An Investigation of the Implications and Effectiveness of Producer Responsibility for the Disposal of WEEE.

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Executive Summary

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Chapter 2: The use and disposal of IT products in the commercial sector

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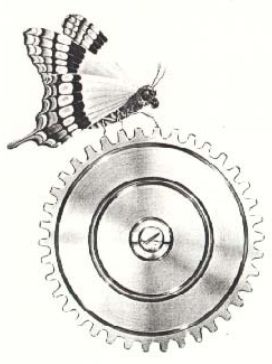

Brunel and Surrey Engineering Doctorate Programme in Environmental Technology – Research Portfolio

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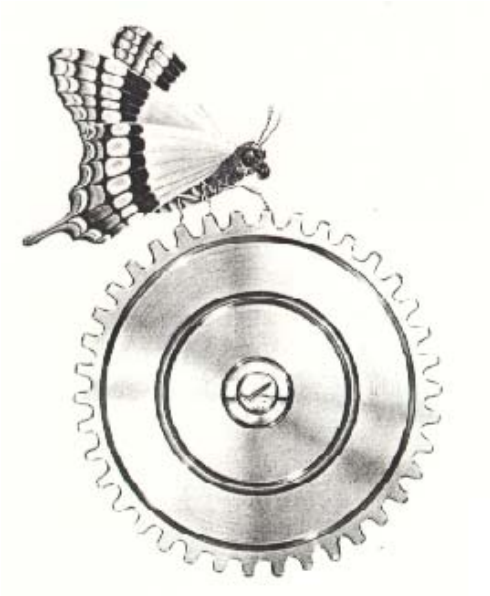

Executive Summary

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Abstract

Waste from Electrical and Electronic Equipment (WEEE) has become an issue of increasing concern to producers since the European Union proposed legislation making them responsible for the treatment and recycling of their products at end-of-life. This "Producer Responsibility" legislation is intended to provide producers with financial incentives to reduce the environmental impacts of their products at end-of-life. Although waste electronics amounts to only 4% by mass of municipal waste in Europe, the recovery, recycling, landfilling, and incineration of this waste can have considerable impacts on the environment. For example, the variety of metals contained in printed circuit boards can be mobilised in the environment during waste management. Using Life Cycle Assessment and Costing methods, this research analyses the likely effectiveness of this legislation in meeting its objective to reduce the environmental impacts of WEEE.

Through samples statistically representative of the UK, the use and disposal of products by householders and companies is also investigated. This area of research has received very little attention in the literature to date. Results show that within the commercial sector, many products are transferred to the domestic sector through reuse. In addition, results show that collection of waste electronics through retailers and municipal collection points will not capture a substantial proportion of waste discarded by householders of lower income, or smaller products mainly discarded as municipal waste.

Based on an example of printer recycling in the UK, findings from the LCA and LCC study bring into question the effectiveness of financial incentives established for producers to adapt the design of their products by the proposed WEEE Directive. For the example studied, results also indicate that the recovery and recycling rates proposed are unlikely to achieve the objectives originally set by the EC, or result in an overall benefit to the environment (given the needs for an integrated environmental product policy in Europe addressing a number of environmental concerns).

The conclusions propose that the end-of-life environmental impacts of WEEE could be better addressed through controls on substance use and tighter emissions controls on recycling processes, combined with improved environmental management and efficient logistics in recycling chains. Suggestions for further work are given.

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Contents

1. Introduction

This Executive Summary presents an overview of the findings of a 5-year research project conducted by the author on the disposal of Waste Electrical and Electronic Equipment (WEEE) in the UK. The work was carried out at Hewlett-Packard Limited under the industrial supervision of Tom Davis and Nick Gunn, and latterly Dr. Zoe Jackson. Academic supervision was provided by Dr. Chris France. The research has been completed as Part of the Engineering Doctorate programme in Environmental Technology at Brunel and Surrey Universities. In this introduction, the research background is explained. The structure of the Executive Summary is summarised at the end of this section.

At the time of writing, the European Commission (EC) had completed a new proposal for a Directive on WEEE requiring producers to provide for the collection, treatment[1], and recycling[2] of their products at "end-of-life" (COM[2000] 347 – 2000/0158[COD])[3]. The Parliament and Council of the EU are currently agreeing amendments to this text (A5-0148/2001 - 2000/0158 [COD]; 9767/01 - 2000/0158 [COD]). The studies included in this research portfolio investigate the overall approach taken to "Producer Responsibility" in the proposed WEEE Directive, relevant to the EC's original proposal from June, 2000.

The research undertaken provides contributions to knowledge in three areas:

1. Analysis of the likely effectiveness of the proposed WEEE Directive in meeting the original objectives of the EU to reduce the environmental impacts of WEEE.
2. Investigate the potential for reducing the environmental impact of End-of-Life Management (EOLM) processes cost effectively for WEEE
3. Investigation of the use and disposal of products by householders and by commercial organisations.

From gaps in the literature, four different research studies were undertaken:

- Analysis of Producer Responsibility policies for WEEE (Mayers and France, 1999; in Chapter 4, Vol. 1) summarised here in Section 2.
- Two research studies on the use and disposal of electronic products by both householders and companies in the UK (described in detail in Chapters 2 and 3, Vol. 1 respectively), summarised here in Section 3 and 4.

[1] In the proposed WEEE Directive, "treatment" means any activity after the WEEE has been handed over to a facility for depollution, disassembly, shredding, recovery, or disposal and any other operation carried out for the recovery and/or the disposal of the WEEE (COM[2000] 347: Article 3[i]).

[2] In the proposed WEEE Directive, "recycling" means the reprocessing in a production process of the waste materials for the original purpose or for other purposes, but excluding energy recovery (COM[2000] 347: Article 3[e]).

[3] In parallel the EC have also proposed a Directive addressing the Restriction of Hazardous Substances (RoHS) in electronic products (COM[2000]347 - 2000/0159[COD]), including lead, cadmium, mercury, brominated flame retardants, and hexavalent chromium. This study investigates requirements in the WEEE Directive rather than RoHS.

- A Life Cycle Assessment and Costing of the potential environmental impacts and costs to producers of increased electronics recycling under the proposed WEEE Directive (described in Chapter 1, Vol. 1), summarised here in Section 5.

In addition to these studies, much of the research conducted focussed on developing a system for managing the environmental performance and commercial viability of electronic products at end-of-life for HP (Mayers *et al.*, 1999; contained in Chapter 4, Vol. 1). This research was of most relevance for producers, which will have to comply with the requirements of Producer Responsibility legislation. As the research progressed, various problems were found with the Producer Responsibility approach (as summarised below), and the focus of the research moved away from the development of management systems.

1.1 Research background

Based on an example of printer products recycled in the UK, this research evaluates problems underlying the European Union's proposed Producer Responsibility Directive for WEEE. This is due to flaws in the two major assumptions forming the basis of the proposal, which have also been put forward and supported within the academic literature.

Firstly, Producer Responsibility is a "market-based" instrument of government policy, based on the polluter pays principle (OECD, 1975). In applying this approach within the proposed WEEE Directive, the EC have assumed that:

> "*Producers should take the responsibility for certain phases of the waste management of their products. This financial or physical responsibility creates an economic incentive for producers to adapt the design of their products to the prerequisites of sound waste management.*" – WEEE - May 2000: 6 [4]

Lifset (1993), Turner and Pearce (1993), and Wilson (1996) originally propounded this assumption within the academic literature. For example:

> "*There is little doubt that extended producer responsibility generates both economic and political incentives for waste recovery and, more broadly, green design.*" – Lifset (1993: 171).

