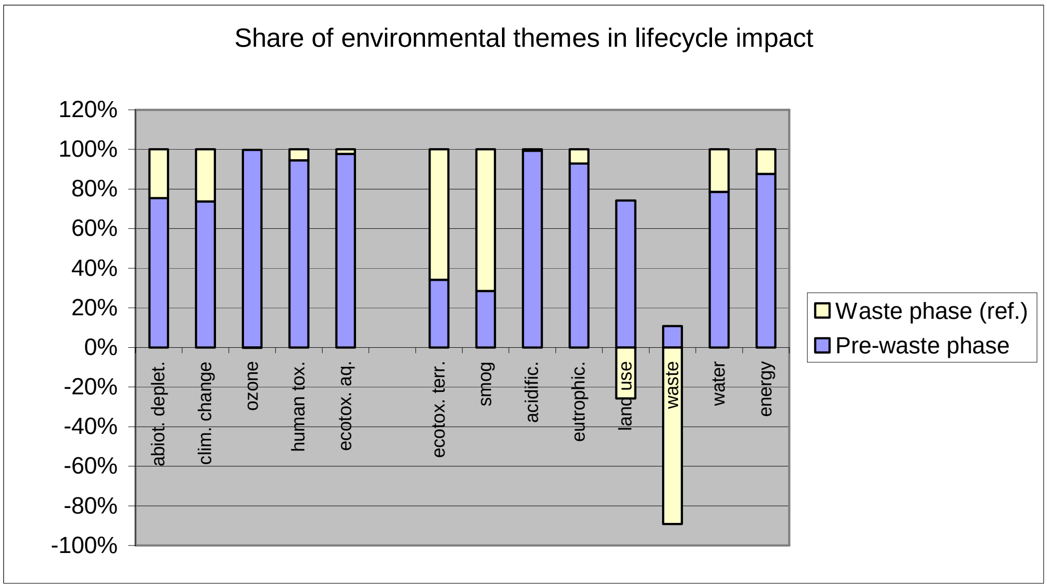
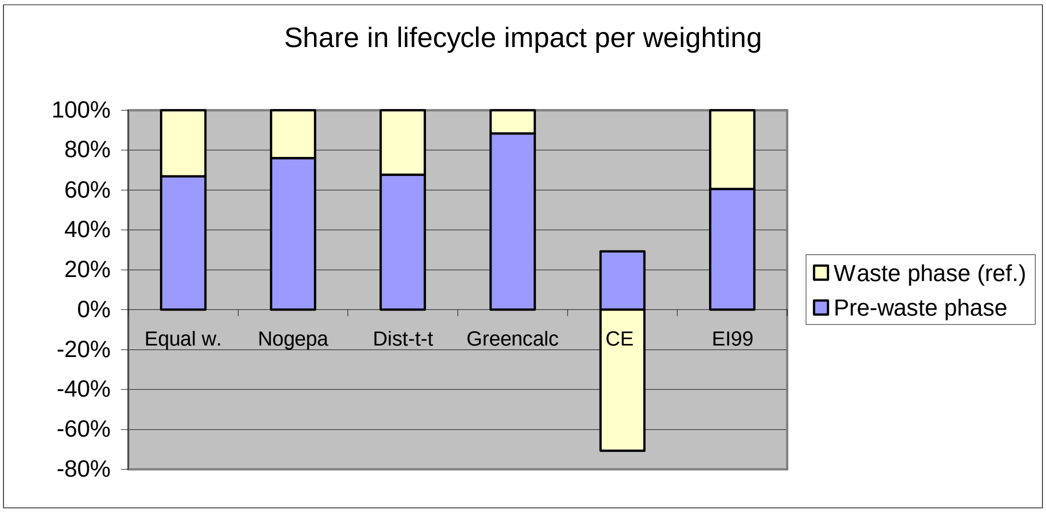


Figure 34 Contribution of pre-waste and waste phase to weighted lifecycle impact, scenario 1 (ref.)



Negative impacts of waste disposal occur only for land use and final waste. The latter is also of influence on the negative score in the CE weighting.

Final scores on tracks A1 and A2

The scores can be weighted to arrive at a single-figure final score, as described in Section 2.3. In Table 39 and Table 40 these final scores are reported for the entire waste stream, for both lifecycle impact and the impact of waste disposal alone.

Table 39 Final scores for lifecycle impact (weighted) for entire waste stream (1.64 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	-4.8E+06	-4.8E+06	-1%
Water consumption (m^3)	1.0E+08	1.0E+08	2%
Energy consumption (MJprim)	6.2E+07	5.3E+07	15%
Ecoindicator99 (E,E)	1.1E+06	6.4E+05	41%
EPS (pre-waste phase only)	5.4E+07	5.4E+07	0%
Equal weighting	2.43E-06	1.71E-06	30%
Nogepa	2.18E-07	1.77E-07	19%
Distance-to-target	4.77E-06	3.42E-06	28%
Greencalc prevention costs	1.42E+00	1.36E+00	5%
CE prevention costs	-5.59E-01	-5.59E-01	0%

Table 40 Final scores for waste disposal (weighted) for entire waste stream (1.64 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	-5.46E+06	-5.43E+06	-1%
Water consumption (m^3)	2.15E+07	2.36E+07	9%
Energy consumption (MJprim)	7.74E+06	-1.32E+06	117%
Ecoindicator99 (E,E)	4.27E+05	-1.31E+04	103%
EPS			
Equal weighting	8.08E-07	8.78E-08	89%
Nogepa	5.24E-08	1.07E-08	79%
Distance-to-target	1.54E-06	1.91E-07	88%
Greencalc prevention costs	1.66E-01	9.93E-02	40%
CE prevention costs	-9.55E-01	-9.56E-01	0%

The difference between the waste disposal options is fairly large, except with the CE weighting. With this weighting method the score for final waste is of the essence, and on this account scenario 1 scores slightly better. Generally speaking, pyrometallurgical processing appears preferable, however.

Waste disposal costs

In the EU the collection and recycling of zink-carbon and alkaline batteries is estimated to cost 2,500 €/t (Arnold 2005, corrected for revenue from secondary materials). This is in good agreement with the estimates reported in Fisher et al. (2006). This gives a figure of € 4.1 million for the aggregate waste stream.

3.19 Accumulators (#92)

Accumulators also feature as part of 'End-of-life-vehicles' (SP11), but here we are concerned with the stream emerging independently (SP30). Lead accumulators (lead batteries in everyday parlance) are by far the greatest single item in this sectoral plan and were taken as the sole focus here. The composition of the waste stream was based on Fisher et al. (2006), viz.: lead (65%), suphuric acid (16%) and polypropylene (remainder).

Processing was also modelled as per Fisher et al. (2006), who use process data from Campine (Belgium). The lead is 100% recycled, the sulphuric acid 44%. In principle the lead produced by Campine is of the same quality as virgin lead, implying one-to-one substitution. According to UA (2006) 7% is landfilled in the Netherlands' so-called C2 waste storage facility. We here assumed landfill of 'inert' material in a 'sanitary landfill' (Ecoinvent).

The following waste disposal scenarios were assessed:

1 7% landfill in the C_2 waste stortage facility, rest via Campine route.
2 100% processing at Campine.

The lifecycle scores per environmental theme are reported in Appendix B.18.

Lead predominates in both the pre-waste and waste phase. The lead 'avoided' through waste disposal compensates for some of the impacts of the pre-waste phase (Figure 35).

Figure 35 Contribution of pre-waste and waste phase to lifecycle impact, by environmental theme, scenario 1 (ref.)

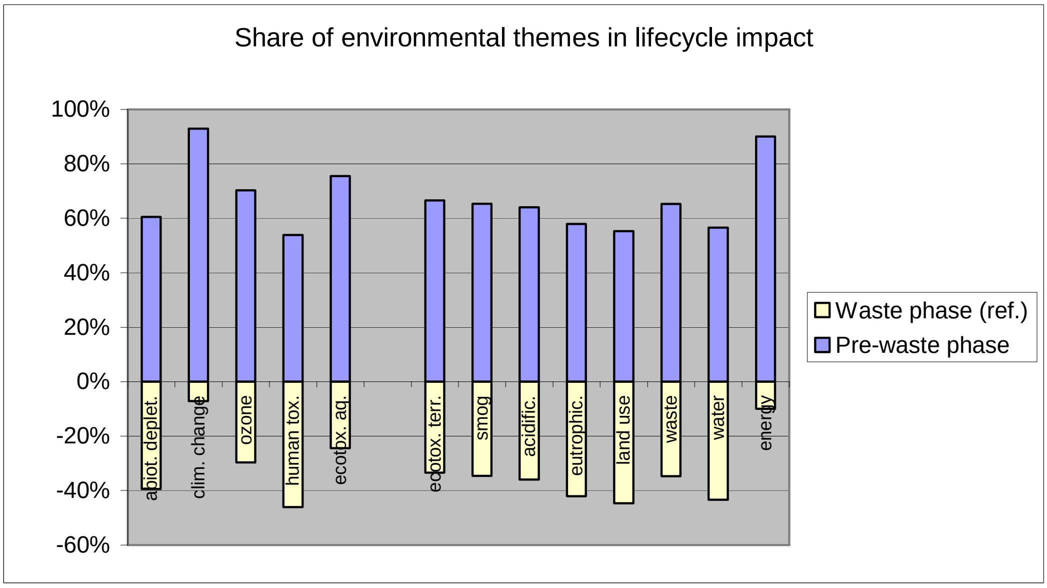
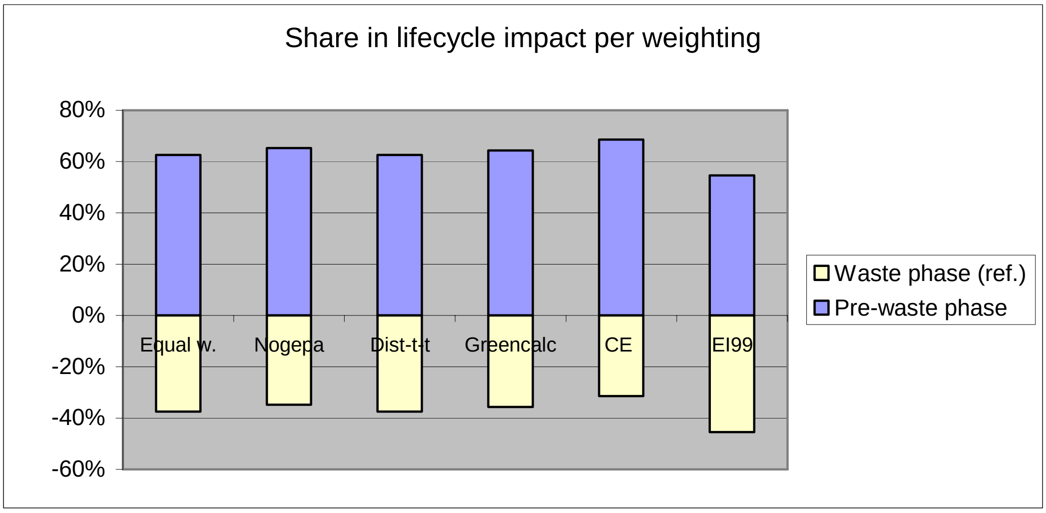


Figure 36 Contribution of pre-waste and waste phase to weighted lifecycle impact, scenario 1 (ref.)



Final scores on tracks A1 and A2

The scores can be weighted to arrive at a single-figure final score, as described in Section 2.3. In Table 41 and Table 42 these final scores are reported for the entire waste stream, for both lifecycle impact and the impact of waste disposal alone.

Table 41 Final scores for lifecycle impact (weighted) for entire waste stream (34 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	6.2E+06	3.1E+06	50%
Water consumption (m^3)	1.5E+08	1.2E+08	25%
Energy consumption (MJprim)	8.5E+08	8.4E+08	1%
Ecoindicator99 (E,E)	4.6E+06	2.9E+06	38%
EPS	7.2E+08	2.4E+07	97%
Equal weighting	8.04E-06	7.03E-06	13%
Nogepa	7.87E-07	7.10E-07	10%
Distance-to-target	1.40E-05	1.22E-05	13%
Greencalc prevention costs	7.54E+00	6.80E+00	10%
CE prevention costs	5.92E+00	5.06E+00	14%

Table 42 Final scores for waste disposal (weighted) for entire waste stream (34 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	-7.1E+06	-1.0E+07	-44%
Water consumption (m^3)	-5.1E+08	-5.5E+08	-8%
Energy consumption (MJprim)	-1.1E+08	-1.1E+08	-8%
Ecoindicator99 (E,E)	-2.3E+07	-2.5E+07	-8%
EPS	-9.3E+09	-1.0E+10	-8%
Equal weighting	-1.20E-05	-1.30E-05	-9%
Nogepa	-8.94E-07	-9.70E-07	-9%
Distance-to-target	-2.10E-05	-2.28E-05	-9%
Greencalc prevention costs	-9.42E+00	-1.02E+01	-8%
CE prevention costs	-5.01E+00	-5.87E+00	-17%

Recycling vehicle batteries obviously has a positive effect on lifecyle environmental impact, but what emerges from these calculations is that the small fraction of material landfilled still makes a fairly substantial contribution to environmental burden. It would therefore make sense to increase the recycling rate still further.

Waste disposal costs

Recycling itself is cost-neutral or even negative (Fisher et al., 2006). According to the same study, collection and sorting cost about 1,000 €/t. With a 7% share for landfill (C_2 waste storage facility), this gives 946 €/t. For the aggregate waste stream this means a total figure of € 32 million.

3.20 Solvents (SP31)

For waste streams #93-95 we assessed the environmental impact of one specific material. Although solvents (low-halogen) were also considered in LAP-EIA (A18), there calculations were based on a series of generic assumptions that did not hold for any one solvent in particular. The types A and B distinguished in LAP-EIA have a heating value of 42.5 MJ/kg. To ensure compatibility we took toluene, a fairly commonly used solvent for which the supply chain data are well established. In line with LAP-EIA A18, we assumed 0.1% chlorine contamination of the solvent.

The following waste disposal scenarios were assessed:
1 Distillation, with co-combustion of residue in cement kiln (minimum standard).
2 100% co-combustion in cement kiln.

For type A solvents the environmental impacts of waste disposal were taken from LAP-EIA A18. For type B solvents the impacts in scenario 1 are slightly lower than for type A and in scenario 2 the same. This means type A gives a better idea of possible ‘extremes’.

The lifecycle scores per environmental theme are reported in Appendix B.19.

The waste disposal method adopted is of major influence on the scores on most themes; in the minimum standard scenario, too, the emissions occurring in the pre-waste phase are almost entirely compensated by useful application and co-combustion in a cement kiln. Only for climate change is this not the case.

Figure 37 Contribution of pre-waste and waste phase to lifecycle impact, by environmental theme, scenario 1 (ref.)

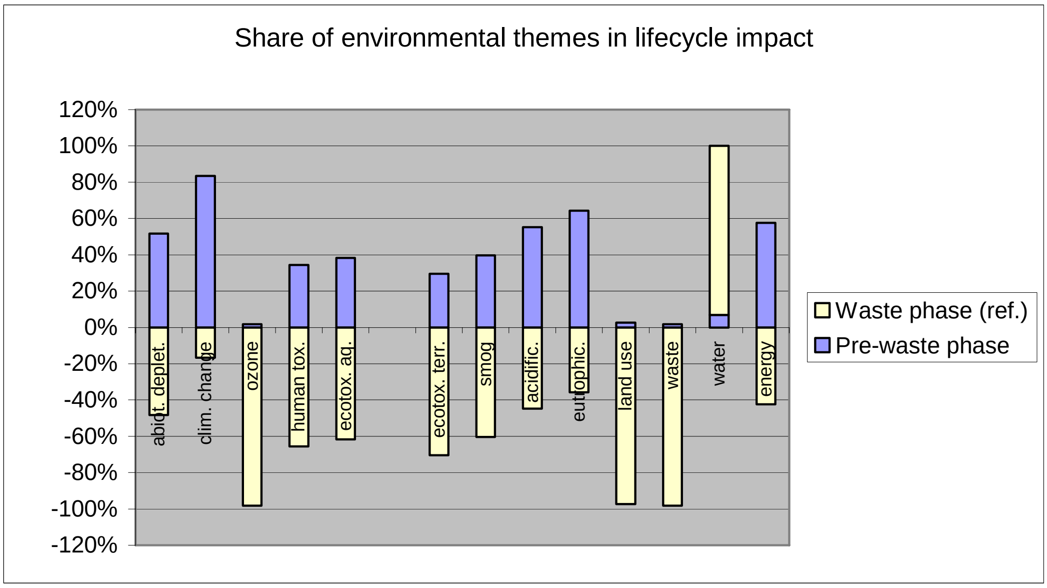
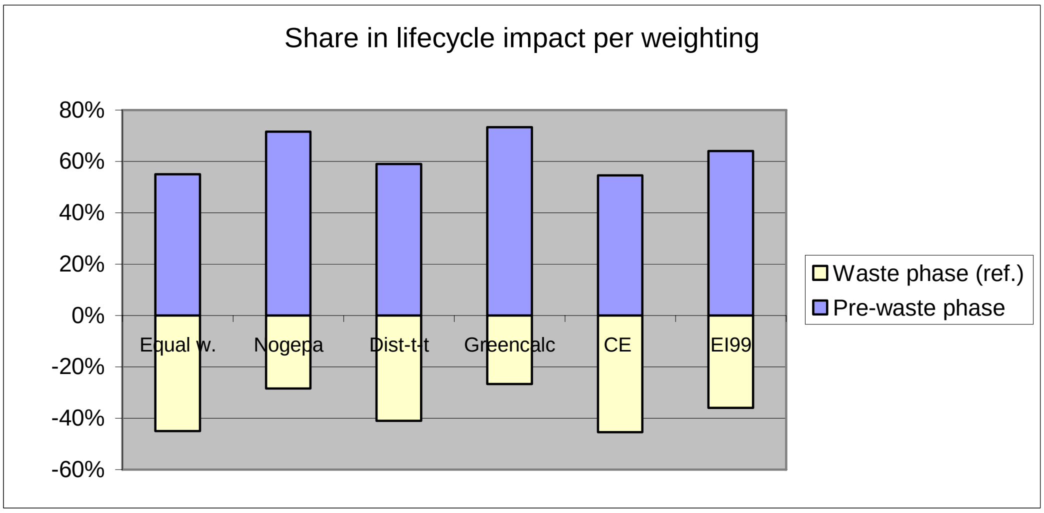


Figure 38 Contribution of pre-waste and waste phase to weighted lifecycle impact, scenario 1 (ref.)



Although some of the individual lifecycle environmental impacts are negative in both scenarios (cf. Appendix B.19), none of the weighting methods assign scenario 1 a negative score (Figure 38; in the case of equal weighting and CE weighting the pre-waste phase is almost entirely offset by waste disposal).

Final scores on tracks A1 and A2

The scores can be weighted to arrive at a single-figure final score, as described in Section 2.3. In Table 43 and Table 44 these final scores are reported for the entire waste stream, for both lifecycle impact and the impact of waste disposal alone. Here we modelled the entire volume of stream #93 (low-halogen, recyclable solvents) using the specific impacts of toluene.

Table 43 Final scores for lifecycle impact (weighted) for entire waste stream (271 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	-7.9E+07	-3.3E+08	-324%
Water consumption (m^3)	5.4E+08	-2.4E+09	547%
Energy consumption (MJprim)	5.3E+09	-8.8E+08	117%
Ecoindicator99 (E,E)	2.7E+07	4.2E+07	36%
EPS (pre-waste phase only)	3.9E+08	3.9E+08	0%
Equal weighting	1.48E-05	-5.55E-05	474%
Nogepa	3.40E-06	-7.59E-08	102%
Distance-to-target	2.14E-05	-5.88E-05	375%
Greencalc prevention costs	3.75E+01	3.20E+00	91%
CE prevention costs	5.51E+00	-5.95E+01	1.180%

Table 44 Final scores for waste disposal (weighted) for entire waste stream (271 kt)

	Scenario 1	Scenario 2	Variation
Final waste (kg)	-8.0E+07	-3.4E+08	-319%
Water consumption (m^3)	5.1E+08	-2.5E+09	588%
Energy consumption (MJprim)	-1.5E+10	-2.1E+10	-42%
Ecoindicator99 (E,E)	-3.4E+07	-1.9E+07	-77%
EPS			
Equal weighting	-6.58E-05	-1.36E-04	-107%
Nogepa	-2.24E-06	-5.72E-06	-155%
Distance-to-target	-4.88E-05	-1.29E-04	-164%
Greencalc prevention costs	-2.13E+01	-5.56E+01	-161%
CE prevention costs	-2.76E+01	-9.26E+01	-235%

In all weighting methods scenario 2 scores considerably better than scenario 1. Once again we see that partial useful application of the material is not necessarily better in environmental terms than useful application of its energy content.

Waste disposal costs

According to LAP-EIA A18, distillation and co-combustion cost 125 €/t. This gives a total figure of € 34 million for the stream as a whole.