To date no empirical studies have been undertaken providing evidence to show that Producer Responsibility can work in practice, a factor that was intentionally ignored by the EC in drafting it's WEEE Directive proposal:

> *"The main reason for the need to legislate in this field is the existence of externalities, i.e. environmental impacts that are not integrated in the price of the product and that are usually paid for by society via cleanup costs or environmental degradation. Although there is general awareness about the problems associated with WEEE, very little research exists that could give a monetary evaluation of the externalities linked to the current management practices of this waste. The absence of such an analysis, for what is a politically pressing issue, cannot however be construed as a reason for inaction."* –WEEE – May, 2000: 22.

[4] This, the EC fifth draft of the now proposed WEEE Directive, included an explanation of the EC's rationale for their approach. This was subsequently dropped from the proposed Directive text.

Using Life Cycle Assessment and Costing methods to evaluate a case study of printer recycling in the UK, this research provides evidence bringing these assumptions into question. The examples and evidence presented here suggests Producer Responsibility would not provide an effective framework of incentives for producers to develop products with reduced environmental impacts at end-of-life (as summarised in Section 5).

Secondly, by increasing recovery[5] and recycling rates (by mass) the EC also assume that the environmental impacts of WEEE will be reduced throughout the product life-cycle. One of the key objectives proposed by the European Commission for the WEEE Directive is to:

> "*…improve the environmental performance of all economic operators involved in the life cycle of electrical and electronic equipment and in particular operators directly involved in the treatment of waste electrical and electronic equipment.*" - COM(2000)347 final 2000/0158(COD): Article 1

Examples given by the EC of the specific environmental concerns to be addressed by the proposal include global warming, the release of hazardous substances, and resource conservation through recycling (WEEE – May 2000: 20, 22-23, 2000/0158[COD]: Recital 7). These three environmental concerns are also highlighted within the EU's draft sustainable development strategy, which is under preparation for the 2002 Earth Summit in Johannesburg[6].

EcoBalance (1999) have conducted the only comprehensive study to date evaluating the environmental impacts of WEEE, using Life Cycle Assessment for 8 different product categories. The findings of this study indicate increased recovery and recycling of WEEE as proposed by the EU will be of overall environmental benefit. However, apparent errors in the LCA assumptions and LCC methods used undermine the conclusions made. The main errors in assumptions were made on reuse[7] rates and environmental implications for reuse, the composition of WEEE, and the environmental burdens of landfilling of specific components (see Chapter 1, Vol. 1 for more details, in Section 3). By addressing some of the apparent weaknesses in the assumptions made by EcoBalance (1999), the results of this research indicate there is unlikely to be an overall environmental benefit to be gained from the increased recovery and recycling rates proposed within the WEEE Directive (as summarised in Section 5).

In order to understand how the requirements in the WEEE Directive can be fulfilled, the use and disposal of electronic products by householders and companies in the UK have both been investigated. This area of research has received very little attention within the academic literature to date. These studies identify and explain complex issues surrounding product consumption and disposal that previously have received little

[5] In the proposed WEEE Directive, "recovery" means any of the applicable operations provided for in Annex II.B to Directive 75/442/EEC (COM[2000] 347: Article 3[g]). This includes processes that do not reprocess materials for use or reuse, but generally utilise some chemical or physical property of waste materials for low-level economic use, such a road filler material.

[6] From draft Communication provided by the EC: "A Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development The Commission's proposal to the Gothenburg European Council" – 15 May, 2001

[7] In the proposed WEEE Directive, re-use means any operation by which WEEE is used for the same purpose for which it was conceived, including the continued use of WEEE which is returned to collection points, distributors, recyclers, or manufacturers (COM[2000] 347: Article 3[d]).

attention, and yet are fundamental to managing WEEE and increasing recycling rates as proposed within the WEEE Directive. For example, findings show that the WEEE Directive does not adequately address the needs of lower-income sectors of society, who are most likely to dispose of their end-of-life products to landfill or illegally due to lower accessibility to existing disposal arrangements and a higher dependency on older second-hand appliances.

In Sections 2 to 5 that follow, an overview is given of different studies conducted in this research. The final section (Section 6) summarises the research conclusions, and provides details on the structure of the research portfolio. A list of publications resulting from the work and conference presentations given over the research period is provided in Appendix 1.

2. The development of Producer Responsibility legislation for WEEE

The development of Producer Responsibility for WEEE in the UK and by the EU is discussed within a paper by the author, published in the peer reviewed Journal, *Greener Management International* in Issue 25, Spring 1999 (Mayers and France, 1999). This paper is included in Chapter 4, Vol. 1 of the research portfolio. The aims of the evaluation were to:

1. Examine the rationale behind Producer Responsibility and its political evolution and development across Europe.
2. Analyse cases for the most practical and workable approaches to Producer Responsibility within the UK.

Based on a review of existing and proposed approaches to Producer Responsibility adopted within European countries, the paper argues that:

- Policy makers and producers must address various practical issues before Producer Responsibility for WEEE can be implemented. These are:

  - Environmental management
  - Operational target date (s)
  - Implementation
  - Goals and objectives
  - Funding mechanisms
  - Financial responsibility
  - Management & operational responsibility
  - Collaborative structure
  - Collection method

  Possible approaches to each of these issues are outlined in the paper. Following publication, these nine areas were used by the author to structure a proposal for a UK product recycling scheme (PRIMER)[8] developed by Hewlett-Packard, Panasonic, Philips, and Sony and presented to the Department of Trade and Industry (ENDS, 1999: 13-14).

- There are practical obstacles to establishing financial responsibility for WEEE under Producer Responsibility:

  - As electronic products remain in use for several years, a price discount rate would apply to *future* take-back costs[9]. This would reduce any *present* incentives for producers to design products with reduced environmental impact at end-of-life.
  - During the long time delay between product sale and disposal, producers are likely to have changing market shares, leading to costs at end-of-life that could be disproportionate to sales. Some producers will cease to exist, leaving their "orphaned" products in the market place without providing for their future treatment and recycling costs.

[8] The Producer's Institute for the Management of Electronics Recycling.

[9] Discount rates are used to calculate the rate of return required on capital investments. It reflects the opportunity cost of investment and means that future costs and benefits are viewed as having lower value than current costs and benefits (Jackson, 1996: 94; Common, 1988: 183-187).

- Unless a satisfactory preventative mechanism could be put in place, companies could easily "cherry pick" products and brands that are most economic to treat and recycle at a loss to the companies that produced them.
- Responsibilities for financing, managing and organising, and processing WEEE at different stages of EOLM are not the same, and should not be confused.

Only subsequent to the publication of this paper were any of these financial aspects addressed in discussions by the European Union. It is possible that the author had some influence on this through involvement in European and UK industry lobby groups and meetings with government officials during the course of the research. For example, amendments to the Commission's original text have been proposed by the European Parliament (A5-0148/2001 - 2000/0158 [COD]) to ensure that each producer is only financially responsible for products they have placed on the market place following the introduction of the Directive.

In the following section, results on the use and disposal of IT products by companies in the UK are summarised.

3. The use and disposal of IT equipment by companies in the UK

The use and disposal of IT equipment by companies is investigated in detail in Chapter 2, Vol. 1 of the research portfolio. This study has been accepted for publication in the peer reviewed Journal of Business and Industrial Marketing (the original manuscript is included in Chapter 4, Vol. 1, Mayers *et al.* 2000)[10]. This research had three principal objectives:

- To identify the main reasons why companies discard their redundant IT equipment.
- To determine how companies discard of their redundant IT equipment.
- To investigate companies requirements for improved redundant IT equipment management services.

This study, completed in May 1998, used a mail survey on a sample of 151 companies[11] that was statistically representative of the UK. The scope of the study included the main categories of electronic equipment used by businesses[12]. An explanation of the research methods used is given in Chapter 2, Vol. 1 (Sections 2 and 3). Results were used as market information for the development of product take-back services within HP (for larger UK business customers).

[10] This survey was undertaken with the assistance of other researchers. The author completed the results analysis and conclusions of this study exclusively. A statement of contributions is given in Chapter 3, Vol. 1, in Appendix 1.
[11] Employing 500 or more people
[12] Including PCs and computers, printers and peripherals, mainframes and servers, office imaging, telecommunications, and point-of-sale equipment.

The results of the study show that:

- Very few companies (5%) used IT products for less than two years before replacing them. This is surprising given the month-on-month technological development and obsolescence within the IT sector. A larger proportion of companies (51%) used their IT equipment for more than 4 years. However, technology related obsolescence was identified as a major cause of product end-of-life. Technological advances, software upgrades, and upgrading of internal administration systems were given as important antecedents for end-of-life by 94%, 93%, and 92% of respondents respectively.

- Although 80% of companies disposed of at least some equipment as waste, most companies also disposed of equipment through routes in which they were reused within households or other companies (such as transfer to employees or charitable refurbishment companies). It is therefore inappropriate to consider all discarded or redundant IT equipment arising from the commercial sector as waste.

- In the large majority of companies (85%), departments given responsibility for managing redundant IT equipment were also involved in the purchase of new products. Therefore, producers could add-value to their after-sales services by providing arrangements for the disposal redundant IT disposal to larger business customers (77% of respondents identified a need for improved services in this area). For example, certified data destruction services were used by only 30% of responding companies, whereas most respondents (almost 80%) believed the development of such services was "very important".

In summary, this study concludes that the increased levels of reuse and recycling resulting from the development of redundant IT equipment management services for the commercial sector could help producers to meet their future obligations under Producer Responsibility legislation. In addition, it concludes that producers could profit from second-hand sale of products while exerting greater control over the quality and competitiveness of these markets.

In the following section, results from a similar survey investigating the use and disposal of household appliances are summarised.

4. The use and disposal of household appliances in the UK

Chapter 3, Vol. 1 of the research portfolio contains the most comprehensive and detailed investigation into the patterns of use and disposal of household appliances undertaken to date in the UK[13]. The findings of this study have been published in Cooper and Mayers (2000), peer reviewed in Cooper and Mayers (2001), and reported in (WRF, 2000). The objectives of this study were to:

[13] This study was completed jointly with Tim Cooper at Sheffield Hallam University. A statement of contributions is given in Chapter 4, Vol. 1, in Section 1. Only the authors own contributions are reported here. Chapter 4, Vol. 1 of the portfolio was written jointly with Tim Cooper, and has been peer reviewed (Cooper and Mayers, 2001).

- Investigate the purchase, use and disposal of household appliances.
- Provide quantitative information on product ownership, lifetime and use, and disposal representative of the UK.
- Identify the likely effectiveness of different approaches to addressing the need to reduce WEEE.

Research was conducted in December 1998 using a demographically and statistically representative sample of 802 households across the UK, and five focus groups. A detailed account of the methodology used is given in Chapter 3, Vol. 1 (Sections 2 and 3) of the research portfolio. The research was used within HP for information on the likely quantities of WEEE that will be collected in the UK under the proposed WEEE Directive. Results were widely reported in the UK press, radio, and TV, illustrating the high level of interest and practical relevance of the findings[14].

For the first time in the UK, the results of this study provide comprehensive statistics on the quantities of household appliances owned, stored, reused, repaired, in need of repair, and discarded by different methods; on the lifetime of appliances; and on differences with householder attitude and demographic factors. The findings of this research were that:

- Households owned, on average, 25 appliances. Ownership of products within the households studied was estimated to have increased by around 60% over the last five years. The product stock was relatively young, most products (88%) being under 10 years old and more than half (57%) under 5 years old.

- At least 476,000 tonnes of household appliances, totalling over 23 million units, were discarded annually in the UK between 1993 and 1998. Large white goods constituted the greatest proportion of the waste stream by mass (77%) and small appliances[15] by number of units (37%).

- Only between 1% and 7% of appliances owned by householders were stored, and between 1% and 13% reused (depending on product category). The proportion of products stored was significantly higher in households of higher Socio-Economic Grouping (SEG), with 2% to 5% of products in storage between the highest and lowest groupings respectively. In comparison, reuse was significantly higher in households of lower SEG, with differences of 3% to 14% between the lowest and highest groupings. Motivations explored in focus group indicated products were stored primarily for future potential reuse. Three conclusions are made based on these and other related results:

  - Policy initiatives encouraging the disposal of appliances in storage for material recycling may preclude possibilities for reuse.
  - Reuse can result in substantial environmental benefits where it displaces the manufacture of new products. This is may not be the case for household appliances. This is because reuse predominates in households of lower socio-

[14] With articles appearing in the Financial Times, Scotsman, Daily Mail, Observer, Women's Own, Real Homes, reviews or interviews on Radio 1, 2 , and 4, on BBC 2, and on several local UK BCC radio stations.

[15] Defined here as small work and personal care appliances, radio and personal radio, stereo and CD, telephones, faxes and answer-phones, mobile phones and pagers, and toys.

economic status, which due to financial circumstances may only have the option to purchase more expensive larger appliances second-hand (as shown above).

– "Bring" systems[16] may fail to capture second-hand appliances discarded by householders of lower socio-economic status, who were significantly less likely to possess their own means of transport, or to trade-in their old appliances (due to less likelihood of buying new products).

- At least 3.6 million small work and personal care appliances[17] were discarded each year with household waste destined for landfill and incineration (which is around 60% of such appliances discarded). In addition, most of the 52,000 tonnes of consumer electronics[18] discarded each year is not presently recycled. To meet the proposed WEEE Directive targets, new collection and recycling processes will be required for these products.

- As almost a quarter (22% by mass) of discarded products were reused, it will not always be the original owner that will eventually dispose of a product as waste for recycling or landfill. The collection of unwanted appliances on the sale of new through retail outlets will not capture a substantial proportion of such waste and thus has only limited potential.

- A majority of households (around 60%) indicated a preference for a fee payable on disposal to fund additional collection and recycling services for WEEE (as opposed to increased product prices or local taxes). This, however, may not be acceptable, as it was found that at least 3,330 tonnes of equipment per year is illegally fly-tipped in skips and on waste ground.

In the following section (Section 5), results of the Life Cycle Assessment and Costing of the likely environmental impacts and costs of WEEE at end-of-life are summarised.

5. The environmental impacts and costs of electronics recycling

In Chapter 1, Vol. 1, the results of an investigation into the environmental impacts and costs to producers of electronics recovery and recycling in comparison to landfilling are described. Using a combination of Life Cycle Assessment (LCA) and Costing methods (LCC), the aims of this research were to:

- Determine the likely environmental impacts and cost implications for producers of the proposed Producer Responsibility legislation for Waste Electrical and Electronic Equipment (WEEE).
- Investigate the potential for reducing the environmental impact of End-of-Life Management (EOLM) processes cost effectively for WEEE

[16] Systems where householders can drop-off any unwanted materials or products for recycling at collection points, such as at municipalities or retail sites as proposed in the WEEE Directive.
[17] Including products such as kitchen appliances, irons, clocks, hair dryers, shavers, deep fat fryers, and sewing machines.
[18] Including Hi-fi and stereo, radio, personal radio, stereo, and CD, televisions, videos and camcorders.

A printer "trade-in" conducted in the UK was used as a case study to evaluate three different levels of recycling and recovery in comparison to landfilling[19]. These were:

1. "*Plastics and PCBs[20] recovered*", corresponding to requirements in the proposed WEEE Directive with a combined recovery and recycling rate of 99.9% (by mass).
2. "*Plastics landfilled*", to investigate the effects of recycling only printed circuit boards and steel and aluminium components, with a recycling rate of 67.8%.
3. "*Plastics and PCBs landfilled*", to investigate the effects of recycling only steel and aluminium components, with a recycling rate of 61.4%.

This study attempts to address weaknesses in the LCA assumptions and LCC methods within the Ecobalance (1999) study on WEEE (introduced in Section 1.1).