3.21 Residual household waste (#01)

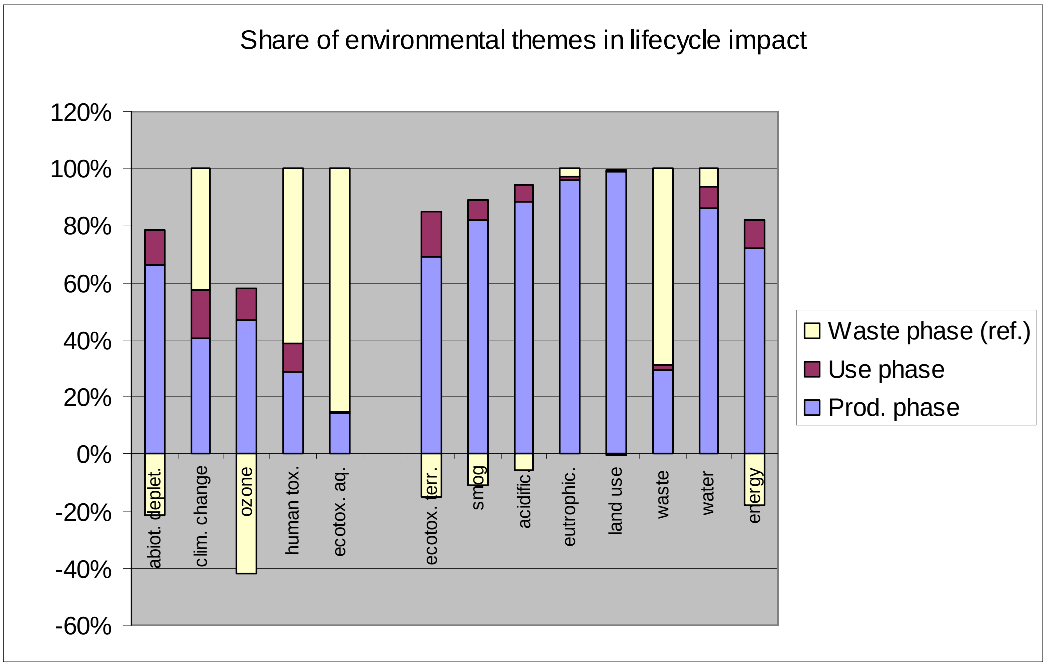
The stream 'Household residual waste' is a mixture of several other streams. To assess the environmental impacts we therefore used the data on the constituent components of this unsorted waste. The percentage breakdown taken is shown in Table 45.

Table 45 Composition of 'Residual household waste' (source : MNP/CBS)

Substream	Share in 2005	Remarks
Organic waste, bread, etc.	35%	As #22, pre-waste phase 50% 'avoidable'
Paper and board	25%	As #63
Plastics	19%	As #65
Glass	4.3%	As #50[30]
Ferro	3.5%	Not included, because under #68
Non-ferro	0.6%	Not included, because under #68
Textiles	3.2%	As #67
HCA/special-category waste	0.1%	Ignored
Other	9%	Composition unknown, same av. impacts as rest

All this waste is currently disposed of in incinerators[31]. The lifecycle scores per environmental theme are reported in Appendix B.20.

Figure 39 Contribution of production phase, use phase and waste phase to lifecycle impact, by environmental theme

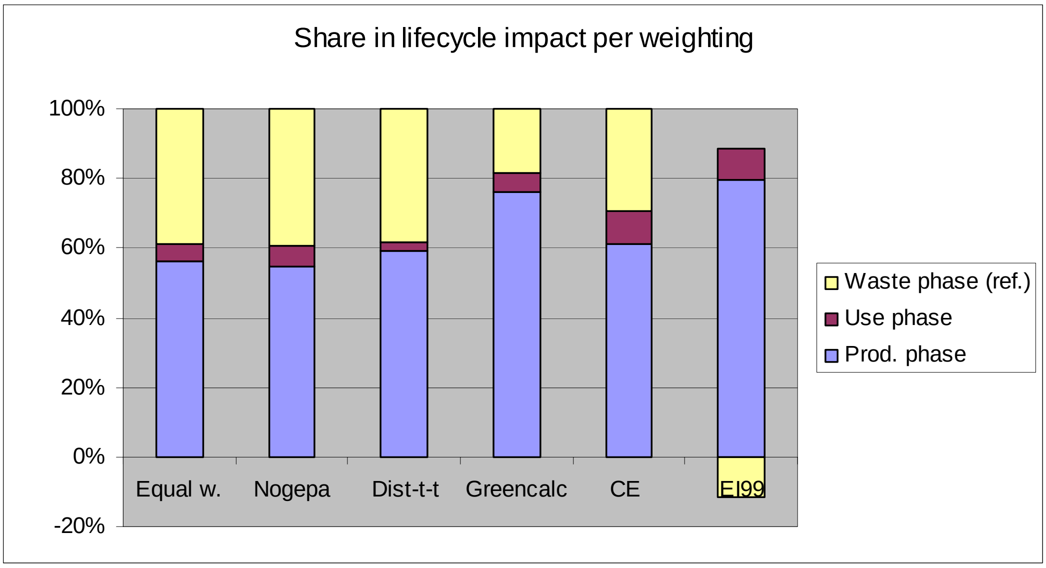


[30] Note that this is plate glass, while household waste contains mainly packaging glass. Over the entire lifecycle, the differences are fairly minor, however, and glass makes up only a small fraction of the whole.

[31] This ignores mechanical separation of the plastics/paper fraction.

With this waste stream the pre-waste phase is fairly preominant. Note that here, too, it is production of virgin materials that is concerned (cf. Section 2.4). In contrast to the separately collected streams with subsequent recycling, in the case of residual waste this approach does affect the aggregate lifecycle score. Our premise, however, was that incinerator disposal makes no difference to a material's overall recycling rate and that the fraction ending up being incinerated must therefore indeed be replaced by primary materials. The decision to allocate recycling to the waste disposal phase is thus one of the reasons why residual household waste features so high in the ranking on track A1.

Figure 40 Contribution of production phase, use phase and waste phase to weighted lifecycle impact, scenario 1 (ref.)



The relatively low-grade energy application of plastics and textiles, in particular, means waste disposal has a high impact (track A2). These substreams are also responsible for a substantial share of the pre-waste-phase impacts of this residual waste.

As we saw in Sections 3.10 and 3.12, recycling of these waste streams makes sense environmentally. One leverage point for reducing the impacts of household residual waste might therefore be to increase separate-collection levels of the constituent substreams. With respect to the plastics, it might be wise to focus first on species other than PE and PP. For these two, energy recovery and materials recycling are pretty much on a par environmentally (CE, 2006b), certainly given the fact that in practice some of the plastics are mechanically separated (with the plastics/paper fraction: PPF) and used as a secondary fuel. For glass and household chemical waste a higher collection rate with subsequent recycling is likewise environmentally superior (cf. Sections 3.8 and 3.18), but because of the small shares of these sub-streams in residual household waste, this effect will be only limited.

Paper and organic waste make up a large fraction of residual household waste, but (as discussed in Sections 3.3 and 3.9) the gains achieved by separate collection of these materials followed by useful application in their current form depend largely on the weight assigned to certain impacts. For paper too, it may be added, use as a secondary fuel leads to greater energy savings and consequently environmental gains than incinerator disposal. To an extent, this is already what happens via PPF separation.

The total annual stream of residual household waste is 3,958 kt. For the cost calculations this figure was used, but for prioritisation with respect to environmental impacts 3,792 kt was taken, because the metals are already included in #68. For the aggregate waste stream, total costs thus come to € 471 million.

3.22 Commercial and institutional residual waste (#04)

The stream ‘Commercial and institutional residual waste’ (retail, office and services only) is again made up of a number of other streams. Table 46 shows the percentage breakdown used in this study.

Table 46 Composition of ‘Commercial and institutional residual waste’ (bulk-collected, UA 2006)

Substream	Share in 2005	Remarks
Organic waste, bread, etc.	5%	As #22, pre-waste phase 50% ‘avoidable’
Paper and board	28%	As #63
Plastics	24%	As #65
Glass	3%	As #50
Textiles	1%	As #67
Other, wood	39%	Composition unknown, same average impacts as rest

Problematical with this category is the substantial contribution of ‘other’, the composition of which is largely unknown. As with residual household waste, we here assumed that the impacts are the same as the average for the substreams that are known, but in this case the uncertainty this introduces is obviously greater.

For the results on commercial and institutional residual waste the same remarks apply as for residual household waste (Section 3.21). Because the shares of textiles and organic waste are substantially lower than for residual household waste, though, in this case the pre-waste phase is less predominant. The share of plastics is higher and policy focus on collection and useful application is once again certainly important.

Figure 41 Contribution of production phase, use phase and waste phase to lifecycle impact, by environmental theme

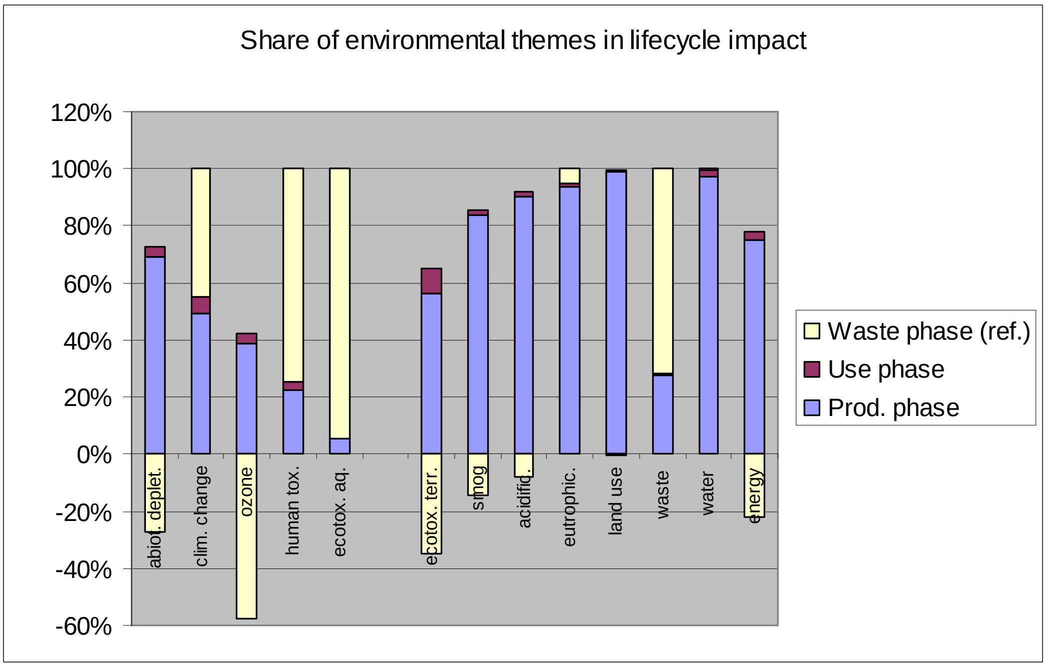
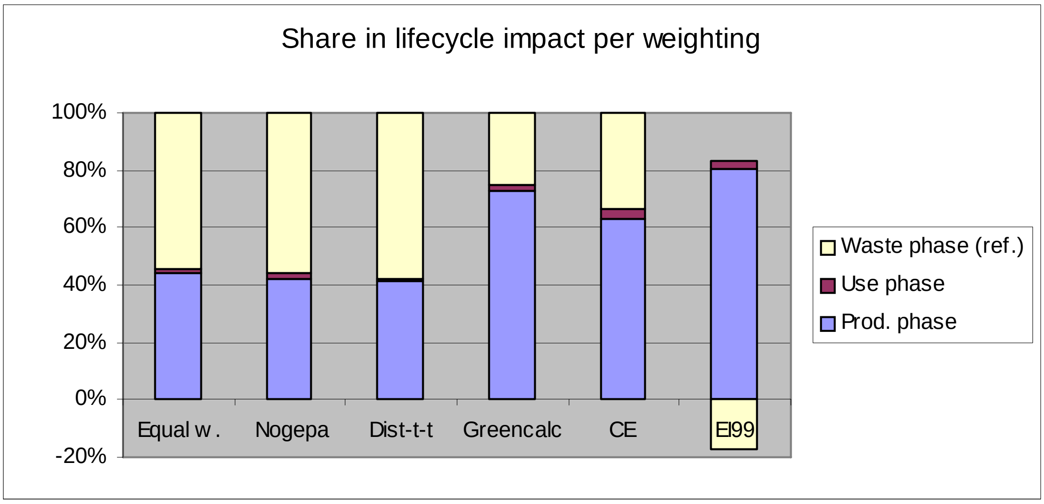


Figure 42 Contribution of production phase, use phase and waste phase to weighted lifecycle impact, scenario 1 (ref.)



The total weight of the above substreams is 1,851 kt. All residual waste is sent to incinerators[32]. The lifecycle scores per environmental theme are reported in Appendix B.21. The total disposal costs for this stream come to € 220 million.

32 This makes no allowance for mechanical separation of PPF.

4 Rankings and policy prioritisation

4.1 Introduction

In Chapter 3 data on 22 waste streams and their production chains were presented. These data were augmented by another 16 streams for which waste disposal data were already available in LAP-EIA. With these data we can now establish the rankings of waste streams on tracks A1 and A2, with 22 and 38 streams, respectively. The share of waste disposal in overall lifecycle impact (track A0) is thus also known for 22 streams.

All in all this yields 24 different rankings, viz.:
- For track A1 (lifecycle environmental impact) according to six different weighting methods.
- For track A2 (waste disposal impact) according to six different weighting methods.
- Share of waste disposal in lifecycle environmental impact according to six different weighting methods, both with and without multiplication by the total volume of the stream.

Another, final ranking was drawn up for the costs of waste disposal. In all cases the cost figure for the entire stream was used for this purpose: in other words, a waste stream's position in the ranking is determined partly by its magnitude. The full rankings are listed in Appendix C.

4.2 Lifecycle environmental impact (track A1)

All weighting methods yield a similar top 10

The waste streams reviewed in this study were ranked as to lifecycle environmental impact using 6 alternative weighting methods. Surprisingly, the rankings all prove very similar, despite the differences in the weighting methods. The combined top 10s include 11 waste categories in all. Although a waste stream featuring at no.1 in the rankings according to several methods is sometimes 1 or 2 positions lower in the others, the differences are fairly minor. The Greencalc method differs most from the others. This is understandable, as this method assigns the greatest weight to land use. This method yields a similar top 10, except for paper and organic waste, the biotic materials for which land use is a major issue. Even though organic waste is assigned to the top 10 in just one weighting method, this category has nonetheless been included in the final ranking. Precisely because this result is influenced by the weighting method adopted, it is important that the biotic waste streams be given additional focus.

Table 47 Top 11: waste streams featuring in a top 10 for lifecycle environmental impact according to six weighting methods, in average order

Code	No. of times in top 10 with the six weighting methods	Category name
1	6	Residual household waste (bulk-collected)
28	6	End-of-life vehicles[c]
4	6	Commercial and institutional residual waste
29	6	End-of-life tyres[c]
63	5	Separately collected paper and board[a]
68	6	Metal waste, general
21	6	Gas-discharge lamps[c]
88	6	Animal waste, SRM/HRM
37	6	Stony materials
67	6	Separately collected textiles[c]
22	1	Household organic waste[b]

a The Greencalc weighting puts #63 right at the bottom, with a negative lifecycle impact.
b Only in the top 10 with Greencalc; with other weightings in position 11-13.
c Including energy consumption in the use phase.

The differences between numbers 1 and 10 in the rankings are around a factor 10 (total weighted environmental impact). In the case of the Greencalc weighting method the difference is even a factor 50. The differences between numbers 10 and 11 in the rankings are approximately a factor 3 to 6, except with the shadow-price weighting methods (Greencalc and CE), for which the difference is around 30% (a factor 1.3). Given the uncertainties discussed in Section 2.5, the difference between the top 10 and the rest as well as the mutual differences among rankings appear to be reasonably significant. This impression is reinforced by the fact that the different weighting methods yield such very similar results.

Note that four of the five categories with an explicit use phase - end-of-life vehicles, end-of-life types, gas-discharge lamps and textiles - feature in the top 11. The only category missing in this respect is waste carpeting, probably because of the fairly small volume of this stream (cf. Section 3.11). The decision to include energy consumption in the use phase in lifecycle impact calculations is obviously of influence here, because total lifecycle impact is generally many times greater than the impact associated with just production and final disposal (cf. Chapter 3). Another interesting point is that stony materials and textiles occupy successive positions, despite differing by a factor of over 200 in total volume. For these two streams the lifecycle environmental impact per kilogram of material is clearly of a very different order.

4.3 Environmental impact of waste disposal (track A2)

The environmental impact of the waste disposal phase alone was also calculated and the results weighted using the same six weighting methods. For those streams not assessed on track A1, use was made of the LAP-EIA data (cf. Appendix A3). From the combined top 10s emerges the top 18 presented below (Table 48).

All weighting methods give similar rankings for waste disposal impact

Once again there are many similarities between the top 10s yielded by the different weighting methods: combining them gives a total of 18 waste categories. Ten streams feature in the top 10 of at least three weightings. Shredder waste and batteries are the exceptions here. Shredder waste is just beyond the top 10 of several weighting methods. The ranking of waste batteries is more varied. In the two shadow-price methods it is fairly low in the ranking, while in the others it scores much the same as shredder waste. This can be explained by the fact that these methods attach relatively little or no weight to toxicity, which for batteries is precisely one of the key environmental themes.

Table 48 Top 12: waste streams featuring in the top 10s yielded by different weighting methods for waste disposal impact (track A2)

Ranking	Code	No. of times in top 10	Category name
1	**1**	**5**	**Residual household waste (bulk-collected)**
2	**63**	**4**	**Separately collected paper and board**
3	**37**	**6**	**Stony materials**
4	**2**	**4**	**Bulky household waste (carpeting only)**
5	**6**	**6**	**Water treatment sludge**
6	**4**	**5**	**Commercial and institutional residual waste**
7	**38**	**6**	**Gypsum**
8	**9**	**6**	**Waste incinerator fly ash**
9	**88**	**3**	**Animal waste, SRM/HRM**
10	**22**	**4**	**Household organic waste**
11	**84**	**2**	**Shredder waste**
12	**91**	**2**	**Batteries (zinc-carbon & alkaline)**
13	10	2	Flue gas treatment residues from waste incinerators, dry
14	76	1	Oil/water/sludge mixtures
15	109	1	Fixer and developer solutions (black/white)
16	23	1	Separately collected commercial and institutional organic waste
17	49	1	Asbestos
18	108	1	Filter cakes (detoxification/neutralisation/dewatering)

Household residual waste ranks high in several top 10s. Climate change and freshwater ecotoxicity contribute most to lifecycle impact. Impact on the latter count is due mainly to plastics incineration and the attendant emissions of heavy metals[33]. Note that besides household and commercial/institutional residual waste, waste incinerator fly ash and flue gas treatment residues also feature in this ranking, based on the LAP-EIA waste disposal data. In principle, the impacts of fly ash and flue gas treatment residues are also already included in the two residual waste streams just cited, albeit modelled differently. Incinerator disposal of residual waste is clearly an issue requiring attention from the perspective of lifecycle environmental impact.

33 This is based on Swiss data; cf. Section 2.4.

Paper and board, animal waste and organic waste feature in the top 10s of three or four weighting methods. In a model ignoring short-cycle CO_2 entirely (cf. Section 2.4) the climate impact and thus the total weighted impact of waste disposal would be lower. Explicit identification of the CO_2 uptake at the beginning of the chain and CO_2 emission at the end is now the methodological standard, however, as this reflects what actually happens.

Note that carpeting waste is in the top 10 of four weighting methods, despite the relatively small size of this stream (cf. Section 3.11). With Ecoindicator99 and CE shadow pricing, however, this stream is far further down the list.

The differences between nos. 1 and 10 on the rankings are considerable: a factor of around 50 to 1,000. The differences between nos. 10 and 11 on the various lists are limited: a factor of about 1.2 to 2. Given the uncertainties discussed in Section 2.5, the precise mutual ranking is not significant.

4.4 Waste phase: contribution to lifecycle impacts (track A0)

Another approach to lifecycle policy thinking departs from the question of where prime responsibility for the lifecycle should lie. For streams with a relatively high environmental impact in the waste disposal phase, the obvious course of action is to address them via waste policy. For streams for which waste disposal impact is relatively insignificant compared with that of the lifecycle as a whole, the more obvious approach is for initial action to be taken from within other policy areas. This is why we have also drawn up a top 11 of the ratio between waste disposal environmental impact and lifecycle impact[34].

[34] Defined as the impact of the waste disposal phase divided by the absolute value of lifecycle environmental impact, so that a negative impact in the waste phase always also gives a negative relative share. Streams with a negative impact in the waste phase are consequently at the bottom end of the ranking.

Table 49 Rankings for ratio between waste phase environmental impact and lifecycle impact, with no factoring in of volume (A0a)

Code	No. of times in top 10	Category name	Remarks
38	**6**	**Gypsum**	
4	**5**	**Commercial and institutional residual waste**	
63	**4**	**Separately collected paper and board**	
91	**5**	**Batteries (zinc-carbon & alkaline)**	
22	**6**	**Household organic waste**	
37	**6**	**Stony materials**	
1	**5**	**Residual household waste (bulk-collected)**	
2	**5**	**Bulky household waste (carpeting only)**	
76	**6**	**Oil/water/sludge mixtures**	
23	**6**	**Separately collected commercial and institutional organic waste**	
88	**3**	**Animal waste, SRM/HRM**	Contribution of waste disposal phase negative with Ecoindicator
28	1	End-of-life vehicles	Contribution of waste disposal negative only with Ecoindicator!
21	1	Gas-discharge lamps	
29	1	End-of-life tyres	

It is striking how similar this ranking is to the A2 ranking for waste disposal environmental impact. With streams having a high environmental impact in the waste phase, this phase obviously features relatively prominently in overall lifecycle impact. With respect to the biotic materials, the same holds here as stated above in Section 4.3.

The rankings for the share of waste disposal in overall lifecycle impact yield approximately the same picture as the A2 rankings, once allowance is made for the fact that the lifecycle of water treatment sludge, fly ash and so on is unknown, so that these streams could not be included here. New in this ranking is #76 (oil/water/sludge mixtures).

In the above approach the volume of the waste stream concerned is not factored into the equation. A ranking was therefore also drawn up in which the waste disposal/life cycle impact ratio was multiplied by the volume of the waste stream in question.