The LCA methods used followed ISO 14040 requirements to compile characterised environmental impacts from the calculated environmental burdens for the different scenarios outlined above. A detailed comparison of results is included in Sections 6 and 7, Chapter 1, Vol. 1. Below, the main findings of this study are summarised, using some illustrative examples. A detailed account of the LCA and LCC methodologies used can be found in Chapter 1, Vol. 1 (Sections 4 & 5). The financial results were used within HP to develop a commercially viable product recycling process for larger business customers in the UK[21].

Based on the example of printer-products used, the findings of this study indicate that:

- Producer Responsibility potentially will not provide an effective framework of financial incentives, encouraging producers to develop products with lower environmental impact at end of life as intended within the proposed WEEE Directive:

  - Due to the use of price discounting in financial accounting, a producer's future EOLM costs could be reduced by 20%-50% for small products with 4 year life spans, to 50%-80% for products with a longer life span such as Hi-fis and stereos at 9 years (depending on the discount rate used). This would reduce incentives for producers to adapt the design of their products, particularly for products with longer life spans.

  - For almost all categories of environmental impact investigated (10 out of 11)[22], no overall relationship between the level of environmental impacts and cost was found. In addition, the distribution of environmental impacts of collection,

[19] Printer products provided a useful case study to evaluate WEEE, as their composition was similar to that of small work and personal care appliances, toys, mobile phones and pagers, telephones, faxes, and answerphones, radio and personal radio, stereo and CD, home and garden tools, video, vacuum cleaners and carpet cleaners, hi-fi and stereo. These types of appliance are made up of a combination of plastics, printed circuit boards, steel and aluminium mechanical and structural components, and wires and cables.

[20] Printed Circuit Boards

[21] This contribution was a significant part of the work completed at HP during the course of the research, for which the author received the HP UK award for "Overall Environmental Champion 1998" and was commended by the then President and CEO of the HP Corporation, Lew Platt.

[22] Corresponding to 12 out of the 16 environmental impact assessments conducted. Some categories of environmental impact involved more than one assessment. For example, the environmental impact category "*global warming potential*" involved 3 assessments (over 20, 100, and 500 year time frames).

treatment, and recycling processes for WEEE did not follow the distribution of costs. For example, materials production accounted for a large proportion of the potential environmental impacts of the printer trade-in. For example, materials production accounted for between 39% and 86% of human toxicity for the "*plastics and PCBs recovered*" scenario (depending on the assessment method used), and between 50% and 63% of terrestrial eco-toxcity. However, materials production only accounted for 10% of the printer trade-in costs. Without a relationship between the environmental impacts and costs of EOLM processes for WEEE, financial incentives will not exist for producers to adapt the design of their products.

– Under the proposed WEEE Directive, producers will not have the exclusive right to any environmental benefits "designed-in" to their products. Unless the EU agree on a text making producers responsible for financing the treatment and recycling of their own products (placed on the market following implementation), companies will be free to "cherry-pick" products with lower end-of-life costs.

- The proposed Directive sets various targets for the recycling[23] and recovery[24] of WEEE, ranging between 50% and 75% for recovery, and 60% and 85% for recycling, depending on product category (COM[2000] 347: Article 6). These specific targets are not, however, based on any assessment of the environmental impacts of different waste management and recycling options. Moreover, these targets are based on an assumed "hierarchy" of waste management options, dictating that recycling and recovery will always have lower environmental impacts than landfilling. The results indicated that the proposed WEEE Directive is unlikely to have an *overall* environmental benefit, and setting of recycling rates by mass has considerable disadvantages.

  Although valuation was not undertaken in the LCA, to determine which level of recovery and recycling is "best", an implicit trade-off must be made between conflicting environmental criteria (as discussed in Section 7.4, Chapter 1, Vol. 1).

  The "*plastics and PCBs recycling*" scenario only resulted in the lowest level of potential impact for resource depletion (which was almost 100% lower in relation to landfilling) and air acidification (which was around 65% lower)[25]. However, the potential impacts of eutrophication, eco-toxicity, human toxicity, global warming, photochemical oxidant formation were:

[23] In the proposed WEEE Directive, "recycling" means the reprocessing in a production process of the waste materials for the original purpose or for other purposes, but excluding energy recovery (COM[2000] 347: Article 3[e]).

[24] In the proposed WEEE Directive, "recovery" means any of the applicable operations provided for in Annex II.B to Directive 75/442/EEC (COM[2000] 347: Article 3[g]). This includes processes that do not reprocess materials for use or reuse, but generally utilise some chemical or physical property of waste materials for low-level economic use, such a road filler material.

[25] Ozone Depletion Potential was also lower. However, the overall level of impact was minimal in comparison to WEEE containing Ozone Depleting Substances, such as refrigerators.

- Better in other scenarios with lower recycling and recovery rates, depending on the specific components and materials recovered or recycled[26]. For example, the "*plastics and PCBs*" recovered scenario actually had the highest level of impact for aquatic eco-toxicity (which was between 250% and 270% higher than 100% landfilling).

- Sometimes better and sometimes worse compared to landfilling. Landfilling had a lower level of impact than the "*plastics and PCBs recycling*" scenario in 7 out of the 16 assessments conducted. For example, landfilling had the most favourable result for eutrophication. This was due to the inputs of energy and emissions arising from the collection and processing of WEEE compared to conventional household waste recycling processes.

Resource conservation and acidification (which were better in the "*plastics and PCBs recovered*" scenario) are not the only priorities of EU environmental policy (as argued further in Section 7). For example, global warming and control of toxic substances are also given high importance. Results indicated that the landfilling of plastics could have the lowest potential for global warming (at 15% and 25% lower than landfilling) and ecological toxicity (from around 50% to 80% lower than landfilling). However, this also increased the potential for resource depletion, human toxicity, eutrophication, air acidification, and photochemical oxidant formation compared to other scenarios.

Debatably for this case study, the results indicated that no scenario, including rates of recovery and recycling proposed in the WEEE Directive, would result in an overall reduction in environmental impact. Arguably in this example, the WEEE Directive is unlikely to achieve the EC's original objective to reduce the environmental impacts of product from a life-cycle perspective or result in overall benefit to the environment.

In the following section (Section 6), the conclusions of the research are discussed.

6. Conclusions and overview of portfolio structure

Previous sections have provided a summary of the background and findings of the research submitted with the portfolio. In Sections 2 to 5, summaries were given of the findings of each research project undertaken. Below in Section 6.1, the implications and main findings of the research are drawn together. The structure of the portfolio and guidelines for readers are given in Section 6.2.

6.1 Research conclusions

The research presented in this portfolio has provided contributions to knowledge in the area of Environmental Technology in three areas:

[26] The potential for photochemical oxidant formation of the "*plastics and PCBs recovered*" scenario was a slight exception, with an impact ranging from 20% below to 50% above "*100% landfilling*" (but with a median of 15% above).

1. Analysis of the likely effectiveness of Producer Responsibility to meet its objectives to reduce the environmental impacts of WEEE.
2. Evaluation of the practical steps producers can take to improve the environmental performance and commercial viability of their EOLM processes for electronic products under Producer Responsibility.
3. Investigation of the use and disposal of products by households and by companies.

The proposed WEEE Directive is likely to be in effect in all Member States by January 2005 at the earliest. On a practical level, producers could use the findings of this research in establishing commercially viable EOLM processes, ensuring that society's needs for disposal arrangements for their unwanted household appliances are properly addressed. For example:

- Householders revealed a need for information on how to dispose of their appliances safely before changing their disposal practices.
- Product recycling services need to capture smaller products currently disposed of in landfill, and also appliances discarded by householders of lower socio-economic status without sufficient access to collection facilities.
- The provision of certified data destruction services by IT producers for larger business customers could add-value to their post-sales services.

Contrary to the assumptions made by the EU and by previous researchers (Section 1.1), the results for the LCA and LCC case study example (Section 5) show that Producer Responsibility potentially will not provide effective incentives to producers to develop products with reduced environmental impact at end-of-life. In addition, results indicate that simply increasing recovery and recycling rates as required in the proposed Directive is unlikely reduce the overall environmental impact of WEEE.

Producer Responsibility could only provide incentives for producers to design products with lower environmental impact at end of life if market mechanisms already fully accounted for the external costs of environmental degradation. Any incentives that might exist can be disrupted due to:

- The use of price discounting to calculate the present value of future EOLM costs to producers.
- The absence of a relationship between the environmental impacts and cost of WEEE.
- A failure to ensure producers will be financially responsible for products they have individually placed on the market following implementation of the WEEE Directive.

The application of the polluter pays principle within the proposed WEEE Directive is therefore potentially flawed.

The proposed WEEE Directive has taken a large category of products including everything from musical socks, to electric toothbrushes, to high-end servers, and adopted mass-based collection and recycling targets on the basic assumption that increased recycling will reduce their environmental impacts from a lifecycle perspective, as introduced in Section 1.1.

The LCA results indicated that the level of environmental impact was dependent on the specific components and materials recovered or recycled, rather than the combined recovery and recycling rate. The level of environmental impact between each scenario, including landfilling, was sometimes better and sometimes worse compared to other scenarios. Determining the Best Environmental Option would require a trade-off or valuation to be made between different environmental impact categories. For example, the landfilling of plastics without energy recovery could support commitments within the Kyoto protocol for reductions in greenhouse gas emissions, and help lower the release of potentially toxic metals to ecosystems compared to other scenarios. However, it would also result in a failure to meet the recycling targets proposed in the WEEE Directive to reduce the consumption of resources and conserve landfill space, and could require closer comparison of the relative effects on ambient air quality between scenarios.

To reduce the overall environmental impact of products through the life-cycle, it is essential that the EU develop a coherent framework of product-based environmental policies, as proposed within the EC's draft Integrated Product Policy (COM [2001] 68 final). Based on the LCA example presented in this research, the implicit trade-off between environmental impacts that would be made by adopting the WEEE Directive arguably would be neither coherent nor legitimate in this respect.

The combined LCA and LCC results therefore bring into question the likely effectiveness of the proposed EU WEEE Directive in meeting its stated aims and objectives.

Before adopting legislation, governments such as the EU should take into account the broader environmental, economic, and social implications of their policies. For example, within the "Agenda 21"report of the Earth Summit in 1992, an objective of international legal instruments is described as:

> "*To identify and prevent actual or potential conflicts, Particularly between environmental and social / economic agreements or instruments, with a view to ensuring that such agreements or instruments are consistent. Where conflicts arise, they should be appropriately resolved…* " – UNCED, 1992: 237.

In determining the scope, legal definitions, requirements and responsibilities for producers, the WEEE Directive should recognise better the way in which society uses and disposes of electrical and electronic appliances. For example:

- The extent of reuse of IT products means much equipment sold into the commercial market, is later transferred for reuse and eventual disposal by householders. This will confuse any distinctions made between requirements for financing and disposal arrangements for "commercial" and "household" wastes.
- The proposed WEEE Directive includes provisions for return of WEEE from the householder to municipal collection yards and retailers, which are less likely to capture WEEE disposed by lower-income sectors of society or small products discarded with ordinary household waste to landfill or incineration.

As discussed in relation to future work within the conclusions of Chapter 1, Vol. 1 (in Section 7), the EC should investigate alternative policy instruments to Producer Responsibility in reducing the environmental impacts of WEEE (which was beyond the scope of this research). These could include:

- Tighter controls on the chemical content of products
- Tighter controls on emissions from recycling and disposal processes
- Improved environmental management and efficient logistics in recycling chains.

If the environmental impacts of WEEE came under appropriate control though the use of these or other approaches, the political will to increase treatment and recycling rates, conserve resource, and reduce landfilling of WEEE could be addressed adequately through policies targeting local waste management authorities.

This research also brings into question the likely environmental benefits of Producer Responsibility for other wastes such as packaging, batteries, and automobiles. In particular, the effectiveness of financial incentives in reducing the environmental impacts of products at end-of-life should be investigated. Subsequent scientific, sociological, and economic research could very usefully advance and test further the findings presented here.

6.2 Portfolio composition

The project portfolio has been divided into two main volumes. Vol. 1, which includes this Executive Summary, contains five different chapters with three different reading options (as shown in Table 6.1).

Vol. 1 has been designed to cover all of the background, development, and conclusions of the work submitted for the EngD degree. It includes the full list of literature referenced in the research. Vol. 2 comprises of the 6 month reports, submission of which is a requirement of the EngD programme. The 6 month reports describe in-detail the status of the project at different stages over the four-year research period. Vol. 2 contains these 7 progress reports in chronological order (Chapters 1-7, Vol. 2).

Vol. 1 contains a full account of the research, in a linear and readable form, which makes Vol. 2 largely redundant and the reader is advised that it need not be read to consider the assessment of this work.

Table 6.1: Readers portfolio reading guidelines

Chapter	Title	Reader's guidelines		
		For an overview read:	For an abridged summary read:	For a full review, read †:
	Executive summary.	✓	✓	✓
1	The environmental impacts and costs of waste electronic product recycling: an assessment of the effectiveness of Producer Responsibility for WEEE.			✓
2	The use and disposal of IT products by UK			✓

	companies.			
3	Prospects for household appliances.			✓
4	Published papers and papers for publication.		✓	✓

† It is recommended that the Examiners follow this reading option

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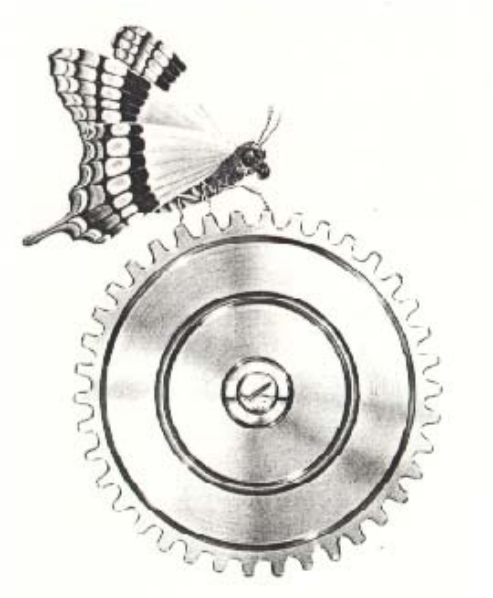
Chapter 1, Vol. 1

An Investigation of the Implications and Effectiveness of Producer Responsibility for the Disposal of WEEE.



The environmental impacts and costs of waste electronic products: an assessment of the effectiveness of Producer Responsibility for WEEE

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Abstract

With the development of 'Producer Responsibility' policies and legislation by governments in countries throughout the developed world, the cost burdens of waste management are shifting away from society to producers, and through cost internalisation, ultimately to the individual consumer. Under this approach, producers are required to provide for the collection, treatment, and recycling of their products at "end-of-life". Such requirements are presently proposed for electronic products in Europe under a new Directive on Waste Electrical and Electronic Equipment (WEEE).

The study presented here investigates the environmental impacts and costs of collection, treatment, and recycling processes for electronic products using Life Cycle Assessment and Costing methods, based on an example of printer recycling conducted in the UK. Contrary to the original assumptions of the EC and previous researchers, findings based on an example of priner recycling indicate that the proposed WEEE Directive is unlikely to establish effective financial incentives for producers to adapt the design of their products. Results also indicate that the recovery and recycling rates proposed within the WEEE Directive are only likely to result in reductions in environmental impacts for resource depletion and air acidification. Other environmental impacts investigated are found to be better at lower recycling rates or with landfilling (such as for eutrophication, global warming potential and ecological toxicity). These results bring into question the ability of the proposed WEEE Directive to fulfill its objective to reduce the environmental impact of products from a life cycle perspective.