Table 50 Rankings for share of waste disposal phase, with volume of stream factored in (A0b)

Code	No. of times in top 10	Category name	Remarks
37	6	Stony materials	
63	4	Separately collected paper and board	
1	5	Residual household waste (bulk-collected)	
38	6	Gypsum	
76	6	Oil/water/sludge mixtures	
4	5	Commercial and institutional residual waste	
91	4	Batteries (zinc-carbon & alkaline)	
23	6	Separately collected commercial organic waste	
22	6	Household organic waste	
2	6	Bulky household waste (carpeting only)	Contribution of waste disposal phase negative with Ecoindicator
88	4	Animal waste, SRM/HRM	Contribution of waste disposal phase negative with Ecoindicator
50	1	Plate glass	Contribution of waste disposal negative only with Ecoindicator!
21	1	Gas-discharge lamps	

There is virtually no difference at all between the waste categories featuring in the rankings with and without allowance for volume of the respective waste stream, except in the case of a few streams with a negative impact in the Ecoindicator top 10. There are differences in the order in which they are ranked, however. In the list with no allowance for volume, #38 (gypsum construction and demolition waste) is consistently higher than #37 (stony CDW), while in the list with allowance made for volume this order is reversed.

Oil/water/sludge mixtures

The only new issue of interest to emerge from the A0 track analysis is the category oil/water/sudge (OWS) mixtures. In the waste disposal rankings (track A2) this stream features in the top 10 of just one weighting method: Ecoindicator. In three others, however, it occupies 12th position. In addition, this stream can be regarded as a proxy for shipping vessel waste (cf. Section 4.8). The conclusion that waste disposal is a major contributor to lifecycle environmental impact may thus hold for a greater volume of waste than narrowly defined ‘OWS mixtures’ alone. For this reason, these and similar streams also merit additional policy focus.

4.5 Combined ranking for lifecycle and waste disposal impact

The rankings based on lifecycle impact and on waste disposal impact have similarities as well as differences. In this section we examine this issue in a little more depth and endeavour to draw up a combined ranking.

Six streams scoring high on both lifecycle and waste disposal impact
The following 6 streams score high in terms of both lifecycle impact and waste disposal impact:
- Residual household residual waste.
- Separately collected paper and board.
- Stony construction and demolition waste.
- Commercial and institutional residual waste (retail, office and services only).
- Animal waste, SRM/HRM.
- Household organic waste.

The volume of some of these streams is very substantial. With a number of categories such as organic waste, animal waste and stony CDW, it is clearly the pre-waste phase that predominates (cf. figures in Chapter 3), but these categories emerge as poor scorers on waste disposal, too.

Of the 11 categories scoring high on track A1 (Table 47) roughly half reoccur in the ranking for track A2 (Table 48). This overlap indicates that a lifecycle approach does not deviate entirely from one based purely on waste disposal alone. In other words, these waste streams merit attention from a lifecycle and waste disposal perspective alike.

Five streams scoring differently on lifecycle impact and waste impact of use phase and/or high recycling rate
The other five waste categories from the top 11 on track A1 are thus not found in any of the top 10s for waste disposal impact:
- End-of-life vehicles.
- End-of-life tyres.
- Gas-discharge lamps.
- Metal waste.
- Separately collected textiles.

With the first three categories we are concerned with products that rank high because of their high energy consumption in the use phase. In the case of car tyres, for instance, 4% of the vehicle’s energy consumption is allocated to each tyre, because of the influence on vehicle fuel efficiency (cf. Section 3.5). With textiles, too, there is a good deal of energy consumption during use (washing, ironing, etc.; cf. Section 3.12).

For all five categories except for gas-discharge lamps, moreover, the waste disposal phase is associated with ‘negative’ impacts (on all themes), because of the high recycling rates. With a very high-impact pre-waste phase (metals production and energy consumption during usage) and environmentally robust waste disposal, then, it is to be expected that for these categories there will be no overlap between track A1 and A2.

Score on waste disposal only
In the track A2 ranking (Table 48) are a number of categories that were not assessed at all on track A1. Based on these categories, then, little can be said about whether or not the two approaches are complementary. Gypsum CDW and batteries (zinc-carbon and alkaline) were assessed on both tracks, however, yet feature only in (one or more of) the weighted top 10s for waste disposal alone.

Looking back to Section 3.7, for gypsum CDW this is understandable. As set out there, waste disposal ('Versatzbau') has a far greater impact than the pre-waste phase. Recycling might reduce the impacts of waste disposal substantially.

For batteries (Section 3.18) this is rather less clear: this waste stream features in the top 10 for waste disposal with two of the weighting methods only. This is probably due mainly to the attendant toxic and smog-forming emissions. In the case of other streams like water treatment sludge, incinerator fly ash and shredder waste (not assessed on track A1, but included in track A2), toxic emissions (during landfill) also play a role. These are all materials on which waste policy has been very focused for many years now.

Bulky household residual waste
Waste carpeting, too (part of 'Bulky household residual waste'), features only in the top 10s for waste disposal. Although it, too, has a prominent pre-waste phase (cf. Section 3.11), at 11 kt the volume is fairly modest. Being a constituent of household residual waste, the waste disposal route considered is 100% incineration. As the analyses show, collection and useful application (secondary fuel or materials recycling) are environmentally attractive. To what extent this also holds for other textile-related components of bulky household waste, such as mattresses and furniture, is hard to say. The types of synthetic fibres used and the recycling options available are of major influence here. What does generally hold is that high-grade energy recovery is superior to incinerator disposal and that these kinds of waste also have their own specific problems at the incinerator, moreover. In all likelihood, therefore, improving separate collection will therefore always be a favourable move.

Combined top 14 for waste policy
The top 12 waste categories to emerge from the assessment of waste disposal impact are all relevant for waste policy. The question now is whether the categories occurring only in the top 11 for lifecycle impact are a useful complement to the former priority list. For each of the categories concerned we shall answer this in qualitative terms.

End-of-life vehicles
The high score of end-of-life vehicles in the lifecycle approach is due to the petrol- and diesel-related emissions associated with vehicle use. By means of technical measures (compression ratio, cylinder size, turbo, more valves, hybrid drive, etc.), behavioural change (switch to public transport and/or cycling, energy labels) and policy measures (road-pricing, differentiation of vehicle purchase tax, etc.) these emissions can be substantially reduced. In this respect the Dutch

government and the EU already have dedicated policies in place that have become considerably more stringent in recent years. These policies are almost entirely disjunction from those directed towards the waste phase, though, and in our opinion it therefore makes little sense to give this stream high priority in waste policy because of its high score on lifecycle impact. The recycling percentage is already extremely high and new ‘post-shredder technology’ will further reduce the amount of shredder waste being landfilled. The influence of the waste disposal options considered in this study on overall lifecycle impact is small (cf. Section 3.4).

White and brown goods (WBG)
In qualitative terms the lifecycle of white and brown goods (WBG, #53) is analogous to that of end-of-life vehicles. The mix of constituent materials is similar, though the share of steel is slightly lower (approx. 50% instead of 75%), with that of other materials consequently higher (e.g. aluminium, copper, glass). For appliances like fridges that are always switched on, the use phase is even more predominant than in the case of the vehicle lifecycle. There is less collection and recycling of WBG than of end-of-life vehicles and collection programmes are lagging behind targets (UA, 2007). The volume of WBG waste is around one-third that of end-of-life vehicles. If this category had been included in the quantitative analysis, it may well have featured (just) in the top 10.

Based on the same considerations as for end-of-life vehicles, though, there seems to be no need for greater policy focus on this category of waste. Standing policy (the AEEA directive) is already aimed at improving collection and recycling and in terms of the energy efficiency of the use phase, too, electrical and electronic appliances are already the focus of considerable policy efforts.

End-of-life tyres
End-of-life tyres score high on the lifecycle track because each tyre is allocated 4% of the vehicle’s lifetime energy consumption (cf. Section 3.5). There is still scope for reducing this consumption by using alternative kinds of tyres; this is an option for transport policy-makers. On top of this, in the case of vehicle tyres, too, there is already a considerable amount of materials and energy recovery. Although reuse in the form of retreading has probably been undervalued in the present study, waste disposal is still associated with a negative impact, i.e. with environmental improvement. There is consequently no reason to include this category in the waste policy list of priorities. Focus on the interaction between reuse (retreading) and the use phase (rolling resistance) is important, though, because the LCA clearly indicates that the tyres on a vehicle are of major influence on the amount of fuel it burns.

Gas-discharge lamps
Tube lighting and compact fluorescent lamps (CFLs) score high on the lifecycle track because of the amount of energy consumed in providing illumination. Their lifecycle impact is an improvement on other lighting options, though, and the impacts of the waste disposal phase are minimal (cf. Section 3.2). There would seem little point in putting this category on the waste policy priority list.

Metal waste: potential waste policy leverage

Metals are associated with major environmental impacts in the ore extraction and processing stage, with energy consumption, mining waste and a variety of toxic emissions all comparatively pronounced. Because of their properties, metals can be very readily recycled with virtually no loss of quality. They can be retrieved via dedicated collection, but equally well from residual waste, using magnets, eddy-current separators and more advanced chemical techniques (as implemented at the AEB plant near Amsterdam, for example). The environmental benefits of recycling are significant. Metal recycling rates are already high, however, certainly in today's booming commodity markets. A further increase in recycling rates might improve lifecycle performance by another 5-10% (cf. Section 3.13).

It is still worth including this stream as a priority category for waste policy, however. In this study an estimated figure of 80% was taken as the maximum recycling rate for aluminium (ECN, 2006), but perhaps there are ways of increasing this still further. In addition, the leaching of the metals remaining in incinerator bottom ash is a major determinant when it comes to the impact of waste disposal. In the analysis of incinerator residues (Section 3.13) these emissions were not included, as they cannot be properly modelled using standard data. This is because in the Netherlands a large proportion of the metals in bottom ash are retrieved using the aformentioned separation methods. Nonetheless, it may be worth directing policy efforts towards improving separate collection rates further.

Textiles: include in waste policy

The lifecycle environmental impact of the textiles chain is determined largely by the use phase (cf. Section 3.12) and by cotton production. With more benign production methods ('eco-cotton') this impact can be reduced by 50-65% (Idemat database). Encouraging use of this kind of cotton will therefore mean a substantial reduction in lifecycle impacts, but is beyond the remit of waste policy. More recycling, as second-hand clothing, would also yield major lifecycle environmental gains, provided this clothing really does substitute for new materials. The same holds for waste prevention, in the form of more extended use of clothing.

The most important issue from the perspective of waste policy is probably to increase the rate of separate collection. The environmental benefits of recycling over incinerator disposal are substantial.

Oil/water/sludge mixtures: waste disposal prominent in lifecycle

OWS mixtures emerge as a stream for which waste disposal accounts for a major proportion of lifecycle impact (track A0). The same may also possibly hold for a larger volume of allied streams (cf. Section 4.8). This is an important issue requiring policy attention.

Interim results on tracks A1 and A2

Based on all the above considerations, a top 15 based on waste and lifecycle environmental impacts combined can be drawn up, as presented in Table 51.

Table 51 Top 15 for waste and recycling policy based on waste and lifecycle impacts combined

Ranking	Code	Category name
1	1	Residual household waste (bulk-collected)
2	63	Separately collected paper and board
3	37	Stony materials
4	2	Bulky household waste (carpeting only)
5	6	Water treatment sludge
6	4	Commercial and institutional residual waste (retail, office and services only)
7	38	Gypsum
8	9	Waste incinerator fly ash
9	84	Shredder waste
10	91	Batteries (zinc-carbon & alkaline)
11	88	Animal waste, SRM/HRM
12	22	Household organic waste
13	68	Metal waste, general
14	67	Textiles (separately and bulk-collected)
15	76	Oil/water/sludge mixtures (and similar streams)

4.6 Costs (track A3)

The top 25 streams with respect to waste disposal costs are presented in Table 52.

Table 52 Top 25 waste streams in terms of waste disposal costs (rankings in column 2 refer to Table 51)

Ranking	Environmental ranking	Costs (million €)	Code	Volume (kt)	Category name
1	3	2,348	37	22,580	Stony materials
2	1	471	1	3,958	Residual household waste (bulk-collected)
3	6	220	4	1,851	Commercial and institutional residual waste (retail, office and services only)
4		188	44	2,606	Waste wood, A- and B-grade
5	5	150	6	1,500	Water treatment sludge
6		117	48	1,000	Tar-containing asphalt
7	4[a]	87	2	671	Bulky household waste (total)
8		55	25	1,226	Separately collected garden waste
9		50	39	480	Screened sand
10		45	5	471	Waste from public spaces
11		40	71	800	Severely contaminated earth
12		36	65	151	Separately collected plastics waste
13		35	53	97	White and brown goods
14		34	93	271	Solvents, recyclable and low-halogen
15		32	92	34	Accumulators

Ranking	Environmental ranking	Costs (million €)	Code	Volume (kt)	Category name
16		28	60	35	HCW/HHW (excl. batteries and gasdischarge lamps)
17	11	23	88	138	Animal waste, SRM/HRM
18		15	108	34	Filter cakes (detoxification/ neutralisation/dewatering)
19		15	19	1,493	Wastes from coal-fired power stations
20		15	15	165	Sludge incinerator bottom ash
21		14	45	62	Waste wood, C-grade
22		13	7	157	Wastes from drinking water preparation
23		11	41	113	Roofing gravel
24		11	101	448	Sulphur-containing waste
25		10	49	43	Asbestos[b]

a In the environmental ranking only the share of carpeting is included.

b Waste disposal of asbestos is here taken to be in the C_2 waste storage facility, while for track A2 (cf. Section 4.3) so-called C_3 landfill in big bags (LAP-EIA A04) was assumed.

Although the differences between categories holding successive positions in the ranking are sometimes fairly large (a factor 1.5 to 5), they are generally around 10%. The difference between nos. 1 and 10 on the ranking is a factor 60, that between nos. 10 and 20 a factor 3. Given the uncertainties discussed in Section 2.5, the exact relative ranking is not significant, but the difference between numbers 1 and 10 is.

It is noteworthy that the top 6 with respect to costs is in reasonable agreement with the environmental ranking, although the sequence is different and separately collected paper and metals do not feature on the list at all, because of the low costs involved (on balance zero or negative). It is also noteworthy that substantial costs are incurred in the disposal of natural materials like waste wood, garden waste and screened sand which have only a modest environmental impact.

Given that plastics waste does not feature in the rankings on either track A1 or A2, the financial efforts devoted to addressing this stream would appear to be overly robust. It should be noted, though, that the estimated costs for this stream are probably on the high side (cf. Section 3.10). Given the uncertainties with respect to costs, recycling rates and degree of ‘downcycling’ (cf. Section 3.10), further research on this category may be in order.

Potential savings

An interesting check is whether there are categories in this cost ranking for which costs can be substantially reduced by means of suitable government policy. If this is the case, this might be a reason for possibly adding them to the list, based on this cost-saving potential.

Two categories with high costs that stand out are waste wood, A- and B-grade (€ 188 million) and separately collected garden waste (€ 55 million). From the perspective of energy policy these two ‘bio-streams’ are good candidates for renewable energy generation and thus carbon emissions reduction. In the case of waste wood, A- and B-grade, 50% use for power generation has already been assumed, but for garden waste the main disposal route is composting. The environmental gains to be derived from power generation are probably greater, however (cf. Section 3.3).

There are also a number of technologies under development (HTU for converting organic waste to biodiesel, for example) that will allow garden waste and wood to be used as a renewable energy feedstock. As the cost of these technologies falls, so too will the waste disposal costs for these two streams, with the prospect of net environmental gains emerging.

Cost effectiveness

The only way to draw any hard and fast conclusions on the cost effectiveness of waste disposal options is to compare the cost and environment impact of two different routes. What can be done though, is to focus additionally on those waste streams that score high on both environmental impact (track A2) and costs (track A3), for here it holds that relatively high costs are not apparently leading to low environmental impact. This is at any rate true of the various categories of residual waste (household, including bulky, and commercial and institutional), stony construction and demolition waste, water treatment sludge and animal waste, although the last of these to a slightly lesser degree. Whether or not there is scope for more cost-effective forms of waste disposal is a question that cannot be answered on the basis of this study, however. In the case of waste streams whereby disposal is associated with high costs and relatively little environmental impact, it can also be queried whether these high costs are really necessary, given the modest impact. Here, our premise has been that the high costs have been (part-)responsible for that modest impact and that there is no reason to assign these steams additional policy priority.

4.7 Combined ranking for lifecycle, waste and costs

Based on the above we obtain the following, indicative top 17 for priority treatment in Dutch waste policy.

Table 53 Top 17 for waste and recycling policy based on waste, lifecycle and cost tracks combined

Ranking	Code	Category name	Remarks
1	37	Stony materials	Over 2 billion costs, no. 3 on waste and lifecycle impacts combined
2	1	Residual household waste (bulk-collected)	No. 1 on waste/lifecycle combined
3	63	Separately collected paper and board	No. 2 on waste/lifecycle combined
4	2	Bulky household waste (total plus specifically carpeting)	No. 4 on waste/lifecycle combined (carpeting) and high costs
5	6	Water treatment sludge	No. 5 on waste/lifecycle combined
6	4	Commercial and institutional residual waste	No. 6 on waste/lifecycle combined
7	38	Gypsum	No. 7 on waste/lifecycle combined
8	9	Waste incinerator fly ash	No. 8 on waste/lifecycle combined
9	84	Shredder waste	No. 9 on waste/lifecycle combined
10	91	Batteries (incl. cat. 90)	No. 10 on waste/lifecycle combined
11	88	Animal waste (incl. cat. 89)	No. 11 on waste/lifecycle combined
12	22	Organic waste (incl. cat. 23 and bulk-collected)	No. 12 on waste/lifecycle combined
13	68	Metal waste, general	No. 6 on lifecycle impact
14	67	Separately collected textiles	No. 10 on lifecycle impact
15	44	Waste wood, A- and B-grade	Interesting for renewable energy and cost savings
16	25	Separately collected garden waste	Interesting for renewable energy and cost savings
17	76	Oil/water/sludge mixtures (plus SP12 and similar)	Waste disposal has major share in lifecycle impact (track A0)

For some of these categories, it may be added, it is not only the specific waste stream itself that deserves priority attention, but also a number of closely allied streams not explicitly included in our quantitative assessment. For example, although it is separately collected textiles that emerge here as a priority category, bulk-collected textiles obviously deserve similar attention, for the lifecycle impact of these is even greater (per unit weight). This is one of the reasons we gave consistent consideration in Chapter 3 to incinerator disposal of separately collected waste streams, as this gives an idea of the environmental performance of the bulk-collected stream.

It would therefore seem an obvious choice to also include category batteries (#90) and all forms of organic waste (#22, #23 and bulk-collected portion of household and commercial/institutional). Apart from their volume, a number of other types of construction and demolition waste are likely to be similar to category #37. Finally, some of the streams in Sectoral Plan 2 are also similar to certain categories in the top 16 ranking below.

4.8 Sectoral Plans 2 and 12

Sectoral Plans 2 (process-dependent industrial waste) and 12 (shipping-related wastes) were excluded from all three assessment tracks, for various reasons. In the case of SP2, the more than 60 sub-streams are extremely diverse and in many cases also immediately put to useful application. The aggregate volume is around 16 Mt, but over 50% of this figure is accounted for by 5 sub-streams only.

Table 54 Major streams of process-dependent industrial waste

Oilseed husks	19%
Furnace slag, bottom ash	15%
Plant waste not included elsewhere (foliage, bark, etc.)	7%
Beet pulp	6%
Animal waste (incl. dairy residues and slaughterhouse and fish waste)	6%

Oilseed husks and beet pulp are used mainly as animal feed. For the former category this application is even in fact one of the main drivers of the production chain, particularly in the case of soy, although the growing demand for vegetable oil for biodiesel is causing something of a shift in this respect. It is therefore a little misleading to designate this stream as 'waste'.

For 'Plant waste not included elsewhere' similar considerations hold as for organic waste, garden waste and wood waste: in terms of environmental impact a high-energy application is desirable, as composting performs little better than incinerator disposal. Animal waste already features in #89 and should as such be included in the priority listing. If the volume of this stream had been included with #88 in the analysis, this category would have been no.1 on track A1 according to several weighting methods, even assuming a lower lifecycle impact because Category 3 animal waste is often used as petfood.

In the case of SP12, the various sub-streams have already been included in other sectoral plans when it comes to waste disposal. The aggregate volume of SP12 waste is 233 kt, but it is very hard to determine its composition as well as the precise way it is treated in the various literature sources consulted. Given the occurrence of oil/water/sludge (OWS) mixtures in the ranking for track A0, this might also be the case for elements of SP12 (with a similar volume to OWS mixtures). It is for this reason that these are included in the ranking of Table 53 along with OWS mixtures *sensu stricto*.

5 Policy leverage

5.1 Introduction

In this final chapter we discuss several specific analysis-related issues and present a number of policy recommendations.

The waste streams selected for inclusion in the ultimate policy priority list presented in the previous chapter prove to fall into several distinct categories:

- High-volume streams with a low separation or recycling rate or low-grade secondary application ((bulky) household waste, commercial/institutional residual waste, stony CDW).
- Streams with high-priority 'material chains', as emerging from the 2004 CE/CML materials study (metals, animal waste, stony CDW, paper/board and organic waste).
- Streams for which the use phase is very predominant (end-of-life vehicles and tyres, gas-discharge lamps, textiles and carpeting).
- Streams for which waste disposal itself is the dominant factor in (toxic) emissions (water treatment sludge, gypsum CDW, incinerator fly ash, shredder waste and batteries).

In the following sections we discuss these issues in further detail.

5.2 Volume scale and separate collection

That the country's vast streams of residual waste are at the top of various rankings comes as no surprise. Household and commercial/institutional residual waste (both bulky and otherwise) comprises a number of priority streams like paper, organic waste and textiles. The stream of stony materials arising during construction and demolition likewise consists largely of priority materials according to the analysis of CE/CML (2004), but at 22 megatonnes it is also the largest waste stream by far. Although this stream is reused almost in its entirety, from an environmental perspective these are low-grade applications. The resultant savings on sand and gravel do not offset the relatively environmentally intensive pre-waste phase of the building materials in question. Cement production, in particular, is a very major source of CO_2 worldwide. A further reduction of cement use through use of alternative construction materials would be an interesting option in broader environmental terms.