Key words: electronic products, environment, waste, recycling, life cycle assessment, life cycle costing, legislation, European Union, printers, product take-back, producer responsibility, WEEE.

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Contents

Foreword

This report presents research investigating the potential environmental impacts and costs of collection, treatment, and recycling processes for waste electronic products. The research has been completed as part of the Engineering Doctorate programme in Environmental Technology at Brunel and Surrey Universities. The report forms the first chapter of the first volume of the Research Engineer's project Portfolio (Chapter 1, Vol. 1). The previous section in this thesis (Executive Summary, Vol. 1) presented a summary overview of the total research and its findings, including reading guidelines for the porfolio. In subsequent chapters (Chapters 2 and 3, Vol. 1), research and findings on the use and disposal of appliances by commerce and householders are presented. An overall summary of the portfolio, including reader's guidelines, is presented in the Executive Summary, Vol. 1 (Section 6.2).

1. Introduction

Following the adoption of "Producer Responsibility" legislation for electronic appliances in the EU, producers will be required to finance and organise the treatment[1] and recycling[2] of their waste products at "end-of-life" (discussed below in Section 1.1). Using Life Cycle Assessment and Costing methods, the aims of this research were to:

- Determine the likely environmental impacts and cost implications for producers of the proposed Producer Responsibility legislation for Waste Electrical and Electronic Equipment (WEEE).
- Investigate the potential for reducing the environmental impact of End-of-Life Management (EOLM) [3] processes for WEEE cost effectively.

Based on the example of printer products investigated, findings (discussed in Section 6) point out potential flaws in the approach taken by the EU on Producer Responsibility for electronics waste:

1. It will result in higher costs to consumers and producers, but appears unlikely to provide incentives for producers to develop products with reduced environmental impacts at end-of-life as intended under Producer Responsibility.
2. The rates of recovery[4] and recycling proposed could result in increases in various environmental impacts compared to landfilling and recycling at lower rates, such as for ecological toxicity, eutrophication, and global warming potential.

Using Life Cycle Assessment, opportunities to improve both the environmental performance and commercial viability of EOLM processes are also evaluated.

A printer "trade-in" conducted in the UK is used as an example in the research evaluation. This trade-in was conducted between a major international producer of IT products and printers (the sponsor company, Hewlett-Packard Limited) and a major group of high-street retailers in the UK (Dixons Stores Group). Consumers were offered various discounts on the price of selected new printer products on exchange for their older printers. During the month of April 1999 (the period of the trade-in) some 3,250 printers, weighing over 20 tonnes in total, were returned through retail outlets to a subcontracted recycling company in the UK (Intex Computers).

Although this trade-in was undertaken principally as a marketing promotion, to increase consumer awareness of new printing technologies and thus stimulate new product sales,

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[1] In the proposed WEEE Directive, "treatment" means any activity after the WEEE has been handed over to a facility for depollution, disassembly, shredding, recovery, or disposal and any other operation carried out for the recovery and/or the disposal of the WEEE (COM[2000] 347: Article 3[i]).
[2] In the proposed WEEE Directive, "recycling" means the reprocessing in a production process of the waste materials for the original purpose or for other purposes, but excluding energy recovery (COM[2000] 347: Article 3[e]).
[3] Processes for the collection, treatment, and recycling of WEEE.
[4] In the proposed WEEE Directive, "recovery" means any of the applicable operations provided for in Annex II.B to Directive 75/442/EEC (COM[2000] 347: Article 3[g]). This includes processes that do not reprocess materials for use or reuse, but generally utilise some chemical or physical property of waste materials for low-level economic use, such a road filler material.

it also offered useful opportunities for research. In terms of logistics requirements, the printer trade-in would be similar to the take-back of products under the proposed WEEE Directive, one of the requirements of which is likely to be the return of products on the sale of new through retail outlets. The printer trade-in example is explained further in Section 5.1.

In this introductory section it is explained why WEEE has become an issue of current environmental concern. In Section 1.1 the development of Producer Responsibility legislation within Europe is reviewed, and in Section 1.2 the environmental impacts of WEEE are discussed. This is provided as background to the research undertaken.

1.1 Producer Responsibility for WEEE

Producer Responsibility is intended to provide financial incentives to producers to design products with reduced environmental impacts at end-of-life. In this section, the development and background of this legislation is described.

At the time of writing, the European Commission had completed a new proposal for a Directive requiring Producers of Electrical and Electronic Equipment to provide for the collection, treatment, and recycling of their products at "end-of-life" (COM[2000] 347 – 2000/0158[COD])[5]. The Parliament and Council of the EU are currently agreeing amendments to this text, through a process known as co-decision (A5-0148/2001 - 2000/0158 [COD]; 9767/01 - 2000/0158 [COD]). The analysis presented in this study addresses the overall approach behind this Directive.

The European Union has already adopted Producer Responsibility Directives for packaging (94/62 EC), batteries (91/157 EEC), and automobiles (2000/53/EC). Many countries throughout the developed world have implemented similar regulations and policies (Mayers and France, 1998).

The EU first highlighted WEEE as a potential environmental problem in 1995, when it was designated as a priority waste stream along with end-of-life vehicles, tyres, chlorinated solvents, construction wastes, and healthcare wastes (DOE, 1995). The reasons given for this included (ENEA, 1995):

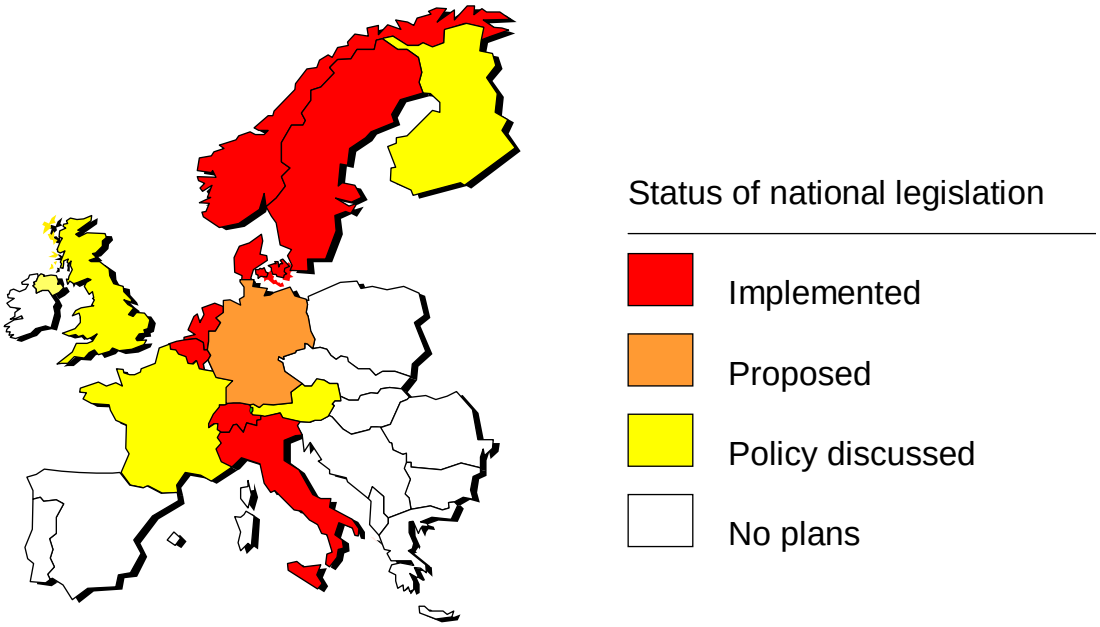
1. Projected future increases in the volume of electronics waste going to landfill or incineration
2. Loss of valuable materials as waste
3. Harmful and hazardous materials that could be released on disposal

Six European countries to date have already implemented Producer Responsibility legislation for electronic products (including four of the fifteen EU Member States): Italy, Switzerland, the Netherlands, Norway, Belgium, and Sweden (as shown in Fig. 1.1). Denmark has implemented electronics recycling legislation, but not with Producer Responsibility. These countries, and others such as Germany that have laid plans for similar legislation, have "forced the hand" of the European Union to implement the

[5] In parallel the EU have also proposed a Directive addressing the Restriction of Hazardous Substances (RoHS) in electronic products (COM[2000]347 - 2000/0159[COD]), including lead, cadmium, mercury, brominated flame retardants, and hexavalent chromium. This study investigates requirements in the WEEE Directive rather than RoHS.

WEEE Directive and improve harmonisation between different approaches by Member States. It is now likely that the proposed WEEE Directive will be implemented in the summer of 2002, with an effective date in all Member States of January 2005.

Figure 1.1: Producer Responsibility legislation for WEEE in European Countries (2001)



The stated objectives of the proposed WEEE Directive are to (COM[2000] 347: Article 1):

1) Prevent WEEE.
2) Reduce the disposal [*landfilling and incineration*] of WEEE through reuse[6], recycling, and recovery.
3) Improve the environmental performance of all economic operators involved in the life cycle of electrical equipment and in particular operators directly involved in the treatment of WEEE.

The objective to "prevent WEEE" is not currently addressed within the Commission's proposed text, as it does not include measures to reduce the quantity of products consumed. The second objective is palpable but is not related to the environmental benefits of the proposed Directive. The third objective is most important in this research as it describes the intention of the EU to reduce the environmental impacts of WEEE. This objective is evaluated in light of the research findings in Section 7.

Examples given by the EC of the specific environmental concerns to be addressed by the proposal include global warming, the release of hazardous substances, and resource conservation through recycling (WEEE – May 2000: 20, 22-23, 2000/0158[COD]: Recital 7). These three environmental concerns are also highlighted within the EU's draft

[6] In the proposed WEEE Directive, re-use means any operation by which WEEE is used for the same purpose for which it was conceived, including the continued use of WEEE which is returned to collection points, distributors, recyclers, or manufacturers (COM[2000] 347: Article 3[d]).

sustainable development strategy, which is under preparation for the 2002 Earth Summit in Johannesburg[7].

To date, EcoBalance (1999) has completed the only comprehensive study evaluating the likely environmental impacts resulting from the proposed WEEE Directive. This study supports the assumptions of the EU, that increasing recycling rates by mass will reduce the environmental impacts of WEEE relative to landfilling and current practice in the UK. However, apparent errors in the assumptions and methods used undermine these findings substantially (as detailed in Section 3). By addressing some of the weaknesses in the assumptions made by EcoBalance (1999), the findings of this research bring into question the reductions in environmental impact that the proposed WEEE Directive will actually achieve (as summarised in Section 6.1).

Producer Responsibility is a market-based instrument of government policy, the aim of which is to provide economic incentives for Producers to reduce the environmental impacts of their waste products (at their so-called "end-of-life"). In the fifth draft of the WEEE Directive, the EC provided a detailed rationale for their approach, including a review of the potential environmental impacts of WEEE[8]. By including the costs of product collection, treatment, and recycling in the cost of new products, the EC have argued that producers would be given incentives to redesign their products and establish product treatment and recycling processes to ensure reduced environmental impacts at end-of-life:

> "*Producers should take the responsibility for certain phases of the waste management of their products. This financial or physical responsibility creates an economic incentive for producers to adapt the design of their products to the prerequisites of sound waste management.*" – WEEE - May 2000: 6

Within the academic literature, Lifset (1993), Turner and Pearce (1993), and Wilson (1996) originally propounded this argument, and advocated the use of Producer Responsibility in government policy. For example:

> "*There is little doubt that extended producer responsibility generates both economic and political incentives for waste recovery and, more broadly, green design.*" – Lifset (1993: 171).

> "*It turns out that a relatively simple tax or levy system can be directed at the packaging waste and litter problem. The simplicity of the system is important….its bureacratic and compliance costs should be relatively low. The levy or tax can be properly related to environmental damage impacts by the incorporation of average costs for waste disposal and litter collection costs (proxy for the full pick-up and disamenity costs of litter) into the computations.*" – Turner and Pearce (1993: 88-89)

To date, no studies have been undertaken providing evidence to show that Producer Responsibility can work in practice, a factor that was intentionally ignored by the EC in drafting it's WEEE Directive proposal:

> *"The main reason for the need to legislate in this field is the existence of externalities, i.e.*

[7] From draft Communication provided by the EC: "A Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development The Commission's proposal to the Gothenburg European Council" – 15 May, 2001

[8] This explanation of the EC's rationale for their approach was subsequently dropped from the proposed Directive text.

> *environmental impacts that are not integrated in the price of the product and that are usually paid for by society via cleanup costs or environmental degradation. Although there is general awareness about the problems associated with WEEE, very little research exists that could give a monetary evaluation of the externalities linked to the current management practices of this waste. The absence of such an analysis, for what is a politically pressing issue, cannot however be construed as a reason for inaction."* –WEEE – May, 2000: 22.

As electrical and electronic products remain in use over a number of years, incentives to reduce the environmental impacts of products at end-of-life are likely to be difficult to establish in practice. This is because product design and end-of-life are too far separated in time for a direct causal link to be established (Mayers and France, 1999: 59-60).

The EC have recognised that manufacturers could loose incentives for product design if the costs of compliance are collectively allocated by producers according current market share, as opposed to waste appliances collected by brand. In August the EC accepted amendments of the parliament made in May 2001 (A5-0148/2001 : COM[2000] 347) that each individual producer should be financially responsible for products they (and not any other producer) have placed on the market following implementation. The European Council, however, has not made such a differentiation in their amendments agreed in June 2001 (9767/01 – COM[2000] 347).

As a further complication, the EC have proposed various parallel regulatory controls on the use of materials and product design:

- The Restriction of Hazardous Substances (RoHS) Directive proposed in parallel to the WEEE Directive proposes standards-based measures to phase out the use of lead, mercury, cadmium, hexavalent chromium, and halogenated flame-retardants from electronic products by 2006 (COM[2000]347 - 2000/0159[COD]) [9].

- The EC have drafted an additional Directive on the design and development of Electrical and Electronic Equipment (EEE – February 2001). Overall this Directive aims to minimise the environmental impacts of products throughout the life cycle. The Directive proposes requirements on producers to conduct environmental assessments of the life cycle of their products, and to meet life-cycle environmental standards continually reviewed by industry, key stakeholders, and the European Commission under CE marking procedures.

- A new EC Directive on Integrated Pollution Prevention and Control (IPPC) entered into force in October 1996. This Directive requires companies with processes on a prescribed list to be to take a much more holistic view on the life-cycle aspects of their production activities including (Nicholas *et al.*, 2000):

  - Control of whole installations rather than processes.
  - Integrated consideration of emissions to air, water, and soil, energy efficiency, use of raw materials, off-site waste disposal, and site restoration.
  - Source reduction as opposed to emissions control.

[9] Requirements for substance restrictions have now been taken out of the WEEE Directive and proposed in a parallel Directive on the Restriction of Hazardous Substances (RoHS) in Electrical and Electronic Equipment (EEE).

There is considerable overlap in approaches proposed by the EC to reduce the environmental impacts of products and processes from a life cycle perspective. While it may be appropriate that different stages of a product life cycle are regulated in different ways, there should be better integration and co-ordination of these different initiatives by the EC. In 1999, the EC drafted an Integrated Product Policy (IPP) with this aim in mind. However, progress to date on IPP has been limited and as yet no specific policies or measures have been decided upon (COM [2001] 68 final; Charter and Belmane, 1999).

In the UK, the government has given priority to voluntary Producer Responsibility initiatives (DOE, 1995). However, prescriptive regulations may be implemented in support of Producer Responsibility under section 93 of the 1995 Environment Act. Similarly, voluntary approaches by industry have also been encouraged and supported by governments in Switzerland, France, and Finland. Here, "voluntary action" refers to actions taken by industry to establish take-back schemes under the threat of prescriptive legislation in the future. Any action taken by industry as a result of such policy is unlikely to be truly voluntary!