It should be noted that for bulky household waste it was only the carpeting fraction that was reviewed on track A2. Nonetheless, this stream scores high on this track if incinerator disposal is assumed. This situation can be improved by increasing the share used as a secondary fuel or recycled (cf. CE, 2008).

For these streams prevention, at-source separation and high-grade application provide potential policy leverage. As discussed in Sections 3.21 and 3.22, when it comes to household and commercial/institutional residual waste, the main focus here should be on plastics and textiles. These account for a major share of the total impact of residual waste, and collection and useful application would lead to a distinct improvement in environmental performance.

5.3 Materials

A number of the priority streams identified here are congruent with the ‘priority material chains’ cited in the aforementioned materials study (CE/CML, 2004). This result is obviously not entirely coincidental, as the selection of streams for track A1 (cf. Appendix A) was itself based partly on that study.

One option for these streams is to seek improvement of the environmental profile of the pre-waste (i.e. production) phase, though in practice this is generally difficult because of the international nature of supply chains. In the case of metals, particularly, the impacts associated with the extraction phase may vary widely, and a greater degree of policy steering based on raw materials sourcing would probably lead to improvements here. One approach might be by way of sustainable procurement or ethical business models. In the case of copper, for example, it would make more sense for energy network operators and government agencies to initiate a ‘clean copper’ procurement drive. The question, though, is how this could be shaped from the angle of waste disposal policy. The differences between basic resource processing routes (blast furnace, smelting, refining) are relatively minor. It is above all differences in energy inputs (gas, oil, hydro) that matter here. In the case of livestock and farming, cutting back on meat consumption and switching to different sources of protein can potentially lead to major environmental gains.

Where feasible, materials substitution also provides a certain degree of leverage, but again this may be difficult to address from a waste policy perspective. As with attempts to improve product environmental profiles, this might be tackled via sustainable procurement programmes and environmental labelling. In the built environment, too, a similar direction might be pursued, as it is to be queried whether the lifecycle energy consumption of the materials used in low-energy dwellings is not now higher than the energy used for space heating, making a supply-chain component a possible useful addition to the Energy Performance standard.

Recycling (concrete, etc.) and prevention (avoidable organic waste) are the kind of policy measures that are more in line with traditional waste policy. In the Netherlands food losses (avoidable organic waste) are significant, with estimates as high as 20% of gross consumption. A Swedish study (Engström, 2004) indicates that food losses at food service institutions result in a significant acreage of ‘unnecessary’ landtake, 90% of which arises as a result of (avoidable) meat waste, even though this represents only 20% of the overall volume of food waste.

When it comes to plastics and glass (#65 and #50), the results presented in the present report differ from those of CE/CML (2004): these did not emerge as priority streams here, but did so in the materials study. The reason for this is that the categories in question form only part of the overall stream of waste plastics (specifically: separately collected plastics, excl. packaging) and glass (specifically: plate glass in CDW). The streams of residual waste (household and commercial/institutional; cf. Section 5.2) also contain plastics and glass, however, as does the category of packaging waste (not considered here).

5.4 Use phase

Five of the streams analysed in Chapter 3 are characterised by a use phase involving substantial energy consumption: end-of-life vehicles and tyres, textiles, carpeting (as part of bulky household waste) and gas-discharge lamps. Apart from carpeting, these categories all feature in the top 10 for lifecycle environmental impact (cf. Section 4.2).

For energy-consuming products, vehicles and gas-discharge lamps, the use phase is the dominant element of lifecycle impact. By analogy with vehicles, the same is probably also true of white and brown goods (cf. text box, page 85). For car tyres, too, it is the use phase that predominates in the overall lifecycle.

From the waste policy angle it is hard to bring any influence to bear on the use phase. The energy efficiency of a product is 'locked in' in the design phase, an issue that is already receiving plenty of attention from the angle of energy and climate policy.

An issue that does merit attention is the fact that improvements in energy efficiency are often accompanied by changes in the materials used in manufacture, with attendant effects in the waste phase. Examples include:

- Hybrid cars with heavy nickel-containing batteries.
- High-efficiency lamps containing mercury (though in small quantities).
- Use of lighter but more environmentally damaging materials like aluminium in vehicles.

It is up to climate and energy policy-makers to respond to these developments, for example via 'design for recycling' and by factoring in waste disposal impacts when promoting energy conservation. It is for this reason that the energy-consuming products have not been selected as priority waste categories.

With textiles and carpeting, the use phase involves the energy consumed in maintenance (i.e. cleaning) and the situation is therefore different. Making appliances like vacuum cleaners and washing machines more energy-efficient immediately has a positive influence on the lifecycle impact of these materials. Another important consideration is that proper maintenance extends the lifetime of clothing and carpeting, thus preventing unnecessary extra waste.

Only in the case of end-of-life tyres does waste disposal possibly have an impact on energy consumption in the use phase. By retreading tyres, various savings on materials and production steps are achieved, and when it comes to waste disposal this is therefore an environmentally attractive option. However, there is no data available on how these retreaded tyres compare with new tyres in terms of rolling resistance. This is an important factor in vehicle energy consumption and due allowance for this was therefore made in assessing the lifecycle impact of tyres (cf. Section 3.5). A sensitivity analysis has shown that an 8% increase in rolling resistance can offset the benefits of retreading entirely (Spriensma et al., 2001).

5.5 Waste disposal

There are a number of streams that score high on waste disposal itself, due in particular to toxic emissions. We are concerned here primarily with water treatment sludge, gysum CDW, incinerator fly ash, shredder waste and batteries, though the same holds for residual waste, too. The relative contribution of toxic emissions varies considerably depending on which weighting method is used, but policy focus on these emissions remains important. As it is waste-from-waste that is involved here, to an extent these emissions are governed by the composition of the incoming waste streams. The composition of residual (household, commercial/institutional) waste thus affects not only the environmental impacts resulting from of its own initial processing but also those associated with the processing of later incinerator residues. The impacts of shredder waste, for their part, can be reduced by ‘design-for-recycling’ with due attention to product composition.

Although dedicated collection of spent batteries is still on the rise, a significant portion is still getting to the waste disposal phase without being separated. In particular, the older generation of rechargeable NiCd batteries (many of them built into appliances) is now being discarded and should really be separately collected in their entirety. For these batteries, consideration might be given to introducing a deposit scheme or even possibly to prohibiting them altogether, for Li-ion and NiMH batteries are far superior alternatives in environmental terms.

Consideration should be given to finding a higher-quality application for waste gypsum. For the other streams, technological improvement is probably the best policy compass to steer by.

5.6 Materials or energy?

For a number of materials there is an ongoing debate about the respective merits of recycling and useful application. The analysis of paper in Chapter 3 gives an idea of the issues concerned. On many environmental themes, recycling is no better than incinerator disposal when it is total lifecycle impact that is being assessed. This is the case with climate change, for example, as was also observed in a study for the Dutch packaging tax (CE, 2007a).

An important methodological issue here is that, in LCAs, use of biotic resources is taken to be climate-neutral across the lifecycle as a whole, it being assumed that the resources in question will be replanted and equilibrium thus attained.

There are also indirect emissions, though, associated with land use and changes in land use (LULUC; cf. Section 3.9). This is a recurring debate in a number of policy fields, witness, for example, the observations by the Cramer Commission with regard to the CO_2 methodology employed for 'sustainable biomass' that the land use changes associated with the harvesting of biotic resources is a crucial issue that needs to be included in the greenhouse gas balance[35].

On the themes of land use and energy consumption (including renewable) the preference is clearly for recycling, though. Land use, in particular, is gaining ever greater prominence as an environmental theme as it becomes ever clearer internationally that government targets for bio fuels worldwide are leading to a growing scarcity of productive farmland and (thus) to increasing pressure on nature (CE, 2007b; MNP, 2007).

This is why, in weighting methods in which land use is factored in, preference is given to recycling. Just how great the impact of weighting method is in the case of precisely these biotic waste streams can be clearly seen in Appendix C.1. With the Greencalc weighting method, paper and board is the waste stream with the lowest (negative) aggregate score, while with the CE method it is the stream with the second highest (positive) score.

When considering the recycling of biotic resources it is therefore very important that land use (or associated biodiversity and other effects) be included in the equation. If the focus is solely on climate impact, the indirect emissions associated with land use should at any rate also be factored in.

There is a similar debate with respect to wood and organic waste (and other plant wastes). Because timber production requires little energy and the recycling of wood is not a closed cycle, but in fact always involves *downcycling* (chipboard, etc.) the balance might swing even more towards recycling. If high-grade recycling (the same application) is unfeasible, high-grade energy recovery (cf. Section 4.5) may be preferable. The same kind of issues are at stake when it comes to household and commercial/institutional residual waste, of which paper and organic waste constitute a substantial fraction (cf. Sections 3.21 and 3.22).

It is worth noting that in the case of a number of *abiotic* materials, too, materials recycling scores worse than use as a secondary fuel, a result that also emerged in LAP-EIA. This is the case with solvents (Section 3.20) and metal-working oils (Section 3.16), for example. Here, all the weighting methods give a similar picture, in contrast to the respective assessments of biotic materials.

5.7 Epilogue

In this study the lifecycle environmental impact of a selection of 22 waste categories from a total of over 110 was assessed. In terms of volume, these 22 waste streams make up around 50% of the total figure of 66 megatonnes. These

35 http://www.senternovem.nl/energietransitiegg/nieuws/duurzaamheidscriteria_voor_biomassa_opgesteld.asp.

22 categories were selected according to two criteria: their probably high environmental impact and the fact that they can also be used as a model for other categories. Given these considerations, this study has charted a considerable portion of the lifecycle impacts of the Netherlands' waste, all the more so because some of the categories that have not been included are also part of other chains (incinerator residues, shredder waste, industrial residues as animal feed). It should be noted once again, though, that the modelling exercises and quantitative data presented in this study are not such that the results can simply be summed.

The analyses show that certain categories of waste are not being optimally disposed of in terms of environmental impact. In particular, several forms of 'useful application' are leading to virtually no reduction in the lifecycle environmental impact of the material concerned, as in the case of stony construction and demolition waste. With several other categories this is the case, though, as with metals for which recycling rates are already excellent but lifecycle environmental impact still nonetheless high. This means that, alongside prevention, improving a material's basic environmental profile can also lead to a substantial reduction in environmental impact. This is not traditionally seen as being part of 'waste policy', though, and thought will have to be given to how these kind of issues can best be tackled, also given the many links and overlaps with other policy areas.

For reasons of environmental impact and/or cost, the 17 waste streams listed in Table 54 deserve to be prioritised in future Dutch waste policy. This does not necessarily mean that current policies on these waste categories are in need of review, though. Before any conclusions can be drawn on this point, more detailed studies are required on the cost and impact of alternative disposal options. Whatever the case, though, the prioritised streams merit additional policy focus in the coming policy planning period.

Table 55 Top 17 for waste and recycling policy based on waste impact, lifecycle impact and cost combined

	Code	Category name
1	37	Stony materials (construction and demolition waste)
2	1	Residual household waste (bulk-collected)
3	63	Separately collected paper and board
4	2	Bulky household waste (total plus specifically carpeting)
5	6	Water treatment sludge
6	4	Residual waste for trade, services and government
7	38	Gypsum (construction and demolition waste)
8	9	Waste incinerator fly ash
9	84	Shredder waste
10	91	Batteries (incl. cat. 90)
11	88	Animal waste (incl. cat. 89)
12	22	Organic waste (incl. cat. 23 and bulk-collected)
13	68	Metal waste, general
14	67	Separately collected textiles
15	44	Waste wood, A- and B-grade (construction and demolition waste)
16	25	Separately collected garden waste
17	76	Oil/water/sludge mixtures (plus SP12 and allied)

One surprising result is the fairly substantial overlap between the three different rankings (lifecycle environmental impact, environmental impact of waste disposal alone and waste disposal costs), though it should be borne in mind that only relatively few waste streams were included in the track A1 and A2 analyses. These streams were selected, however, on the basis of their anticipated high lifecycle impact. Within the first two tracks, too, there is a fair degree of correspondence between the different weighting methods used in this study, the only exception being the impacts associated with biotic materials. During further elaboration of the options for these biotic materials, due allowance should at any rate be made for the fact that land is becoming an increasingly scarce resource and that there is growing pressure to use biotic materials in high-value energy applications.

While providing a fairly substantial body of data, this study was unable to address a number of issues that would make the analysis even more useful, viz.:

1 A detailed analysis and review of concrete policy options for improving the situation with respect to the top 17 waste streams and then ranking these according to environmental impact, cost and cost effectiveness.
2 Household residual waste emerges from the analysis as the stream with the greatest environmental impact in the waste phase. Being a mix of different materials, for this waste stream in particular further analysis is required to elaborate options for improving the situation.
3 To assess the environmental impact of the key category of bulky household waste, this analysis focused on the share of carpeting. It is recommended to undertake further analysis of this category, encompassing all the various sub-streams and the diverse opportunities for improvement.
4 To an extent, current energy and climate policy is transferring environmental problems to the waste phase (as in case of high-efficiency lamps, hybrid cars and insulation materials, for example). If this kind of policy, too, were to become more lifecycle-oriented, there would be greater scope for satisfactorily addressing these issues.

References

ARN, 2007
ARN Milieujaarverslag (Environmental report) 2006
Amsterdam : Auto Recycling Nederland (ARN), 2007

Arnold, 2006
Olivier Arnold
Direction des Etudes Economiques et de l'Evaluation Environnementale
Efficacite de la Filiere Piles et Accumulateurs
Paris : French Ministry of the Environment, 2006

AOO, 2002
Milieueffectrapport Landelijk Afvalbeheer Plan (LAP) 2002-2012
Utrecht : Afval Overleg Orgaan (AOO), 2002

AJI-Europe, 2004
Information system on plastic waste management, European overview 2002+2003 data, for APME
Paris : AJI-Europe, 2004

Allwood, 2006
Julian M. Allwood, Søren E. Laursen, Cecilia M. de Rodriguez, Nancy M. P. Bocken
Well Dressed? The present and future sustainability of clothing and textiles in the UK : Mass balance and scenario analysis for UK clothing and textiles
Cambridge : University of Cambridge, 2006

BRBS, 2007
D. van de Hoeven (ed.)
Naar duurzaam grondstoffenmanagement : recycling als voorportaal
Zaltbommel : Branchevereniging Recycling Breken en Sorteren (BRBS), 2007

BRBS, 2007 (pers. comm. 22-10-2007)
Contact: Mr. de Vries

CE, 2002
Marc Davidson
Update schaduwprijzen
Delft : CE Delft, 2002

CE, 2003
Maartje Sevenster
Verwerkingsroutes voor tapijt : Toetsing aan criterium energie
Delft : CE Delft, 2003

CE/CML, 2004
Sander de Bruyn, Maartje Sevenster, Geert Warringa, Ester van der Voet, Lauran van Oers
Economic-wide materials flows and environmental policy :
An analysis of indicators and policy uses for economy-wide material flow policy
Delft/Leiden : CE Delft/CML, 2004

CE, 2006
Jan Vroonhof, Harry Croezen
Afvalverwerking en CO_2 : Quickscan van de broeikasgasemissies van de afvalverwerkingssector in Nederland 1990-2004
English summary
Delft : CE Delft, 2006

CE, 2006
Maartje Sevenster, Jan Vroonhof
Kunststoffen, harsen en additieven : Inzicht in de milieudruk binnen de keten
Delft : CE Delft, 2006

CE, 2007
Maartje Sevenster, Lonneke Wielders, Geert Bergsma, Jan Vroonhof
Milieukentallen van verpakkingen voor de verpakkingenbelasting in Nederland,
Delft : CE Delft, 2007

CE, 2007
Geert Bergsma, Bettina Kampman, Harry Croezen, Maartje Sevenster
Biofuels and their global influence on land availability for agriculture and nature :
A first evaluation and a proposal for further fact finding
Delft : CE Delft, 2007

CE, 2008
M. Sevenster, M. Otten
Hergebruik tapijt
Study for Senternovem (in progress)
Delft : CE Delft, 2008

CE, 2008
G.C. Bergsma, M. Sevenster
Update methodiek verpakkingenbelasting
Study for VROM (in progress)
Delft : CE Delft, 2008

ECN, 2006
Recycling aluminium : annex to ‘option document 2010/2020’
Petten : ECN, 2006

Engström, 2004
R. Engström, A. Carlsson-Kanyama
Food losses in food service institutions : Examples from Sweden
In : Food Policy 29 (2004), 203-213

Flanagan, 2003
J. Flanagan et al.
Glass recycling : life cycle carbon dioxide emissions
Sheffield : British glass manufacturers association, 2003

DEFRA, 2006
Karen Fisher, Erika Wallén, Pieter Paul Laenen, Michael Collins
Environmental Resources Management (ERM)
Battery Waste Management Life Cycle Assessment, final report
London : Defra, 2006

Greencalc method, 2002
www.greencalc.com, versie 2002

Huppes, 2003
G. Huppes, M.D. Davidson, J. Kuyper, L. van Oers, H.A. Udo de Haes, G. Warringa
Eco-efficient environmental policy in oil and gas production in the Netherlands
Leiden/Delft : CML/CE Delft, 2003

Idemat, 2001
Delft Technological University database
http://www.io.tudelft.nl/research/dfs/idemat/index.htm

Infomil, 2007
Oliefilters splitten in drie fracties
http://www.infomil.nl/aspx/get.aspx?xdl=/views/infomil/xdl/page&ItmIdt=158693&SitIdt=111&VarIdt=82&popup=true

Matheys, 2006
Julien Matheys, Jean-Marc Timmermans, Wout Van Autenboer, Joeri Van Mierlo, Gaston Maggetto, Sandrine Meyer, Arnaud the Groof, Walter Hecq, Peter Van den Bossche
Conference paper LCE2006 : Comparison of the environmental impact of 5 electric vehicle battery technologies using LCA
Leuven : Leuven Catholic University, 2006

NVMP, 2007
Over de verwijderingsbijdrage en de financiële voorzieningen voor toekomstige kosten van de inzameling en recycling van elektr(on)ische apparatuur
Zoetermeer : Stichting NVMP, 2007
http://www.nvmp.nl/uploaded/content/File/Aanpassingen%20juni/Final2Reactieverwijderingsbijdrage.pdf

MNP, 2007
B. ten Brink, R. Alkemade, M. Bakkenes, J. Clement, B. Eickhout, L. Fish, M. de Heer, T. Kram, T. Manders, H. van Meijl, L. Miles, C. Nellemann, I. Lysenko, M. van Oorschot, F. Smout, A. Tabeau, D. van Vuuren, H. Westhoek
Cross-roads of Life on Earth : Exploring means to meet the 2010 Biodiversity Target
Bilthoven : Milieu and Natuur Planbureau (Netherlands Environmental Assessment Agency), 2007

PRé Consultants, 1999
M. Goedkoop, R. Spriensma
Ecoindicator 1999 : A damage oriented method for life cycle impact assessment
Amersfoort : PRé Consultants B.V., 1999

PRé Consultants, 2001
R. Spriensma et al.
Life cycle assessment of an average European car tyre. Third party report 2001
Amersfoort : PRé Consultants B.V., 2001

Rense, 2005
De kosten van gemeenten voor verpakkingsafval en oud papier in 2004 en 2006 : Advice for VAOP Coöperatie
Hilversum : Rense Milieuadvies, 2005

Rendac, 2007
Verbonden met mens, dier en milieu : Jaarverslag 2006
Son : Rendac, 2007

TNO, 2004
O. Bordes, L. Feenstra, E. Roelofs
Materiaalkringloopsluiting gips in de bouwsector : haalbaarheidsproject
Apeldoorn : TNO Environment, Energy and Process Innovation, 2004

Tauw, 2007
Onderzoek bepalen kentallen methaan en lachgas composteerbedrijven
S.l. : Tauw, 2007

UA, 2004
Gemeentelijke benchmark afvalscheiding
Utrecht : SenterNovem, Uitvoering afvalbeheer, 2004

UA, 2005
Uitvoering Afvalbeheer
Nederlands afval in cijfers 2000-2004
Utrecht : SenterNovem, Uitvoering afvalbeheer, 2005

UA, 2006
Nederlands afval in cijfers 2000-2005,
Utrecht : SenterNovem, Uitvoering Afvalbeheer, 2006

UA, 2006a
Monitoring bedrijfsafval uit de KWD-sector 2005
Utrecht : SenterNovem, Uitvoering Afvalbeheer, 2006

UA, 2007
Monitoring rapportage huishoudelijk afval, resultaten 2005
Utrecht : SenterNovem, Uitvoering Afvalbeheer, 2007

UA, 2007
Afval van de doelgroep Verkeer en vervoer
http://www.senternovem.nl/uitvoeringafvalbeheer/Cijfers/Afvalcijfers/Afval_per_doelgroep/Verkeer_en_vervoer/index.asp

UA/Rense, 2007
Monitoringrapportage bouw- en sloopafval, resultaten 2004-2005,
Utrecht : SenterNovem, Uitvoering afvalbeheer, 2007

VRN, 2006
Jaarverslag Vlakglas Recycling Nederland 2006
Ridderkerk : VRN, 2007

VROM, 1996
Ministerie van VROM ; IPO (Interprovinciaal Overleg)
Milieu-effectrapport : Meerjarenplan gevaarlijke afvalstoffen II
The Hague : VROM (Netherlands Ministry of Housing, Spatial Planning and the Environment), 1996

VROM, 2002
Landelijk afvalbeheerplan 2002-2012 (LAP)
The Hague : VROM (Netherlands Ministry of Housing, Spatial Planning and the Environment), 2002

Zavin, 2007 (e-mail)
Contact: Mr L. Leest

CE Delft
Solutions for environment, economy and technology

Oude Delft 180
2611 HH Delft
The Netherlands
tel: +31 15 2 150 150
fax: +31 15 2 150 151
e-mail: ce@ce.nl
website: www.ce.nl
KvK 27251086

Future Dutch waste policy: priorities and leverage points

Appendices

Report

Delft, April 2008

Authors: Maartje Sevenster
Geert Bergsma
Derk Hueting
Lonneke Wielders
Femke Brouwer

A Waste streams and selection

A.1 Selection steps

The 34 sectoral plans detailed in the National Waste Management Plan (LAP) can be further subdivided into around 110 individual waste streams. For the purposes of the present study the following categorisation scheme was employed (Table 56). For policy prioritisation on tracks A1 and A2, in a series of subsequent 'rounds' a subset of streams was selected for quantitative assessment (see below).

Table 56 Initial selection for track A1 (lifecycle environmental impact), based on relevance for lifecycle strategy, feasibility of lifecycle assessment and anticipated trend in waste volume

LAP-1 sectoral plan	Code	Category name	Initial selection for track A1?	Why rejected?
1	1	Residual household waste	Yes	
	2	Bulky household waste	Yes (part bulk-collected)	
2	3	Process-dependent industrial waste	One stream singled out	
3	4	Residual waste for trade, services and government	Yes (Retail, office and services)	
4	5	Waste from public spaces		Not part of 'target product' chain
5	6	Water treatment sludge		Not part of 'target product' chain
	7	Wastes from drinking water preparation		
6	8	Waste incinerator bottom ash		Not part of 'target product' chain
	9	Waste incinerator fly ash		
	10	Flue gas treatment residues from waste incinerators, dry		
	11	Flue gas treatment residues from waste incinerators, wet		
	12	Rotary furnace fly ash		
	13	Rotary furnace bottom ash		
	14	Flue gas treatment residues from rotary furnaces		
	15	Sludge incinerator bottom ash		
	16	Sludge incinerator fly ash		
	17	Sludge incinerator carbon		
	18	Sludge incinerator filter cake		
7	19	Wastes from coal-fired power stations		Not part of 'target product' chain
	20	Wastes from combustion of wood and other high-calorific materials and biomass		
8	21	Gas-discharge lamps	Yes	
9	22	Household organic waste	Some fraction avoidable (product wastage)	
	23	Separately collected commercial and institutional organic waste		

LAP-1 sectoral plan	Code	Category name	Initial selection for track A1?	Why rejected?
	24	Bulk-collected commercial and institutional organic waste	Part of Retail, office and services	
	25	Separately collected garden waste		Pre-waste phase undefinable
10	26	Body parts and organs, infected waste, and cytotoxic and cytostatic medicines		Pre-waste phase too diverse or undefinable; no data relevant to waste policy
	27	Waste with infection risk		
11	28	End-of-life vehicles	Yes	
	29	End-of-life tyres	Yes	
12	30	Aqueous shipping waste containing chemicals		Pre-waste phase too diverse, lack of data. To an extent, not part of 'target product' chain
	31	Separated sludge fraction		
	32	Cargo-related wastes		
	33	Dry cargo residues		
	34	Separated chemicals		
	35	Non-aqueous shipping waste containing chemicals		
	36	Shipping-related sludge		
13	37	Stony materials	Yes	
	38	Gypsum and aerated concrete	Yes	
	39	Screened sand	Yes	
	40	Bituminous roofing waste	Yes	
	41	Roofing gravel	Yes	
	42	Tar mastic	Yes	No new input due to phase-out
	43	Roofing composites waste	Yes	
	44	Waste wood, A- and B-grade	Yes	
	45	Waste wood, C-grade	Yes	
	46	Cleanable blasting grit	From slag formation onwards	
	47	Non-cleanable blasting grit	From slag formation onwards	
	48	Tar-containing asphalt		No new input due to phase-out
	49	Asbestos		No new input due to phase-out
	50	Plate glass	Yes	
14	51	Separately collected packaging waste	Yes	
	52	Bulk-collected packaging waste	Yes (Retail, office and services)	
15	53	White and brown goods	Yes	
16	54	Waste ammunition		Pre-waste phase too diverse; lack of data
	55	Fireworks		
	56	Other explosive waste		
	57	LPG tanks		#59 singled out
	58	Gas cylinders		
	59	Hand-held fire extinguishers (small and large)	Yes	

LAP-1 sectoral plan	Code	Category name	Initial selection for track A1?	Why rejected?
17	60	HCW/HHW		Too diverse; in weight terms, largely packaging
	61	Waste paint packaging		
	62	Packaging with other hazardous constituents		
18	63	Separately collected paper and board	Yes	
	64	Rejects from paper processing	Yes	
19	65	Separately collected plastics waste	Yes	
	66	Bulk-collected plastics waste	Retail, office and services	
20	67	Separately collected textiles	Yes	
21	68	Metal waste, general	Yes	
	69	Metal waste contaminated with oils or emulsions		Too diverse, lack of data
	70	Recovered underground tanks		Comparable to #59
22	71	Severely contaminated earth		Pre-waste phase undefinable
23	72	Oil filters	Yes	
	73	Spent oil, Category I	Yes	
	74	Spent oil, Category II	Yes	
	75	Spent oil, Category III	Yes	
	76	Oil/water/sludge mixtures (+ residues)	Yes	
	77	Oil-containing sludges	Yes	
	78	Fuel residues	Yes	
	79	Oil-containing drilling muds and wastes	Yes	
	80	Metal-working oils	Yes	
	81	Solid and pasty oil-containing waste	Yes	
24	82	Equipment containing PCBs (and wastes)		No new input due to phase-out
	83	Oil containing PCBs (= spent oil, cat. IV)		
25	84	Shredder waste		Pre-waste phase already under 'End-of-life vehicles' and 'White & brown goods'
26	85	Paper- and plastic-insulated cables	Yes	
	86	Glassfibre cable waste	Yes	
27	87	Industrial wastewater		Too diverse, not a 'target product' chain
28	88	Animal waste, SRM/HRM	Yes	
	89	Animal waste, LRM	Yes	
29	90	Batteries (Ag, HgO, NiCd, Pb & AgO)	Yes	
	91	Batteries (zinc-carbon & alkaline)	Yes	
30	92	Accumulators	Yes	

LAP-1 sectoral plan	Code	Category name	Initial selection for track A1?	Why rejected?
31	93	Solvents, recyclable and low-halogen	One case singled out	
	94	Solvents, halogenated		
	95	Solvents, non-recyclable		
	96	Distillation residues		Already under #93-95
32	97	AsS sludge		Very small volumes and numbers of parties disposing. Mercury: no new input
	98	Hardening salts		
	99	Metal-containing plastics additives		
	100	Mercury-containing waste		
	101	Sulphur-containing waste	Yes	
	102	Sulphuric acid	Yes	
	103	Acid tars	Yes	
33	104	Iron-containing pickling liquor	Yes	
	105	Noble-metal-containing pickling liquor	Yes	No data
	106	Metal-containing wastewater with organic contaminants	Yes	
	107	Other acid-, base- and metal-containing wastewater		Too diverse, lack of data
	108	Filter cakes (detoxification/ neutralisation/dewatering)		Already under #104 & 106
34	109	Fixer and developer solutions (black & white)		Rapidly declining input
	110	Bleach fixer and colour developer solutions		
	111	Photographic hazardous waste		

Table 57 Second selection for track A1 (lifecycle environmental impact), based on volume and composition of waste stream and current knowledge of environmental impact of materials concerned, plus potential for using a different stream as a policy proxy

Code	Category name	Final selection for track A1	Comments
1	Residual household waste	Yes	Mainly paper, plastics & organic waste
2	Bulky household waste	Carpeting (see #67)	Remainder extremely diverse
3	Process-dependent industrial waste		Main streams plant-derived: compare SP9
4	Residual waste for trade, services and government	Yes	Mainly paper, plastics & organic waste
21	Gas-discharge lamps	Yes	
22	Household organic waste	Yes	Some fraction avoidable (product wastage)
23	Separately collected commercial and institutional organic waste	Yes	Some fraction avoidable (product wastage)
24	Bulk-collected commercial and institutional organic waste		Under #4
28	End-of-life vehicles	Yes	
29	End-of-life tyres	Yes	
37	Stony materials	Yes	
38	Gypsum	Yes	(Aerated concrete under #37)
39	Screened sand		Compare #37, volume ~2%
40	Bituminous roofing waste		Volume small
41	Roofing gravel		Compare #37, volume < 1%
43	Roofing composites waste		Volume unknown
44	Waste wood, A- and B-grade		Not a priority material chain
45	Waste wood, C-grade		Not a priority material chain
46	Cleanable blasting grit		Low-impact chain from slag formation onwards
47	Non-cleanable blasting grit		Low-impact chain from slag formation onwards
50	Plate glass	Yes	
51	Separately collected packaging waste		Total lifecycle impact low
52	Bulk-collected packaging waste		Under #4
53	White and brown goods		Lifecycle similar to #28 (policy proxy; magnitude: approx. 1/3 of #28)
59	Hand-held fire extinguishers (small and large)		As metal (#68)
63	Separately collected paper and board	Yes	
64	Rejects from paper processing		Small volume, under SP 2
65	Separately collected plastics waste	Yes	
66	Bulk-collected plastics waste		Under #4 (Retail, office and services)
67	Separately collected textiles	Yes	Carpeting and other textiles separate
68	Metal waste, general	Yes	
72	Oil filters		Volume small
73	Spent oil, category I		Compare #75
74	Spent oil, category II		Compare #75
75	Spent oil, category III	Yes	

Code	Category name	Final selection for track A1	Comments
76	Oil/water/sludge mixtures (+ residues)	Yes	
77	Oil-containing sludges		Compare #76
78	Fuel residues		Compare #75
79	Oil-containing drilling muds and wastes		Compare #76
80	Metal-working oils	Yes	
81	Solid and pasty oil-containing waste		Compare #75
85	Paper- and plastic-insulated cables		Volume negligible
86	Glassfibre cable waste		Volume negligible
88	Animal waste, SRM/HRM	Yes	Chains and minimum standard the same
89	Animal waste, LRM		
90	Batteries (Ag, HgO, NiCd, Pb & AgO)		Similar to #91 in policy terms; volume slightly smaller
91	Batteries (zinc-carbon & alkaline)	Yes	
92	Accumulators	Yes	
93	Solvents, recyclable and low-halogen	Toluene singled out	
94	Solvents, halogenated		
95	Solvents, non-recyclable		
101	Sulphur-containing waste		Volume small/unknown
102	Sulphuric acid		Volume small/unknown
103	Acid tars		Volume small/unknown
104	Iron-containing pickling liquor		Volume small/unknown
106	Metal-containing wastewater with organic contaminants		Volume small/unknown

Table 58 Final selection for track A1 (full lifecycle assessment) and track A2 (waste disposal; as selection A1, but supplemented with LAP-EIA streams)

LAP-1 sectoral plan	Code	Category name	Track A1 quantitative	Track A2 (A1 + LAP-EIA streams)
1	1	Residual household waste	Yes	Yes
	2	Bulky household waste	Yes (incl. carpeting)	Yes
2	3	Process-dependent industrial waste		
3	4	Residual waste for trade, services and government	Yes	Yes
4	5	Waste from public spaces		
5	6	Water treatment sludge		Yes (A27)
	7	Wastes from drinking water preparation		
6	8	Waste incinerator bottom ash		
	9	Waste incinerator fly ash		Yes (A25)
	10	Flue gas treatment residues from waste incinerators, dry		Yes (A21)
	11	Flue gas treatment residues from waste incinerators, wet		Yes (A20)
	12	Rotary furnace fly ash		Yes (A26)
	13	Rotary furnace bottom ash		
	14	Flue gas treatment residues from rotary furnaces		

LAP-1 sectoral plan	Code	Category name	Track A1 quantitative	Track A2 (A1 + LAP-EIA streams)
	15	Sludge incinerator bottom ash		
	16	Sludge incinerator fly ash		
	17	Sludge incinerator carbon		
	18	Sludge incinerator filter cake		
7	19	Wastes from coal-fired power stations		
	20	Wastes from combustion of wood and other high-calorific materials and biomass		
8	21	Gas-discharge lamps	Yes	Yes (A12)
9	22	Household organic waste	Yes	Yes (A14)
	23	Separately collected commercial organic waste		
	24	Bulk-collected commercial and institutional waste	Yes (Retail, office and services)	
	25	Separately collected garden waste		Yes (A15)
10	26	Body parts and organs, infected waste, and cytotoxic and cytostatic medicines		
	27	Waste associated risk of infection		
11	28	End-of-life vehicles	Yes	Yes
	29	End-of-life tyres	Yes	Yes
12	30	Aqueous shipping waste containing chemicals		
	31	Separated sludge fraction		
	32	Cargo-related wastes		
	33	Dry cargo residues		
	34	Separated chemicals		
	35	Non-aqueous shipping waste containing chemicals		
	36	Shipping-related sludge		
13	37	Stony materials	Yes	Yes
	38	Gypsum	Yes	Yes
	39	Screened sand		
	40	Bituminous roofing waste		
	41	Roofing gravel		
	42	Tar mastic		Yes (A24)
	43	Roofing composites waste		
	44	Waste wood, A- and B-grade		
	45	Waste wood, C-grade		
	46	Cleanable blasting grit		Yes (A23)
	47	Non-cleanable blasting grit		
	48	Tar-containing asphalt		
	49	Asbestos		Yes (A04)
	50	Plate glass	Yes	Yes
14	51	Separately collected packaging waste		
	52	Bulk-collected packaging waste		
15	53	White and brown goods		
16	54	Waste ammunition		
	55	Fireworks		
	56	Other explosive waste		
	57	LPG tanks		
	58	Gas cylinders		

LAP-1 sectoral plan	Code	Category name	Track A1 quantitative	Track A2 (A1 + LAP-EIA streams)
	59	Hand-held fire extinguishers (small and large)		
17	60	HCW/HHW		? (A13)
	61	Waste paint packaging		
	62	Packaging with other hazardous constituents		
18	63	Separately collected paper and board	Yes	Yes
	64	Rejects from paper processing	Yes	
19	65	Separately collected plastics waste	Yes	Yes
	66	Bulk-collected plastics waste	Yes (Retail, office and services)	
20	67	Separately collected textiles	Yes	Yes
21	68	Metal waste, general	Yes	Yes
	69	Metal waste contaminated with oils or emulsions		
	70	Recovered underground tanks		
22	71	Severely contaminated earth		
23	72	Oil filters		
	73	Spent oil, category I		
	74	Spent oil, category II		
	75	Spent oil, category III	Yes	Yes (A03)
	76	Oil/water/sludge mixtures (+ residues)	Yes	Yes (A19)
	77	Oil-containing sludges		
	78	Fuel residues		
	79	Oil-containing drilling muds and wastes		? (A06)
	80	Metal-working oils	Yes	Yes (A06)
	81	Solid and pasty oil-containing waste		
24	82	Equipment containing PCBs (and wastes)		
	83	PCB-containing oil (= spent oil, cat. IV)		
25	84	Shredder waste		Yes (A22)
26	85	Paper- and plastic-insulated cables		
	86	Glassfibre cable waste		
27	87	Industrial wastewater		
28	88	Animal waste, SRM/HRM	Yes	Yes
	89	Animal waste, LRM		
29	90	Batteries (Ag, HgO, NiCd, Pb & AgO)		
	91	Batteries (zinc-carbon & alkaline)	Yes	Yes (A05)
30	92	Accumulators	Yes	
31	93	Solvents, recyclable and low-halogen	One case singled out	Yes (A18)
	94	Solvents, halogenated		
	95	Solvents, non-recyclable		
	96	Distillation residues		
32	97	AsS sludge		
	98	Hardening salts		
	99	Metal-containing plastics additives		
	100	Mercury-containing waste		Yes (A16)
	101	Sulphur-containing waste		
	102	Sulphuric acid		
	103	Acid tars		

LAP-1 sectoral plan	Code	Category name	Track A1 quantitative	Track A2 (A1 + LAP-EIA streams)
33	104	Iron-containing pickling liquor		
	105	Noble-metal-containing pickling liquor		
	106	Metal-containing wastewater with organic contaminants		
	107	Other acid-, base- and metal-containing wastewater		
	108	Detoxification/deneutralisation/dewatering filter cake		Yes (A17)
34	109	Fixer and developer solutions (black & white)		Yes (A10,11)
	110	Bleach fixer and colour developer solutions		Yes (A07, A08?)
	111	Photographic hazardous waste		Yes (A09)

Table 59 LAP-EIA processing options considered in this study for waste categories in A2 not included in A1

Code	Name	LAP-EIA processing option
6	Water treatment sludge	Incineration
9	Waste incinerator fly ash	'Versatzbau'
12	Rotary furnace fly ash	Landfill: cold immobilisation
10	Flue gas treatment residues from waste incinerators, dry	Landfill: big bags
11	Flue gas treatment residues from waste incinerators, wet	Landfill: cold immobilisation
25	Separately collected garden waste	Composting
42	Tar mastic	Incineration
47	Non-cleanable blasting grit	Landfill
49	Asbestos	Landfill
61	Waste paint packaging	Cryogenic (mixed packaging)
84	Shedder waste	Landfill
100	Mercury-containing waste	Vacuum distillation
108	Filter cakes (detoxification/neutralisation/dewatering)	C_2 waste storage facility
109	Fixer and developer solutions (black & white)	Average of options and fix./dev.
110	Bleach fixer and colour developer solutions	Average of options and fix./dev.
111	Photographic hazardous waste	Average of options

A.2 Volume and cost data used

Table 60 provides a synopsis of the cost and volume data employed in the present study for each waste stream. In cases where the volume is zero, this is explicitly indicated. Where volumes or costs are unknown, this is indicated by'?'.

Table 60 Volume and cost data (italicised codes: changed order; volumes in brackets: different volumes in track A1 and A2; see explanation, Chapter 3)

Code	Name	Volume (kt)	Source	Cost (€/tonne)	Source
1	Residual household waste	3,958 (3,792)	MNP data, CBS data for 2005	119	UA, 2004
2	Bulky household waste	671 (11)	UA, 2007	129	UA, 2004
3	Process-dependent industrial waste	16,091	CBS data for 2003	n.a.	-
4	Residual waste for trade, services and government	1,851	UA, 2006a[36]	119	UA, 2004
5	Waste from public spaces	471	Based on Euralcodes	96	Expert judgement JVr
6	Water treatment sludge	1,500	UA, 2005	100	Expert judgement JVr
7	Wastes from drinking water preparation	157	Based on Euralcodes	81	Expert judgement JVr
8	Waste incinerator bottom ash	820	UA, 2005	12	Expert judgement DH
13	Rotary furnace bottom ash	0	No rotary furnaces in NL		
15	Sludge incinerator bottom ash	165	UA, 2005	90	Expert judgement DH
9	Waste incinerator fly ash	82	UA, 2005	110	Expert judgement DH
12	Rotary furnace fly ash	0	No rotary furnaces in NL		
16	Sludge incinerator bottom ash	17	UA, 2005	110	
10	Flue gas treatment residues from waste incinerators, dry	38	UA, 2005	130	Expert judgement DH
11	Flue gas treatment residues from waste incinerators, wet	2	Based on Euralcodes	130	Expert judgement DH
14	Flue gas treatment residues from rotary furnaces	0	No rotary furnaces in NL		
17	Sludge incinerator carbon	0	Based on Euralcodes	90	Expert judgement DH
18	Sludge incinerator filter cake	8	Based on Euralcodes	90	Expert judgement DH
19	Wastes from coal-fired power stations	1,493	Based on Euralcodes	10	Expert judgement DH
20	Wastes from combustion of wood and other high-calorific materials and biomass	-	Under different SP (#19)	-	-
21	Gas-discharge lamps	4	Based on Euralcodes	775	Based on LAP-EIA
22	Household organic waste	136	UA, 2007 (product wastage fraction only; cf. Chapter 3)	46	Based on LAP-EIA
23	Separately collected commercial and institutional organic waste	36	UA, 2007 (product wastage fraction only; cf. Chapter 3)	46	Based on LAP-EIA
24	Bulk-collected commercial and institutional organic waste	-	Under different SP	-	-

[36] Excluding separately collected waste (paper/board, glass, wood, textiles, plastics) and all metal waste. These waste streams are included in the sectoral plans for the relevant materials.

Code	Name	Volume (kt)	Source	Cost (€/tonne)	Source
25	Separately collected garden waste	1,226	UA, 2007	45	Expert judgement MSe
26	Body parts and organs, infected waste, and cytotoxic and cytostatic medicines	8	Zavin, 2007	750	Zavin, 2007
27	Waste with infection risk	?	-	?	-
28	End-of-life vehicles	276	Based on Euralcodes	16	ARN, 2006
29	End-of-life tyres	100	UA, 2007a	70	Based on *Besluit Beheer Autobanden*
30	Aqueous shipping waste containing chemicals	-	Under different SP	-	-
31	Separated sludge fraction	-	Under different SP	-	-
32	Cargo-related wastes	-	Under different SP	-	-
33	Dry cargo residues	-	Under different SP	-	-
34	Separated chemicals	-	Under different SP	-	-
35	Non-aqueous shipping waste containing chemicals	-	Under different SP	-	-
36	Shipping-related sludge	-	Under different SP	-	-
37	Stony materials	22,580	UA/Rense, 2007	104	BRBS, 2007
38	Gypsum	200	UA/Rense, 2007	13	BRBS, 2007
39	Screened sand	480	UA/Rense, 2007	104	BRBS, 2007
40	Bituminous roofing waste	6	UA/Rense, 2007	100	Based on LAP-EIA
41	Roofing gravel	113	UA/Rense, 2007	99	BRBS, 2007
42	Tar mastic	8	UA/Rense, 2007	100	Based on LAP-EIA
43	Roofing composites waste	?	-	58	Based on LAP-EIA
44	Waste wood, A- and B-grade	2,606	UA/Rense, 2007	72	UA, 2004
45	Waste wood, C-grade	62	UA/Rense, 2007	230	C_2 storage facility
46	Cleanable blasting grit	7	UA/Rense, 2007	0	Based on LAP-EIA
47	Non-cleanable blasting grit	16	UA/Rense, 2007	58	Based on LAP-EIA
48	Tar-containing asphalt	1,000	Expert judgement SenterNovem	117	Based on LAP-EIA
49	Asbestos	43	UA/Rense, 2007	230	Based on VROM, 2002
50	Plate glass	74	Plate glass recycling (2007 collection data)	35	Waste disposal fee 0.50 €/m^2
51	Separately collected packaging waste	1,827	O.b.v. UA, 2006a and UA 2007	0	Estimate for 100% useful application; large share of paper

Code	Name	Volume (kt)	Source	Cost (€/tonne)	Source
52	Bulk-collected packaging waste	-	Under different SP (#1,3)	-	-
53	White and brown goods	97	Based on Euralcodes	360	NVMP, 2007
54	Waste ammunition	0	Based on Euralcodes	-	Small
55	Fireworks	0.2	Based on Euralcodes	-	Small
56	Other explosive waste	0.1	Based on Euralcodes	-	Small
57	LPG tanks	0.01	Based on Euralcodes	-	Small
58	Gas cylinders	0.01	Based on Euralcodes	-	Small
59	Hand-held fire extinguishers (small and large)	1.5	Based on Euralcodes	-	Small
60	HCW/HHW	35	Based on UA, 2005 and expert judgement SenterNovem	788	UA, 2004
61	Waste paint packaging	7	Based on UA, 2005 and expert judgement SenterNovem	788	Based on UA, 2004
62	Packaging with other hazardous constituents	?	?	788	Based on UA, 2004
63	Separately collected paper and board	2,461	Based on Euralcodes	0	Returns more or less equal to costs
64	Rejects from paper processing	12	Based on CE, 2007a	?	-
65	Separately collected plastics waste	151	Based on Euralcodes; waste from MFSU[37] under SP2FD	240	Upper limit, based on Rense, 2005 (cf. Chapter 3)
66	Bulk-collected plastics waste	-	Under different SP		
67	Separately collected textiles	71	Based on Euralcodes	18	UA, 2004
68	Metal waste, general	1,098	Based on Euralcodes	0	UA, 2004 (net returns)
69	Metal waste contaminated with oils or emulsions	2	Based on Euralcodes	?	Small
70	Recovered underground tanks	?	-	?	Small
71	Severely contaminated earth	800	Based on UA, 2006 and expert judgement SenterNovem	50	Based on SenterNovem, bodem+
72	Oil filters	2	Based on Euralcodes	390	Infomil, 2007
73	Spent oil, category I	28	UA, 2005	120	Based on LAP-EIA
74	Spent oil, category II	0	Assumed minor rel. to #73 and #75	?	-
75	Spent oil, category III	28	UA, 2005	120	Based on LAP-EIA
76	Oil/water/sludge mixtures (+ residues)	180	Expert judgement SenterNovem	44	LAP-EIA

[37] Manufacture, Formulation, Supply and Use.

Code	Name	Volume (kt)	Source	Cost (€/tonne)	Source
77	Oil-containing sludges	25	Based on Euralcodes	100	Estimate based on #76
78	Fuel residues	49	Based on Euralcodes	?	-
79	Oil-containing drilling muds and wastes	34	UA, 2005	?	-
80	Metal-working oils	30	Based on VROM, 1996	4	LAP-EIA
81	Solid and pasty oil-containing waste	?	-	?	-
82	Equipment containing PCBs (and wastes)	2	Based on Euralcodes and expert judgement SenterNovem	?	-
83	Oil containing PCBs (= spent oil, cat. IV)	0.4	Based on Euralcodes and expert judgement SenterNovem	140	Based on LAP-EIA
84	Shredder waste	136	UA, 2005[38]	58	Based on LAP-EIA
85	Paper- and plastic-insulated cables	2	Expert judgement SenterNovem	?	-
86	Glassfibre cable waste	0	Based on Euralcodes	?	-
87	Industrial wastewater	318	Based on Euralcodes	?	-
88	Animal waste, SRM/HRM	138	Rendac, 2007	165	Based on Rendac, 2007
89	Animal waste, LRM	954	CBS, 2003 industrial waste data	?	-
90	Batteries (Ag, HgO, NiCd, Pb & AgO)	1	Based on Euralcodes	0	StiBat, 2007
91	Batteries (zinc-carbon & alkaline)	2	Based on Euralcodes	2.500	Based on Arnold, 2005
92	Accumulators	34	Based on Euralcodes	946	Based on UA, 2006 and Fisher et al., 2006
93	Solvents, recyclable and low-halogen	271	Total SP 339 kt, allocation based on Euralcodes	125	Based on LAP-EIA
94	Solvents, halogenated	51	Total SP 339 kt, allocation based on Euralcodes	125	Based on LAP-EIA
95	Solvents, non-recyclable	10	Total SP 339 kt, allocation based on Euralcodes	174	Based on LAP-EIA
96	Distillation residues	7	Total SP 339 kt, allocation based on Euralcodes	0	-
97	AsS sludge	0.03	Based on Euralcodes	230	C_2 storage facility
98	Hardening salts	0	Expert judgement SenterNovem	230	C_2 storage facility
99	Metal-containing plastics additives	0	Expert judgement SenterNovem	166	Based on UA, 2006

[38] Volume after separation of metals.

Code	Name	Volume (kt)	Source	Cost (€/tonne)	Source
100	Mercury-containing waste	2	Expert judgement SenterNovem	43	Based on UA, 2006
101	Sulphur-containing waste	448	Expert judgement SenterNovem	24	Based on UA, 2006
102	Sulphuric acid	4	Based on Euralcodes	12	Based on UA, 2006
103	Acid tars	11	Based on Euralcodes	230	C_2 storage facility
104	Iron-containing pickling liquor	6	Expert judgement SenterNovem	80	VROM, 1996[39]
105	Noble-metal-containing pickling liquor	?	-	?	-
106	Metal-containing wastewater with organic contaminants	?	-	?	-
107	Other acid-, base- and metal-containing wastewater	?	-	?	-
108	Filter cakes (detoxification/neutralisation/dewatering)	34	Based on Euralcodes	450	LAP-EIA
109	Fixer and developer solutions (black & white)	7	Based on Euralcodes and expert judgement SenterNovem	?	-
110	Bleach fixer and colour developer solutions	0	Based on Euralcodes and expert judgement SenterNovem	?	-
111	Photographic hazardous waste	7	Based on Euralcodes	?	-

[39] Use of HCl.

B Background data on individual waste streams

B.1 Gas-discharge lamps (#21)

The following waste disposal scenarios were assessed:

1 100% shredder.
2 100% end-cut/air-push.

Table 61 Lifecycle impact, *including use phase* (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	12.372	12.372	0.00%
Climate change (GWP100)	1,623.365	1,623.366	0.00%
Ozone layer depletion (ODP)	0.000	0.000	0.00%
Human toxicity (HTP)	365.175	365.405	0.06%
Freshwater ecotoxicity (FAETP)	25.459	25.459	0.00%
Terrestrial ecotoxicity (TETP)	20.276	20.272	0.02%
Smog formation (POCP)	0.109	0.109	0.05%
Acidification (AP)	2.565	2.565	0.01%
Eutrophicastion (EP)	0.313	0.313	0.01%
Land use (m^2 year)	29.360	29.361	0.00%
Final waste (kg)	14.112	14.083	0.21%
Water consumption (m^3)	1,233.794	1,233.209	0.05%
Energy consumption (MJprim)	26,573.688	26,573.258	0.00%

Table 62 Impact of waste phase (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	0.0005955	0.0007215	17%
Climate change (GWP100)	0.089806293	0.091266301	2%
Ozone layer depletion (ODP)	2.05E-09	5.9E-11	97%
Human toxicity (HTP)	-0.0176	0.213	108%
Freshwater ecotoxicity (FAETP)	0.000916	0.000467	49%
Terrestrial ecotoxicity (TETP)	0.0205	0.01735	15%
Smog formation (POCP)	-0.0000465	0.0000129	460%
Acidification (AP)	0.0000228	0.0001565	85%
Eutrophicastion (EP)	2.40235E-05	0.00006265	62%
Land use (m^2 year)	-0.002975	-0.002	-49%
Final waste (kg)	-0.0362	-0.06535	-81%
Water consumption (m^3)	3.88	3.295	15%
Energy consumption (MJprim)	0.619	0.1895	69%

B.2 Household and other organic waste (SP9)

The following waste disposal scenarios were assessed:

1 95% composting, 5% digestion.
2 100% bulk collection and incinerator disposal.
3 100% gasification and co-firing in power station.

The impacts of waste disposal were taken from LAP-EIA (A14). Because the Ecoinvent-data are based on short-cycle CO_2 uptake at the beginning of the cycle and release at the end, the short-cycle emissions had to be added to the LAP-EIA data. Taking a dry-matter content of 40% and a carbon content of 29% gives a CO_2 emission of 0.425 kg per kg organic waste incinerated. With composting, the effective emission is 0.383 kg CO_2 per tonne organic waste (10% net carbon fixation). For composting, moreover, emissions of methane (from 2,400 to 169 grams per tonne) and nitrous oxide (from 96 to 70 grams per tonne) were adjusted to accommodate the latest findings of Tauw (2007).

Table 63 Lifecycle impact (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Scenario 3	Variation
Abiotic depletion (ADP)	0.0012	0.0016	-0.0017	204%
Climate change (GWP100)	-0.0644	0.1088	-0.2836	361%
Ozone layer depletion (ODP)	1.9E-08	2.1E-08	-9.9E-09	146%
Human toxicity (HTP)	0.1578	0.1612	0.1343	17%
Freshwater ecotoxicity (FAETP)	0.2941	0.2945	0.2932	0%
Terrestrial ecotoxicity (TETP)	0.0556	0.0558	0.0554	1%
Smog formation (POCP)	4.2E-05	4.0E-05	-2.1E-05	151%
Acidification (AP)	0.0025	0.0024	0.0013	49%
Eutrophicastion (EP)	0.0028	0.0027	0.0025	8%
Land use (m^2 year)	0.8879	0.8883	0.8851	0%
Final waste (kg)	0.1091	0.0517	-0.0337	131%
Water consumption (m^3)	1.2813	1.5959	-11.9601	849%
Energy consumption (MJprim)	11.5647	12.1994	7.7604	36%

Table 64 Scores over the waste phase (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Scenario 3	Variation
Abiotic depletion (ADP)	-3.56E-05	3.94E-04	-2.94E-03	846%
Climate change (GWP100)	2.99E-01	4.72E-01	7.98E-02	83%
Ozone layer depletion (ODP)	-3.53E-10	1.72E-09	-2.96E-08	1,821%
Human toxicity (HTP)	-8.65E-05	3.30E-03	-2.36E-02	815%
Freshwater ecotoxicity (FAETP)	-1.16E-04	2.62E-04	-1.08E-03	512%
Terrestrial ecotoxicity (TETP)	-4.77E-05	1.59E-04	-2.07E-04	230%
Smog formation (POCP)	1.31E-05	1.09E-05	-5.02E-05	483%
Acidification (AP)	3.01E-04	2.02E-04	-9.27E-04	408%
Eutrophicastion (EP)	1.39E-04	6.73E-05	-8.71E-05	163%
Land use (m^2 year)	9.16E-04	1.31E-03	-1.89E-03	244%
Final waste (kg)	7.62E-02	1.88E-02	-6.66E-02	187%
Water consumption (m^3)	2.41E-01	5.56E-01	-1.30E+01	2,438%
Energy consumption (MJprim)	-3.57E-02	5.99E-01	-3.84E+00	741%

B.3 End-of-life vehicles (#28)

The following waste disposal scenarios were assessed:

1 83% materials recycling, 10% shredder waste to landfill.
2 83% materials recycling, 10% shredder waste to pyrolysis.
3 95% materials recycling, 5% shredder waste to landfill.

Table 65 Lifecycle impact, *including use phase* (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Scenario 3	Variation
Abiotic depletion (ADP)	0.209	0.209	0.206	2%
Climate change (GWP100)	32.898	32.820	32.689	1%
Ozone layer depletion (ODP)	0.000	0.000	0.000	0%
Human toxicity (HTP)	20.872	20.864	20.767	1%
Freshwater ecotoxicity (FAETP)	1.123	1.121	1.118	0%
Terrestrial ecotoxicity (TETP)	0.049	0.049	0.047	3%
Smog formation (POCP)	0.039	0.039	0.039	0%
Acidification (AP)	0.140	0.140	0.138	2%
Eutrophicastion (EP)	0.021	0.021	0.021	1%
Land use (m^2 year)	0.202	0.199	0.200	1%
Final waste (kg)	0.526	0.392	0.474	34%
Water consumption (m^3)	24.897	24.895	24.828	0%
Energy consumption (MJprim)	484.511	483.300	476.319	2%

Table 66 Impact of waste phase (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Scenario 3	Variation
Abiotic depletion (ADP)	-6.64E-03	-7.35E-03	-1.01E-02	-52%
Climate change (GWP100)	-6.88E-01	-7.66E-01	-8.97E-01	-30%
Ozone layer depletion (ODP)	-4.84E-08	-5.37E-08	-5.05E-08	-11%
Human toxicity (HTP)	-1.82E+00	-1.83E+00	-1.93E+00	-6%
Freshwater ecotoxicity (FAETP)	-3.71E-01	-3.72E-01	-3.76E-01	-1%
Terrestrial ecotoxicity (TETP)	-1.25E-02	-1.27E-02	-1.41E-02	-12%
Smog formation (POCP)	-4.02E-04	-4.27E-04	-4.80E-04	-19%
Acidification (AP)	-4.60E-03	-4.97E-03	-6.90E-03	-50%
Eutrophicastion (EP)	-5.69E-04	-6.12E-04	-7.19E-04	-26%
Land use (m^2 year)	-3.57E-02	-3.86E-02	-3.75E-02	-8%
Final waste (kg)	-2.80E-02	-1.63E-01	-8.07E-02	-482%
Water consumption (m^3)	-7.64E+00	-7.64E+00	-7.71E+00	-1%
Energy consumption (Mjprim)	-1.39E+01	-1.51E+01	-2.20E+01	-59%

B.4 End-of-life tyres (#29)

The following waste disposal scenarios were assessed:

1. 45% materials recycling and 55% incineration with energy recovery (ref.).
2. 100% materials recycling.

Table 67 Lifecycle impact, *incl. use phase* (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	0.361	0.356	1.38%
Climate change (GWP100)	57.682	56.315	2.43%
Ozone layer depletion (ODP)	0.000	0.000	1.95%
Human toxicity (HTP)	34.400	33.953	1.32%
Freshwater ecotoxicity (FAETP)	0.893	0.750	19.01%
Terrestrial ecotoxicity (TETP)	0.062	0.058	7.05%
Smog formation (POCP)	0.066	0.066	0.30%
Acidification (AP)	0.220	0.216	1.91%
Eutrophicastion (EP)	0.036	0.035	1.63%
Land use (m^2 year)	0.259	0.230	12.59%
Final waste (kg)	0.332	0.252	31.96%
Water consumption (m^3)	18.950	16.799	12.81%
Energy consumption (Mjprim)	830.733	814.164	2.04%

Table 68 Impact of waste phase (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	-0.115	-0.158	-37%
Climate change (GWP100)	0.807	-11.093	1,475%
Ozone layer depletion (ODP)	-1.08E-06	-2.33E-06	-116%
Human toxicity (HTP)	-3.510	-7.403	-111%
Freshwater ecotoxicity (FAETP)	-0.934	-2.176	-133%
Terrestrial ecotoxicity (TETP)	-0.029	-0.065	-122%
Smog formation (POCP)	-0.002	-0.004	-91%
Acidification (AP)	-0.044	-0.080	-82%
Eutrophicastion (EP)	-0.004	-0.009	-130%
Land use (m^2 year)	-0.442	-0.694	-57%
Final waste (kg)	-0.316	-1.017	-222%
Water consumption (m^3)	-16.821	-35.559	-111%
Energy consumption (Mjprim)	-237.351	-381.650	-61%

B.5 Stony construction and demolition waste (#37)

The following waste disposal scenarios were assessed:

1 96% road foundations and 4% concrete filler (ref.).
2 80% road foundations and 20% concrete filler.

Table 69 Lifecycle impact (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	0.00083	0.00083	0.3%
Climate change (GWP100)	0.16504	0.16474	0.2%
Ozone layer depletion (ODP)	0.00000	0.00000	0.2%
Human toxicity (HTP)	0.02987	0.02967	0.7%
Freshwater ecotoxicity (FAETP)	0.00287	0.00281	2.1%
Terrestrial ecotoxicity (TETP)	0.00021	0.00021	1.4%
Smog formation (POCP)	0.00002	0.00002	0.3%
Acidification (AP)	0.00042	0.00042	0.3%
Eutrophicastion (EP)	0.00006	0.00006	0.3%
Land use (m^2 year)	0.00302	0.00347	12.8%
Final waste (kg)	0.00824	0.00786	4.6%
Water consumption (m^3)	0.25520	0.24418	4.3%
Energy consumption (MJprim)	1.99270	1.98039	0.6%

Table 70 Impact of waste phase (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	0.0001	0.0001	2%
Climate change (GWP100)	0.0134	0.0131	2%
Ozone layer depletion (ODP)	1.89E-09	1.87E-09	1%
Human toxicity (HTP)	0.0014	0.0012	14%
Freshwater ecotoxicity (FAETP)	0.0003	0.0002	21%
Terrestrial ecotoxicity (TETP)	2.18E-05	1.89E-05	13%
Smog formation (POCP)	1.56E-06	1.48E-06	5%
Acidification (AP)	0.0001	0.0001	2%
Eutrophicastion (EP)	1.11E-05	1.09E-05	2%
Land use (m^2 year)	-0.0034	-0.0030	-15%
Final waste (kg)	0.0007	0.0003	56%
Water consumption (m^3)	-0.0161	-0.0271	-69%
Energy consumption (MJprim)	0.2092	0.1969	6%

B.6 Gypsum construction and demolition waste (#38)

The following waste disposal scenarios were assessed:

1 100% Versatzbau.
2 50% materials recycling, 50% Versatzbau.

Table 71 Lifecycle impact (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	0.00253	0.00160	37%
Climate change (GWP100)	0.34169	0.22012	36%
Ozone layer depletion (ODP)	0.00000	0.00000	39%
Human toxicity (HTP)	0.07432	0.04834	35%
Freshwater ecotoxicity (FAETP)	0.01627	0.01130	31%
Terrestrial ecotoxicity (TETP)	0.00081	0.00055	33%
Smog formation (POCP)	0.00005	0.00003	37%
Acidification (AP)	0.00149	0.00091	39%
Eutrophicastion (EP)	0.00028	0.00017	41%
Land use (m^2 year)	0.02106	0.01944	8%
Final waste (kg)	1.02828	0.51605	50%
Water consumption (m^3)	0.80558	0.59479	26%
Energy consumption (MJprim)	6.18315	4.00128	35%

Table 72 Impact of waste phase (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	0.0016	0.0006	60%
Climate change (GWP100)	0.2065	0.0850	59%
Ozone layer depletion (ODP)	3.52E-08	1.51E-08	57%
Human toxicity (HTP)	0.0448	0.0188	58%
Freshwater ecotoxicity (FAETP)	0.0093	0.0044	53%
Terrestrial ecotoxicity (TETP)	0.0004	0.0002	64%
Smog formation (POCP)	3.20E-05	1.38E-05	57%
Acidification (AP)	0.0011	0.0005	54%
Eutrophicastion (EP)	0.0002	0.0001	51%
Land use (m^2 year)	0.0030	0.0014	54%
Final waste (kg)	1.0240	0.5118	50%
Water consumption (m^3)	0.2619	0.0511	80%
Energy consumption (MJprim)	3.6359	1.4540	60%

B.7 Plate glass construction and demolition waste (#50)

The following waste disposal scenarios were assessed:

1 100% useful application (breakdown as per VRN 2006).
2 100% landfill.

Table 73 Lifecycle impact (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	8.2E-04	6.2E-03	87%
Climate change (GWP100)	1.2E-01	1.1E+00	89%
Ozone layer depletion (ODP)	1.1E-08	8.7E-08	88%
Human toxicity (HTP)	-3.1E+00	2.4E-01	1,362%
Freshwater ecotoxicity (FAETP)	-2.7E-02	2.9E-02	193%
Terrestrial ecotoxicity (TETP)	-1.6E-02	2.1E-03	861%
Smog formation (POCP)	-1.2E-05	3.1E-04	104%
Acidification (AP)	-2.0E-04	9.1E-03	102%
Eutrophicastion (EP)	1.6E-05	7.1E-04	98%
Land use (m^2 year)	-5.8E-02	6.1E-02	195%
Final waste (kg)	5.6E-02	1.1E+00	95%
Water consumption (m^3)	9.4E-01	1.8E+00	48%
Energy consumption (MJprim)	1.8E+00	1.4E+01	87%

Table 74 Impact of waste phase (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	-0.0053	0.0001	>>100%
Climate change (GWP100)	-0.9355	0.0074	>>100%
Ozone layer depletion (ODP)	-7.37E-08	2.19E-09	>>100%
Human toxicity (HTP)	-3.3101	0.0029	>>100%
Freshwater ecotoxicity (FAETP)	-0.0559	0.0003	>>100%
Terrestrial ecotoxicity (TETP)	-0.0177	0.0000	>>100%
Smog formation (POCP)	-0.0003	0.0000	>>100%
Acidification (AP)	-0.0093	0.0000	>>100%
Eutrophicastion (EP)	-0.0007	0.0000	>>100%
Land use (m^2 year)	-0.1179	0.0016	>>100%
Final waste (kg)	-0.0319	0.9994	>>100%
Water consumption (m^3)	-0.8519	0.0098	>>100%
Energy consumption (MJprim)	-12.1402	0.2056	>>100%

B.8 Paper and board (#63)

The following waste disposal scenarios were assessed:

1. 100% recycling (current situation).
2. 100% disposal in waste incinerator.

Table 75 Lifecycle impact (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	0.0118	0.0018	85%
Climate change (GWP100)	2.7347	0.9384	66%
Ozone layer depletion (ODP)	1.2E-07	2.3E-08	80%
Human toxicity (HTP)	0.5158	0.6899	25%
Freshwater ecotoxicity (FAETP)	0.4593	0.2647	42%
Terrestrial ecotoxicity (TETP)	0.0096	0.0007	93%
Smog formation (POCP)	0.0002	0.0001	38%
Acidification (AP)	0.0044	0.0036	18%
Eutrophicastion (EP)	0.0002	0.0008	76%
Land use (m^2 year)	-5.9553	2.2390	366%
Final waste (kg)	0.2538	0.1639	35%
Water consumption (m^3)	8.4277	6.1672	27%
Energy consumption (MJprim)	4.3223	21.8230	80%

Table 76 Impact of waste phase (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	0.0061	-0.0040	166%
Climate change (GWP100)	2.7463	0.9499	65%
Ozone layer depletion (ODP)	5.78E-08	-3.50E-08	161%
Human toxicity (HTP)	0.2565	0.4306	40%
Freshwater ecotoxicity (FAETP)	0.3950	0.2004	49%
Terrestrial ecotoxicity (TETP)	0.0055	-0.0034	161%
Smog formation (POCP)	0.0001	0.0000	169%
Acidification (AP)	0.0003	-0.0005	255%
Eutrophicastion (EP)	-0.0004	0.0002	283%
Land use (m^2 year)	-8.1988	-0.0044	>>1,000%
Final waste (kg)	0.1961	0.1062	46%
Water consumption (m^3)	2.0818	-0.1787	109%
Energy consumption (MJprim)	-25.8729	-8.3722	-209%

B.9 Plastics waste (#65)

The following waste disposal scenarios were assessed:

1. Recycling of all PE and PP, remainder incinerated.
2. Recycling of all PVC, remainder incinerated.
3. 100% incineration.

Table 77 Lifecycle impact (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Scenario 3	Variation
Abiotic depletion (ADP)	0.0045	0.0092	0.0197	77%
Climate change (GWP100)	0.8100	1.5808	3.1027	74%
Ozone layer depletion (ODP)	8.5E-09	-7.4E-08	-1.1E-07	1,372%
Human toxicity (HTP)	0.1892	0.7506	1.2666	85%
Freshwater ecotoxicity (FAETP)	0.1638	2.7763	2.9515	94%
Terrestrial ecotoxicity (TETP)	0.0017	-0.0218	0.0015	1,355%
Smog formation (POCP)	4.5E-05	3.2E-04	4.6E-04	90%
Acidification (AP)	0.0014	0.0109	0.0157	91%
Eutrophicastion (EP)	0.0004	0.0010	0.0015	75%
Land use (m^2 year)	0.0048	-0.0430	-0.0097	994%
Final waste (kg)	0.0361	0.0184	0.0617	70%
Water consumption (m^3)	3.0355	-1.2948	0.2581	143%
Energy consumption (MJprim)	13.3783	25.1045	49.8272	73%

Table 78 Impact of waste phase (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Scenario 3	Variation
Abiotic depletion (ADP)	-0.0275	-0.0227	-0.0123	-123%
Climate change (GWP100)	-1.2282	-0.4574	1.0645	215%
Ozone layer depletion (ODP)	8.28E-09	-7.41E-08	-1.08E-07	1,401%
Human toxicity (HTP)	0.1058	0.6672	1.1832	91%
Freshwater ecotoxicity (FAETP)	0.1388	2.7514	2.9265	95%
Terrestrial ecotoxicity (TETP)	-0.0091	-0.0326	-0.0093	-259%
Smog formation (POCP)	-0.0005	-0.0002	-0.0001	-373%
Acidification (AP)	-0.0159	-0.0064	-0.0017	-854%
Eutrophicastion (EP)	-0.0010	-0.0004	0.0001	806%
Land use (m^2 year)	0.0041	-0.0437	-0.0104	1,163%
Final waste (kg)	0.0179	0.0002	0.0435	99%
Water consumption (m^3)	2.9643	-1.3660	0.1869	146%
Energy consumption (MJprim)	-61.6009	-49.8748	-25.1521	-145%

B.10 Textiles (#67)

The following waste disposal scenarios were assessed:

1 Reuse 23%, recycling/cleaning rags 61%, incineration 16%.
2 Reuse 100%.
3 Recycling/cleaning rags 100%.

Table 79 Lifecycle impact (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Scenario 3	Variation
Abiotic depletion (ADP)	0.10315	0.06794	0.10566	36%
Climate change (GWP100)	12.14563	8.91090	12.15410	27%
Ozone layer depletion (ODP)	4.3E-07	2.8E-07	4.4E-07	36%
Human toxicity (HTP)	2.75845	1.99683	2.67293	28%
Freshwater ecotoxicity (FAETP)	0.76744	0.13989	0.60760	82%
Terrestrial ecotoxicity (TETP)	0.11551	0.10854	0.11768	8%
Smog formation (POCP)	0.00102	0.00060	0.00104	42%
Acidification (AP)	0.02528	0.01410	0.02577	45%
Eutrophicastion (EP)	0.04325	0.00173	0.04446	96%
Land use (m^2 year)	0.22291	0.15999	0.22770	30%
Final waste (kg)	0.20405	0.08010	0.20254	61%
Water consumption (m^3)	11.65634	6.73838	11.92574	43%
Energy consumption (MJprim)	216.4179	145.9428	221.6268	34%

Table 80 Impact of waste phase (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Scenario 3	Variation
Abiotic depletion (ADP)	-0.0489	-0.0841	-0.0464	-81%
Climate change (GWP100)	-3.9608	-7.1956	-3.9524	-82%
Ozone layer depletion (ODP)	-2.05E-07	-3.54E-07	-1.92E-07	-84%
Human toxicity (HTP)	-0.7399	-1.5015	-0.8254	-103%
Freshwater ecotoxicity (FAETP)	-0.4227	-1.0503	-0.5826	-148%
Terrestrial ecotoxicity (TETP)	-0.0130	-0.0200	-0.0109	-84%
Smog formation (POCP)	-0.0006	-0.0010	-0.0005	-82%
Acidification (AP)	-0.0148	-0.0260	-0.0144	-81%
Eutrophicastion (EP)	-0.0546	-0.0961	-0.0534	-80%
Land use (m^2 year)	-0.0883	-0.1512	-0.0835	-81%
Final waste (kg)	-0.1478	-0.2718	-0.1494	-84%
Water consumption (m^3)	-6.6752	-11.5931	-6.4058	-81%
Energy consumption (MJprim)	-98.0923	-168.5675	-92.8834	-81%

B.11 Carpeting (as part of Bulky household waste)

The following waste disposal scenarios were assessed:

1. Incinerator disposal.
2. Co-combustion in a cement kiln.
3. Recycling of the polymers.

Table 81 Lifecycle impact (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Scenario 3	Variation
Abiotic depletion (ADP)	0.03791	0.03113	0.02900	24%
Climate change (GWP100)	5.41918	4.73949	3.51025	35%
Ozone layer depletion (ODP)	5.1E-08	8.2E-08	1.1E-07	52%
Human toxicity (HTP)	1.18896	0.51693	0.60609	57%
Freshwater ecotoxicity (FAETP)	1.83027	0.06258	0.05397	97%
Terrestrial ecotoxicity (TETP)	0.01740	0.02742	0.02395	37%
Smog formation (POCP)	0.00061	0.00059	0.00028	55%
Acidification (AP)	0.01783	0.01659	0.00700	61%
Eutrophicastion (EP)	0.00234	0.00200	0.00088	62%
Land use (m^2 year)	0.05113	0.02343	0.07351	68%
Final waste (kg)	0.05350	0.04320	0.03462	35%
Water consumption (m^3)	1.90336	2.15001	2.80411	32%
Energy consumption (MJprim)	84.2348	78.8949	62.7880	25%

Table 82 Impact of waste phase (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Scenario 3	Variation
Abiotic depletion (ADP)	-0.0070	-0.0137	-0.0159	-128%
Climate change (GWP100)	0.5874	-0.0923	-1.3216	325%
Ozone layer depletion (ODP)	-3.51E-08	-3.85E-09	2.01E-08	275%
Human toxicity (HTP)	0.6070	-0.0651	0.0241	111%
Freshwater ecotoxicity (FAETP)	1.7636	-0.0041	-0.0127	101%
Terrestrial ecotoxicity (TETP)	-0.0102	-0.0002	-0.0036	-6,041%
Smog formation (POCP)	-0.0001	-0.0001	-0.0004	-571%
Acidification (AP)	-0.0012	-0.0025	-0.0121	-880%
Eutrophicastion (EP)	0.0001	-0.0002	-0.0014	1,627%
Land use (m^2 year)	-0.0144	-0.0421	0.0080	626%
Final waste (kg)	0.0127	0.0024	-0.0062	149%
Water consumption (m^3)	-0.5886	-0.3419	0.3122	289%
Energy consumption (MJprim)	-14.8303	-20.1702	-36.2771	-145%

B.12 Metal waste (#68)

The following waste disposal scenarios were assessed:

1 72% recycling of aluminium, 95% recycling of other metals, rest to landfill.
2 80% recycling of aluminium, 100% recycling of other metals, rest to landfill.

Table 83 Lifecycle impact (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	0.01128	0.01021	9%
Climate change (GWP100)	1.50090	1.38218	8%
Ozone layer depletion (ODP)	9.9E-08	9.4E-08	5%
Human toxicity (HTP)	8.21560	7.78554	5%
Freshwater ecotoxicity (FAETP)	1.70901	1.65714	3%
Terrestrial ecotoxicity (TETP)	0.03813	0.03757	1%
Smog formation (POCP)	0.00064	0.00056	12%
Acidification (AP)	0.00975	0.00901	8%
Eutrophicastion (EP)	0.00132	0.00125	5%
Land use (m^2 year)	0.11257	0.10840	4%
Final waste (kg)	0.69886	0.63458	9%
Water consumption (m^3)	17.29859	15.14191	12%
Energy consumption (MJprim)	27.71603	25.52154	8%

Table 84 Impact of waste phase (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	-0.0109	-0.0119	-10%
Climate change (GWP100)	-1.1688	-1.2876	-10%
Ozone layer depletion (ODP)	-4.66E-08	-5.15E-08	-10%
Human toxicity (HTP)	-4.4474	-4.8774	-10%
Freshwater ecotoxicity (FAETP)	-0.5382	-0.5901	-10%
Terrestrial ecotoxicity (TETP)	-0.0078	-0.0084	-7%
Smog formation (POCP)	-0.0008	-0.0009	-9%
Acidification (AP)	-0.0089	-0.0096	-8%
Eutrophicastion (EP)	-0.0008	-0.0009	-9%
Land use (m^2 year)	-0.0518	-0.0560	-8%
Final waste (kg)	-0.0957	-0.1600	-67%
Water consumption (m^3)	-206.488	-22.8055	-10%
Energy consumption (MJprim)	-21.7176	-23.9121	-10%

B.13 Spent oil, Category III (#75)

The following waste disposal scenarios were assessed:
1 Combustion in a cement kiln.
2 Combustion in a rotary furnace.

Table 85 Lifecycle impact (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	-0.034	0.017	298%
Climate change (GWP100)	-0.261	3.210	108%
Ozone layer depletion (ODP)	0.000	0.000	124%
Human toxicity (HTP)	0.151	0.315	52%
Freshwater ecotoxicity (FAETP)	0.013	0.034	62%
Terrestrial ecotoxicity (TETP)	-0.039	0.001	4,116%
Smog formation (POCP)	0.000	0.000	202%
Acidification (AP)	-0.009	0.007	233%
Eutrophicastion (EP)	-0.001	0.002	147%
Land use (m^2 year)	-0.002	-0.094	-3,669%
Final waste (kg)	-1.179	-0.025	-4,592%
Water consumption (m^3)	-7.849	-32.229	-311%
Energy consumption (MJprim)	-20.807	43.513	148%

Table 86 Impact of waste phase (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	-0.0574	-0.0056	-923%
Climate change (GWP100)	-0.6987	2.7716	125%
Ozone layer depletion (ODP)	-5.66E-07	-1.70E-08	-3,229%
Human toxicity (HTP)	-0.1830	-0.0195	-838%
Freshwater ecotoxicity (FAETP)	-0.0229	-0.0020	-1,074%
Terrestrial ecotoxicity (TETP)	-0.0405	-0.0010	-3,794%
Smog formation (POCP)	-0.0008	0.0001	793%
Acidification (AP)	-0.0146	0.0011	1,404%
Eutrophicastion (EP)	-0.0013	0.0011	228%
Land use (m^2 year)	-0.0107	-0.1020	-853%
Final waste (kg)	-1.1900	-0.0359	-3,215%
Water consumption (m^3)	-8.7200	-33.1000	-280%
Energy consumption (MJprim)	-73.6000	-9.2800	-693%

B.14 Oil/water/sludge mixtures (#76)

The following waste disposal scenarios were assessed:

1. Minimum standard: sludge to TGI, oil fraction to cement kiln.
2. Sludge to cement kiln, oil fraction to power station.

The environmental impacts of the waste phase were taken from LAP-EIA (A19).

Table 87 Lifecycle impact (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	0.0028	0.0013	55%
Climate change (GWP100)	0.0869	0.0363	58%
Ozone layer depletion (ODP)	5.2E-08	3.7E-08	29%
Human toxicity (HTP)	0.1529	0.0320	79%
Freshwater ecotoxicity (FAETP)	0.0589	0.0035	94%
Terrestrial ecotoxicity (TETP)	0.0301	0.0005	98%
Smog formation (POCP)	4.2E-05	2.4E-05	43%
Acidification (AP)	0.0007	0.0004	38%
Eutrophicastion (EP)	0.0001	0.0001	29%
Land use (m^2 year)	0.0018	0.0017	6%
Final waste (kg)	-0.0005	-0.0259	-4,661%
Water consumption (m^3)	0.0348	-0.2034	685%
Energy consumption (MJprim)	6.1382	4.2068	31%

Table 88 Impact of waste phase (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	0.0002	-0.0013	632%
Climate change (GWP100)	0.0380	-0.0127	133%
Ozone layer depletion (ODP)	2.36E-09	-1.25E-08	631%
Human toxicity (HTP)	0.1154	-0.0055	105%
Freshwater ecotoxicity (FAETP)	0.0549	-0.0005	101%
Terrestrial ecotoxicity (TETP)	0.0298	0.0002	99%
Smog formation (POCP)	5.39E-06	-1.23E-05	328%
Acidification (AP)	0.0001	-0.0002	377%
Eutrophicastion (EP)	1.66E-05	-6.63E-06	140%
Land use (m^2 year)	0.0000	-0.0001	228%
Final waste (kg)	-0.0019	-0.0273	-1,371%
Water consumption (m^3)	-0.0644	-0.3026	-370%
Energy consumption (MJprim)	0.2416	-1.6898	799%

B.15 Metal-working oils (#80)

The following waste disposal scenarios were assessed:
1 Minimum standard: use as a reducing agent.
2 Co-combustion in a cement kiln.

The environmental impacts of the waste phase were taken from LAP-EIA (A06).

Table 89 Lifecycle impact (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	-0.0003	-0.0022	-779%
Climate change (GWP100)	0.0142	-0.0176	224%
Ozone layer depletion (ODP)	1.1E-08	-8.5E-09	176%
Human toxicity (HTP)	0.0142	0.0090	37%
Freshwater ecotoxicity (FAETP)	0.0016	0.0007	56%
Terrestrial ecotoxicity (TETP)	-0.0001	-0.0005	-603%
Smog formation (POCP)	8.8E-06	-2.9E-05	428%
Acidification (AP)	0.0001	-0.0006	633%
Eutrophicastion (EP)	4.5E-05	-5.0E-05	211%
Land use (m^2 year)	0.0022	-0.0002	109%
Final waste (kg)	-0.0369	-0.0740	-101%
Water consumption (m^3)	-0.2817	-0.4977	-77%
Energy consumption (MJprim)	1.0194	-1.4106	238%

Table 90 Impact of waste phase (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	-0.0017	-0.0036	-118%
Climate change (GWP100)	-0.0122	-0.0440	-262%
Ozone layer depletion (ODP)	-1.59E-08	-3.56E-08	-124%
Human toxicity (HTP)	-0.0060	-0.0112	-87%
Freshwater ecotoxicity (FAETP)	-0.0005	-0.0014	-172%
Terrestrial ecotoxicity (TETP)	-0.0002	-0.0007	-241%
Smog formation (POCP)	-1.09E-05	-4.84E-05	-344%
Acidification (AP)	-0.0002	-0.0009	-297%
Eutrophicastion (EP)	0.0000	-0.0001	928%
Land use (m^2 year)	0.0017	-0.0007	140%
Final waste (kg)	-0.0375	-0.0746	-99%
Water consumption (m^3)	-0.3320	-0.5480	-65%
Energy consumption (MJprim)	-2.1900	-4.6200	-111%

B.16 Animal waste, category 1 and 2 (#88)

The only waste disposal scenario assessed was the Rendac process (2007).

Table 91 Lifecycle impact (per kg waste)

Environmental theme	Scenario 1
Abiotic depletion (ADP)	0.00252
Climate change (GWP100)	6.21321
Ozone layer depletion (ODP)	0.00000
Human toxicity (HTP)	0.30804
Freshwater ecotoxicity (FAETP)	0.04190
Terrestrial ecotoxicity (TETP)	0.00384
Smog formation (POCP)	0.00045
Acidification (AP)	0.05854
Eutrophicastion (EP)	0.04573
Land use (m^2 year)	10.59559
Final waste (kg)	Unknown
Water consumption (m^3)	0.50599
Energy consumption (MJprim)	13.10983

Because data from the Danish LCAFOOD database were used for the pre-waste phase, for this category of waste the impact on final waste was unknown. The impact on water use is incomplete, because of a lack of data on water consumption for fodder crop cultivation. Finally, the choices made with respect to allocation (extending the ‘system boundaries’) also lead to low scores for the pre-waste phase. A case in point is soy oil, a by-product of fodder production, which leads to very high avoided impacts at the beginning of the production chain.

Table 92 Impact of waste phase (per kg waste)

Environmental theme	Scenario 1
Abiotic depletion (ADP)	-0.0052
Climate change (GWP100)	0.9361
Ozone layer depletion (ODP)	2.2E-08
Human toxicity (HTP)	0.0839
Freshwater ecotoxicity (FAETP)	0.0072
Terrestrial ecotoxicity (TETP)	0.0022
Smog formation (POCP)	-2.2E-05
Acidification (AP)	-0.0010
Eutrophicastion (EP)	-0.0001
Land use (m^2 year)	-0.0234
Final waste (kg)	0.0036
Water consumption (m^3)	0.3873
Energy consumption (MJprim)	-2.3708

B.17 Batteries (zinc-carbon and alkaline) (#91)

The following waste disposal scenarios were assessed:

1 Electric arc furnace.
2 Pyrometallurgical processing.

Table 93 Lifecycle impact (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	0.0157	0.0137	13%
Climate change (GWP100)	2.1480	1.9304	10%
Ozone layer depletion (ODP)	1.2E-07	1.3E-07	12%
Human toxicity (HTP)	8.8353	8.3688	5%
Freshwater ecotoxicity (FAETP)	1.0358	1.0169	2%
Terrestrial ecotoxicity (TETP)	0.6155	0.2181	65%
Smog formation (POCP)	0.0028	0.0008	71%
Acidification (AP)	0.0182	0.0199	9%
Eutrophicastion (EP)	0.0016	0.0021	21%
Land use (m^2 year)	0.0858	0.0963	11%
Final waste (kg)	-2.9256	-2.9056	-1%
Water consumption (m^3)	61.1091	62.4091	2%
Energy consumption (MJprim)	37.9591	32.4321	15%

Table 94 Impact of waste phase (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	0.0039	0.0019	51%
Climate change (GWP100)	0.5624	0.3448	39%
Ozone layer depletion (ODP)	-1.85E-10	1.57E-08	101%
Human toxicity (HTP)	0.4810	0.0145	97%
Freshwater ecotoxicity (FAETP)	0.0235	0.0046	81%
Terrestrial ecotoxicity (TETP)			
Smog formation (POCP)	0.4050	0.0076	98%
Acidification (AP)	0.0020	0.0000	99%
Eutrophicastion (EP)	0.0001	0.0019	94%
Land use (m^2 year)	0.0001	0.0005	78%
	-0.0458	-0.0353	-30%
Final waste (kg)	-3.3300	-3.3100	-1%
Water consumption (m^3)	13.1000	14.4000	9%
Energy consumption (MJprim)	4.7200	-0.8070	117%

B.18 Accumulators (#92)

The following waste disposal scenarios were assessed:

1 7% landfill in the C_2 storage facility, rest via Campine route.
2 100% processing at Campine.

Table 95 Lifecycle impact (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	0.012	0.010	14%
Climate change (GWP100)	1.282	1.273	1%
Ozone layer depletion (ODP)	3.1E-08	3.0E-08	6%
Human toxicity (HTP)	0.335	0.180	46%
Freshwater ecotoxicity (FAETP)	0.052	0.040	23%
Terrestrial ecotoxicity (TETP)	0.011	0.010	8%
Smog formation (POCP)	0.001	0.001	9%
Acidification (AP)	0.018	0.016	10%
Eutrophicastion (EP)	5.0E-04	4.0E-04	20%
Land use (m^2 year)	0.038	0.026	33%
Final waste (kg)	0.183	0.092	50%
Water consumption (m^3)	4.537	3.411	25%
Energy consumption (MJprim)	25.053	24.793	1%

Table 96 Impact of waste phase (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	-0.0216	-0.0233	-8%
Climate change (GWP100)	-0.1059	-0.1149	-8%
Ozone layer depletion (ODP)	-2.31E-08	-2.51E-08	-9%
Human toxicity (HTP)	-1.9828	-2.1381	-8%
Freshwater ecotoxicity (FAETP)	-0.0248	-0.0368	-48%
Terrestrial ecotoxicity (TETP)	-0.0106	-0.0114	-8%
Smog formation (POCP)	-0.0008	-0.0008	-8%
Acidification (AP)	-0.0225	-0.0242	-8%
Eutrophicastion (EP)	-0.0013	-0.0014	-8%
Land use (m^2 year)	-0.1630	-0.1756	-8%
Final waste (kg)	-0.2091	-0.3002	-44%
Water consumption (m^3)	-14.9318	-16.0581	-8%
Energy consumption (MJprim)	-3.1171	-3.3769	-8%

B.19 Solvents (#93)

The following waste disposal scenarios were assessed:

1 Distillation, with co-combustion of residue in cement kiln (minimum standard).
2 100% co-combustion in cement kiln.

Table 97 Lifecycle impact (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	0.002	-0.026	1,217%
Climate change (GWP100)	1.339	1.020	24%
Ozone layer depletion (ODP)	-1.6E-07	-5.9E-07	-278%
Human toxicity (HTP)	-0.023	-0.163	-603%
Freshwater ecotoxicity (FAETP)	-0.004	-0.017	-316%
Terrestrial ecotoxicity (TETP)	-0.002	-0.010	-537%
Smog formation (POCP)	-1.3E-04	-5.5E-04	-306%
Acidification (AP)	0.001	-0.007	588%
Eutrophicastion (EP)	3.6E-04	-6.0E-04	267%
Land use (m^2 year)	-0.006	-0.011	-99%
Final waste (kg)	-0.291	-1.235	-324%
Water consumption (m^3)	2.009	-8.991	547%
Energy consumption (MJprim)	19.554	-3.246	117%

Table 98 Impact of waste phase (per kg waste)

Environmental theme	Scenario 1	Scenario 2	Variation
Abiotic depletion (ADP)	-0.0320	-0.0600	-88%
Climate change (GWP100)	-0.3247	-0.7334	-126%
Ozone layer depletion (ODP)	-1.59E-07	-5.93E-07	-273%
Human toxicity (HTP)	-0.0489	-0.1890	-287%
Freshwater ecotoxicity (FAETP)	-0.0107	-0.0236	-121%
Terrestrial ecotoxicity (TETP)	-0.0027	-0.0109	-311%
Smog formation (POCP)	-0.0004	-0.0008	-105%
Acidification (AP)	-0.0065	-0.0153	-135%
Eutrophicastion (EP)	-0.0005	-0.0014	-212%
Land use (m^2 year)	-0.0058	-0.0114	-96%
Final waste (kg)	-0.2960	-1.2400	-319%
Water consumption (m^3)	1.8700	-9.1300	588%
Energy consumption (MJprim)	-54.3000	-77.1000	-42%

B.20 Residual household waste (#01)

100% incinerator disposal, metals fraction not included (cf. Section 3.21).

Table 99 Lifecycle impact (per kg waste)

Environmental theme	Scenario 1
Abiotic depletion (ADP)	0.0101
Climate change (GWP100)	1.6299
Ozone layer depletion (ODP)	1.0E-8
Human toxicity (HTP)	0.6390
Freshwater ecotoxicity (FAETP)	0.8273
Terrestrial ecotoxicity (TETP)	0.0151
Smog formation (POCP)	0.0002
Acidification (AP)	0.0066
Eutrophicastion (EP)	0.0046
Land use (m^2 year)	0.7970
Final waste (kg)	0.1355
Water consumption (m^3)	2.8499
Energy consumption (MJprim)	29.3330

Table 100 Impact of waste phase (per kg waste)

Environmental theme	Scenario 1
Abiotic depletion (ADP)	-0.0038
Climate change (GWP100)	0.6892
Ozone layer depletion (ODP)	-3.26E-08
Human toxicity (HTP)	0.3919
Freshwater ecotoxicity (FAETP)	0.7051
Terrestrial ecotoxicity (TETP)	-0.0032
Smog formation (POCP)	-3.01E-05
Acidification (AP)	-0.0004
Eutrophicastion (EP)	0.0001
Land use (m^2 year)	-0.0033
Final waste (kg)	0.0933
Water consumption (m^3)	0.1832
Energy consumption (MJprim)	-8.1117

B.21 Residual waste for trade, services and government (retail, office and services only) (#04)

100% incinerator disposal, metals fraction not included (cf. Section 3.22).

Table 101 Lifecycle impact (per kg waste)

Environmental theme	Scenario 1
Abiotic depletion (ADP)	0.0114
Climate change (GWP100)	2.0153
Ozone layer depletion (ODP)	-1.5E-08
Human toxicity (HTP)	0.9042
Freshwater ecotoxicity (FAETP)	1.3271
Terrestrial ecotoxicity (TETP)	0.0047
Smog formation (POCP)	0.0003
Acidification (AP)	0.0091
Eutrophicastion (EP)	0.0032
Land use (m^2 year)	1.0796
Final waste (kg)	0.1655
Water consumption (m^3)	3.4659
Energy consumption (MJprim)	35.7775

Table 102 Impact of waste phase (per kg waste)

Environmental theme	Scenario 1
Abiotic depletion (ADP)	-0.0068
Climate change (GWP100)	0.9050
Ozone layer depletion (ODP)	-5.85E-08
Human toxicity (HTP)	0.6750
Freshwater ecotoxicity (FAETP)	1.2509
Terrestrial ecotoxicity (TETP)	-0.0054
Smog formation (POCP)	-0.0001
Acidification (AP)	-0.0008
Eutrophicastion (EP)	0.0002
Land use (m^2 year)	-0.0062
Final waste (kg)	0.1190
Water consumption (m^3)	0.0190
Energy consumption (MJprim)	-13.9676

C Rankings

C.1 Track A1 (lifecycle environmental impact)

Table 103 shows the rankings of the waste streams on track A1 as assessed by all six weighting methods. The empty cells in each column indicate the transition point at which the lifecycle impact becomes negative. The percentages are the ratio of the weighted impact of the stream to the no. 1 on the respective ranking.

Table 103 Rankings of waste categories according to lifecycle environmental impact (track A1)

Equal weighting		Nogepa		Distance-to-target		Greencalc		CE, 2002		EI99	
1	100.0%	1	100.0%	1	100.0%	1	100.0%	28	100.0%	28	100.0%
28	66.7%	28	79.3%	4	56.0%	28	65.3%	1	92.9%	1	77.8%
4	60.5%	4	56.6%	28	53.7%	4	53.4%	63	70.4%	29	61.7%
68	50.4%	68	50.8%	68	45.0%	29	40.2%	29	60.3%	21	49.0%
29	39.4%	29	48.0%	29	31.2%	68	33.0%	4	51.2%	68	43.5%
63	31.7%	63	42.9%	63	25.9%	88	30.3%	21	49.2%	4	40.4%
21	28.2%	21	31.8%	88	18.6%	21	29.0%	68	39.6%	37	28.2%
37	15.5%	37	21.0%	21	15.0%	37	19.9%	37	38.2%	88	27.4%
88	13.0%	88	17.5%	37	10.6%	67	10.9%	88	18.6%	63	12.1%
67	9.4%	67	11.1%	67	10.1%	22	2.0%	67	11.4%	67	8.5%
22	1.7%	22	1.4%	22	1.9%	65	0.7%	38	6.1%	22	3.0%
65	0.9%	65	0.9%	65	0.6%	23	0.5%	65	1.2%	38	1.0%
76	0.6%	2	0.5%	23	0.5%	38	0.5%	22	1.0%	65	0.9%
2	0.6%	38	0.5%	76	0.5%	2	0.4%	92	0.8%	92	0.8%
38	0.4%	76	0.4%	2	0.4%	92	0.3%	2	0.6%	23	0.8%
23	0.4%	23	0.4%	38	0.3%	76	0.2%	23	0.3%	76	0.6%
92	0.4%	92	0.4%	92	0.3%	91	0.1%	76	0.2%	2	0.5%
91	0.1%	91	0.1%	91	0.1%	80	0.0%	50	0.0%	75	0.5%
80	0.0%	80	0.0%	80	0.0%					91	0.2%
										80	0.0%
						50	0.0%	80	0.0%		
50	0.0%	50	0.0%	50	0.0%	75	-0.1%	91	-0.1%		
75	-0.4%	75	-0.1%	75	-0.2%	63	-90.0%	75	-1.1%	50	0.0%

Table 104 Categories occurring in a 'top 10' on track A1 (X in final column: based on LAP-EIA waste disposal data)

Category code	Number of times in top 10	Category name	
1	6	Residual household waste (bulk-collected)	
28	6	End-of-life vehicles	(X)
4	6	Residual waste for trade, services and government	
29	6	End-of-life tyres	
63	5	Separately collected paper and board	
68	6	Metal waste, general	
21	6	Gas-discharge lamps	X
88	6	Animal waste, SRM/HRM	
37	6	Stony materials	
67	6	Separately collected textiles	
22	1	Household organic waste	X

C.2 Track A2 (waste disposal impact)

Table 105 shows the rankings of the waste streams on track A2 as assessed by all six weighting methods. The empty cells in each column indicate the transition point at which the waste disposal impact becomes negative. The percentages are the ratio of the weighted impact of the stream to the no. 1 on the respective ranking.

Table 105 Rankings of waste categories according to waste disposal impact (track A2)

Equal weighting		Nogepa		Distance-to-target		Greencalc		CE, 2002		EI99	
1	100.0%	1	100.0%	1	100.0%	1	100.0%	63	100.0%	37	100.0%
4	84.2%	63	89.3%	4	84.6%	4	72.9%	1	46.0%	6	46.4%
63	46.2%	4	80.0%	63	42.1%	37	6.8%	4	28.7%	38	15.3%
37	4.4%	37	5.1%	37	3.5%	6	5.8%	6	11.7%	9	4.3%
6	2.4%	6	2.7%	6	1.8%	88	2.4%	38	9.8%	84	3.7%
38	0.7%	88	1.3%	2	0.7%	38	1.6%	84	6.0%	91	2.0%
2	0.7%	38	0.8%	38	0.6%	22	1.1%	37	6.0%	10	1.0%
9	0.3%	2	0.6%	9	0.3%	9	0.7%	9	3.9%	76	0.8%
22	0.2%	22	0.5%	22	0.2%	2	0.4%	49	1.9%	109	0.6%
91	0.1%	9	0.3%	88	0.1%	23	0.3%	10	1.8%	108	0.4%
84	0.1%	23	0.1%	91	0.1%	84	0.2%	108	1.5%	49	0.3%
76	0.1%	76	0.1%	84	0.1%	76	0.2%	88	1.4%	47	0.1%
23	0.1%	84	0.1%	23	0.1%	10	0.1%	22	1.0%	22	0.1%
109	0.0%	91	0.1%	10	0.0%	109	0.1%	47	0.7%	11	0.1%
10	0.0%	109	0.1%	76	0.0%	111	0.1%	23	0.3%	23	0.0%
108	0.0%	10	0.1%	61	0.0%	61	0.1%	100	0.1%		
49	0.0%	111	0.1%	109	0.0%	42	0.1%	11	0.1%		
21	0.0%	42	0.0%	108	0.0%	108	0.1%	76	0.1%	50	0.0%
100	0.0%	61	0.0%	100	0.0%	100	0.0%	2	0.1%	111	-0.2%
47	0.0%	100	0.0%	49	0.0%	49	0.0%	109	0.0%	100	-0.6%
11	0.0%	108	0.0%	21	0.0%	91	0.0%	42	0.0%	80	-0.7%
		49	0.0%	111	0.0%	47	0.0%			21	-1.1%
		47	0.0%	47	0.0%	11	0.0%			42	-1.7%
50	0.0%	21	0.0%	11	0.0%	21	0.0%	21	0.0%	2	-1.8%
111	0.0%	11	0.0%					50	0.0%	61	-1.9%
80	0.0%							80	-0.1%	88	-4.8%
42	0.0%			50	0.0%	50	0.0%	111	-0.1%	25	-7.3%
61	-0.1%	50	0.0%	80	0.0%	80	0.0%	61	-0.2%	75	-7.8%
88	-0.1%	80	0.0%	42	0.0%	75	-1.2%	91	-0.2%	29	-41.4%
25	-0.7%	75	-0.6%	25	-0.7%	29	-1.4%	29	-0.6%	92	-107.1%
92	-1.4%	29	-0.9%	75	-0.7%	92	-2.1%	92	-1.2%	67	-114.2%
75	-1.6%	92	-1.0%	92	-1.2%	25	-3.2%	25	-1.3%	28	-121.0%
29	-1.9%	25	-1.5%	29	-1.2%	93	-4.7%	75	-2.1%	65	-146.2%
65	-4.6%	93	-2.6%	65	-2.5%	65	-6.6%	28	-4.2%	93	-160.3%
93	-7.9%	65	-3.1%	93	-2.7%	28	-13.4%	65	-4.7%	4	-273.2%
28	-9.2%	28	-8.9%	28	-7.9%	67	-53.9%	93	-6.5%	1	-304.5%
67	-20.3%	67	-24.5%	67	-28.0%	68	-102.9%	67	-13.1%	63	-546.1%
68	-61.5%	68	-65.5%	68	-53.1%	63	-765.1%	68	-31.3%	68	-1,081.8%

Table 106 Categories occurring in a ‘top 10’ on track A2 (X in final column: based on LAP-EIA waste disposal data)

Category code	Number of times in top 10	Category name	
1	5	Residual household waste (bulk-collected)	
63	4	Separately collected paper and board	
37	6	Stony materials	
2	4	Bulky household waste (carpeting only)	
6	6	Water treatment sludge	
4	5	Residual waste for trade, services and government	
38	6	Gypsum	
9	6	Incinerator fly ash	X
84	2	Shedder waste	X
91	2	Batteries (zinc-carbon & alkaline)	X
88	3	Animal waste, SRM/HRM	
10	2	Flue gas treatment residues from waste incinerators, dry	X
22	4	Household organic waste	X
76	1	Oil/water/sludge mixtures	X
109	1	Fixer and developer solutions (black & white)	X
23	1	Separately collected commercial and institutional organic waste	X
49	1	Asbestos	X
108	1	Filter cakes (detoxification/deneutralisation/ dewatering)	X

C.3 Track A0 (A2 : A1)

Table 107 shows the rankings of the waste streams on track A0 (share of waste disposal in lifecycle impact, i.e. A2:A1) as assessed by all six weighting methods. The empty cells in each column indicate the transition point at which the score on this track becomes negative. The percentages are the share of waste disposal in lifecycle impact according to the weighting method in question. In these rankings, there is as yet no multiplication by the volume of the stream.

Table 107 Ranking of waste categories on track A0 (with no allowance for volume)

Equal weighting		Nogepa		Distance-to-target		Greencalc		CE, 2002		EI99	
38	65.8%	63	82.1%	38	71.2%	38	63.1%	38	95.5%	38	58.3%
63	56.7%	38	65.9%	63	62.1%	4	25.3%	63	84.4%	91	39.4%
4	54.1%	4	55.7%	2	58.0%	2	19.9%	22	60.4%	37	13.4%
2	46.4%	2	41.3%	4	57.7%	1	18.5%	23	60.4%	76	5.2%
1	38.9%	1	39.5%	1	38.2%	76	17.5%	4	33.2%	22	0.1%
91	33.2%	91	24.0%	91	32.3%	91	11.6%	1	29.4%	23	0.1%
37	11.1%	23	14.4%	37	12.6%	22	9.9%	76	25.4%		
22	5.0%	22	14.4%	22	4.4%	23	9.9%	37	9.3%		
23	5.0%	37	9.6%	23	4.4%	37	6.3%	2	7.3%	21	-0.1%
76	4.5%	76	9.1%	76	3.6%	88	1.4%	88	4.5%	88	-0.7%
21	0.0%	88	2.8%	88	0.3%	21	0.0%			29	-2.5%
		21	0.0%	21	0.0%					28	-4.6%
								21	0.0%	2	-12.5%
88	-0.3%					29	-0.7%	29	-0.6%	1	-14.8%
29	-1.9%	29	-0.7%	29	-1.5%	28	-3.8%	28	-2.5%	4	-25.6%
28	-5.3%	28	-4.5%	28	-5.6%	80	-24.0%	68	-47.0%	67	-50.8%
68	-47.5%	80	-42.2%	80	-42.7%	68	-57.8%	67	-68.3%	75	-62.4%
67	-84.3%	68	-50.9%	68	-45.1%	67	-91.9%	92	-84.7%	68	-94.1%
92	-148.7%	67	-87.2%	67	-106.4%	92	-124.9%	75	-117.7%	80	-124.4%
75	-159.9%	92	-113.6%	65	-147.5%	63	-157.4%	80	-160.0%	63	-170.9%
65	-211.3%	65	-129.7%	92	-149.4%	65	-170.7%	91	-171.0%	92	-499.2%
50	-241.5%	75	-194.1%	75	-152.9%	75	-221.3%	65	-233.2%	65	-633.1%
80	-536.8%	50	-210.1%	50	-227.4%	50	-223.2%	50	-625.3%	50	-1,589.1%

In Table 108 the individual results reported in the previous table have been multiplied by the volume of the waste stream in question to yield new rankings. The percentages indicate the ratio of the weighted impact to the no. 1 of the respective ranking.

Table 108 Ranking of waste categories on track A0 (with allowance for volume)

Equal weighting		Nogepa		Distance-to-target		Greencalc		CE, 2002		EI99	
37	100.0%	37	100.0%	37	100.0%	37	100.0%	37	100.0%	37	100.0%
1	59.0%	63	93.1%	63	53.5%	1	49.1%	63	99.0%	38	3.8%
63	55.8%	1	69.0%	1	50.7%	4	32.7%	1	53.2%	76	0.3%
4	40.1%	4	47.5%	4	37.4%	38	8.8%	4	29.3%	91	0.0%
38	5.3%	38	6.1%	38	5.0%	76	2.2%	38	9.1%	22	0.0%
76	0.3%	22	0.9%	76	0.2%	22	0.9%	22	3.9%	23	0.0%
22	0.3%	76	0.8%	2	0.2%	23	0.2%	76	2.2%		
2	0.2%	23	0.2%	22	0.2%	2	0.2%	23	1.0%		
23	0.1%	2	0.2%	23	0.1%	88	0.1%	88	0.3%	21	0.0%
91	0.0%	88	0.2%	91	0.0%	91	0.0%	2	0.0%	88	0.0%
21	0.0%	91	0.0%	88	0.0%	21	0.0%			2	0.0%
		21	0.0%	21	0.0%					50	-0.1%
								21	0.0%	29	-0.1%
50	0.0%					50	0.0%	50	0.0%	28	-0.4%
88	0.0%	50	0.0%	50	0.0%	29	0.0%	29	0.0%	75	-0.6%
29	-0.1%	29	0.0%	29	-0.1%	80	-0.5%	91	-0.1%	67	-1.2%
28	-0.6%	28	-0.6%	80	-0.4%	28	-0.7%	28	-0.3%	80	-1.2%
75	-1.8%	80	-0.6%	28	-0.5%	92	-3.0%	92	-1.4%	92	-5.6%
92	-2.0%	92	-1.8%	75	-1.5%	75	-4.3%	75	-1.6%	4	-15.6%
67	-2.4%	75	-2.5%	92	-1.8%	67	-4.6%	80	-2.3%	1	-18.5%
80	-6.4%	67	-2.9%	67	-2.7%	65	-18.0%	67	-2.3%	65	-31.5%
65	-12.8%	65	-9.0%	65	-7.8%	68	-44.4%	65	-16.8%	68	-34.0%
68	-20.9%	68	-25.7%	68	-17.3%	63	-271.0%	68	-24.6%	63	-138.5%

C.4 Track A3 (cost)

Table 109 Ranking of waste categories according to costs, for streams with waste disposal costs (incl. returns) exceeding zero (excl. streams of minimal volume and/or unknown costs)

Costs (million €)	Category code	Category name
2.348	37	Stony materials
471	1	Residual household waste (bulk-collected)
220	4	Residual waste for trade, services and government
188	44	Waste wood, A- and B-grade
150	6	Water treatment sludge
117	48	Tar-containing asphalt
87	2	Bulky household waste (total)
55	25	Separately collected garden waste
50	39	Screened sand
45	5	Waste from public spaces
40	71	Severely contaminated earth
36	65	Separately collected plastics waste
35	53	White and brown goods
34	93	Solvents, recyclable and low-halogen
32	92	Accumulators
28	60	HCW/HHW (excl. batteries and gas-discharge lamps)
23	88	Animal waste, SRM/HRM
15	108	Filter cakes (detoxification/neutralisation/dewatering)
15	19	Wastes from coal-fired power stations
15	15	Sludge incinerator bottom ash
14	45	Waste wood, C-grade
13	7	Wastes from drinking water preparation
11	41	Roofing gravel
11	101	Sulphur-containing waste
10	49	Asbestos
10	8	Waste incinerator bottom ash
9	9	Waste incinerator fly ash
8	76	Oil/water/sludge mixtures
8	84	Shedder waste
7	29	End-of-life tyres
6	94	Solvents, halogenated
6	26	Body parts and organs, infected waste, and cytotoxic and cytostatic medicines
6	22	Household organic waste
6	61	Waste paint packaging
5	10	Flue gas treatment residues from waste incinerators, dry
4	28	End-of-life vehicles
4	91	Batteries (zinc-carbon & alkaline)
3	73	Spent oil, category I
3	75	Spent oil, category III
3	21	Gas-discharge lamps
3	38	Gypsum
3	50	Plate glass
3	103	Acid tars
2	77	Oil-containing sludges
2	16	Sludge incinerator fly ash
2	95	Solvents, non-recyclable
2	23	Separately collected commercial and institutional organic waste
1	67	Separately collected textiles
1	47	Non-cleanable blasting grit
1	72	Oil filters
1	42	Tar mastic
1	18	Sludge incinerator filter cake

Costs (million €)	Category code	Category name
1	40	Bituminous roofing waste
0.5	104	Iron-containing pickling liquor
0.3	11	Flue gas treatment residues from waste incinerators, wet
0.1	80	Metal-working oils
0.1	100	Mercury-containing waste
0.05	83	Oil containing PCBs (= spent oil, cat. IV)
0.04	102	Sulphuric acid
0.01	97	Arsenic sulphide sludge