Within the UK, the extent to which government and industry can reach agreement over areas of responsibility left to determination by Member States in the proposed Directive (through the principle of subsidiarity), such as product collection, will influence the future of such initiatives:

> *"The electronics industry is clearly in an advantageous position to negotiate and even propose a product take-back system within the UK…the development of an agreed UK product-take-back system model could provide a stronger basis for Member State representation and negotiation within Europe."* – Mayers and France (1999: 61-62), in Chapter 4, Vol. 1.

To determine the overall effectiveness of the proposed WEEE Directive, both the costs and environmental impacts of product collection, treatment, and recycling processes should be considered (a discussion of environmental impacts is given in Section 1.2 below). The adoption of the WEEE Directive is likely to have significant economic impacts on the electronics industry, and affect product prices substantially:

- In 1991 it was estimated that the cost of complying with Producer Responsibility legislation in the UK would be over £100 million annually, which was around 0.4% of the total revenue of the electronics industry at that time (Roy, 1991). Current industry estimates put this cost at £125-175 million depending on collection requirements (whether collecting from municipal civic amenity sites or directly from households door-to-door is required).[10]

- In the Netherlands, the introduction of Producer Responsibility legislation has resulted in price increases from 7.00 Euros for small white goods and video equipment, to 18.00 Euros for refrigerators and freezers (Innemee, 1999).

- Based on the results of twelve product take-back trials, the EC has been estimated it will cost between 500 - 900 million Euros per year to meet the obligations of the proposed WEEE Directive (WEEE – May 2000: 20-21). Yearly treatment and recovery costs have been estimated at 200-300 million Euros, and the cost of

[10] Information provided from study conducted by Cleanaway, Hewlett-Packard, Panasonic, Philips, and Sony (2000).

collection at 300-600 million Euros. An analysis of approaches to financing WEEE can be found in Chapter 4, Vol. 1 (Mayers and France, 1999). The WEEE Directive will place the responsibility for the treatment and recovery of WEEE on producers, but not collection which has been left to subsidiarity, and therefore will be determined at a national level within each member state.

1.2 The environmental impacts of WEEE

Estimates of the total quantity of waste electronics arising in the UK vary between 0.65 - 0.9 million tonnes/yr. (ICER [a], 1998). This is only 1.3 - 1.7% by mass of industrial, commercial, and domestic wastes (DOE, 1995:3). Similarly, in Europe it has been estimated that the 6.5 to 7.5 million tonnes of WEEE arising annually only constitutes around 4% by mass of the waste handled by municipal authorities within Member States (Ogilvie, 1997: 15).

Due to the low quantity of appliances discarded each year in Europe, it could be argued that this focus on the recycling and disposal of waste electronic products would make little difference to the overall environmental consequences of their production and use. The issue of WEEE has been assigned a level of priority that other, arguably more important environmental issues have not. For example, around 1% (by mass) of waste discarded by UK householders as municipal waste can be classified as hazardous, including garden chemicals, paints and solvents, medicines, batteries, and oils (WRF, 1996: Information Sheet). It has been estimated that 75% by mass of household hazardous waste is made up of used paints (WRF, 1996: Information Sheet). It has also been estimated that up to 20,000 tonnes of waste oil is disposed of improperly in the UK, and that 7,540 tonnes of oil is disposed from waste automobile filters (NHHWF, 1997: 4). While policy-makers to date have focussed on specific waste stream initiatives, such as WEEE, automobiles, and tyres, the disposal of hazardous wastes by households is almost entirely unregulated in the UK.

In its current form, it has not been demonstrated that the WEEE Directive will achieve its objectives to reduce the environmental impact of electrical and electronic products at end-of-life *through market-based measures* and *from a life-cycle perspective*, and the Directive includes no measures to assess any resultant reductions or increases in environmental impact. The EC have argued that there are potential environmental benefits that could be realised from improved treatment and increased recycling of electronics waste (WEEE – May 2000: 7-15). This is examined in further detail below, by reviewing the environmental impacts of both disposal and recycling processes for WEEE.

1.2.1 Environmental impacts of landfilling and incinerating WEEE

Some specific environmental problems relating to the disposal of electronic products have been identified. For example, various toxic substances can be released to the environment from the disposal of WEEE through landfill or incineration:

- Organic pollutants:

  Poly-chlorination bi-phenyls (PCBs):
  The use of PCBs, which are bio-accumulative and potentially carcinogenic, has been banned in OECD countries for over a decade. However, PCBs can be released from

from capacitors in old appliances during incineration (Niemeyer and Woldt, 1997; Poll, 1993).

Halogenated flame retardants:
Certain halogenated flame retardants[11] used in plastic casings and printed circuit boards to meet fire safety standards, can lead to the formation of potentially carcinogenic compounds known as polybrominated dibenzo - dioxins and furans (PDBEs) during the incineration of electronic products (OECD, 1998; Hardy, 1997). The accumulation of these substances in the tissues of certain marine animals (Phillips, 1998) and human breast milk (Hooper and McDonald, 2000), and their chemical similarity to PCBs and DDT has lead to concerns over the production, use, and disposal of products which contain them.

Dioxins:
The incineration of poly vinyl chloride (PVC) contained within electrical and electronic casing can lead to the formation and release of dioxins during combustion, which are bio-accumulative and potentially carcinogenic [12] (Danish Environmental Protection Agency, 1997)

- Inorganic pollutants:

Metals:
A wide variety of metals from components such as cathode ray tubes (Voute, 1993) and printed circuit boards can be leached out of WEEE in landfill (Yang, 1993) or emitted to the environment during incineration. Some rare metals found in electronic components have virtually unknown environmental effects, such as tantalum, antimony, and gallium (BifA, 1997; Legarth *et al.*, 1995)

- Resource consumption:

Non-renewable resources:
A major environmental concern over the disposal of electronic equipment is the loss of the materials they may contain. For example, it has been estimated that around 7% of plastics consumed in Western Europe by mass are used in the production of electronic products (Wogrolly, 1994), and that around 85,000 tonnes of lead were consumed in the production of computer monitors in 1998 (Smith *et al.*, 1996). The recycling of materials contained in WEEE could result in substantially reduced impacts on the environment over materials production from virgin resources, as argued within the Explanatory Memorandum of the proposed WEEE Directive:

> "*Primary production of metals constitutes 10% of the world CO_2 emissions. Depending on the metal, between 70% and 95% of the energy used for the primary extraction of metals could be saved through enhanced recycling. In view of the fact that more than 3.5 million tonnes of metals are contained in the WEEE generated annually, the present Proposal contributes significantly to the CO_2 reduction required to reach the Kyoto targets.*" – WEEE (May 2000: 20)

Product reuse:

[11] The most studied being polybrominated biphenyls (PBBs), polybrominated diphenyl oxides (PBDOs), and tetrabromobisphenol A (TBBPA).
[12] The most toxic dioxin is known as 2378-TCDD with an LD_{50} of 0.6 µg / kg by mass when ingested orally (Danish Environmental Protection Agency, 1997: 17)

The EC also seek to increase levels of product reuse, which is given a higher priority within the waste management hierarchy than recycling. From research in the UK described in Chapter 3, Vol. 1 of this portfolio, it was found that although around one third of household appliances are still functioning when discarded, only 24% enter reuse. The remaining 9% are either disposed of as waste or enter scrap recovery processes[13] (Chapter 3, Vol. 1: Section 5.2). The consideration of reuse in environmental assessment is discussed in Section 5.2.3.

1.2.2 Environmental impacts of recycling WEEE

In addition to the impacts of landfill and incineration described above, recycling itself can also have significant environmental impacts which should be taken into consideration when determining the best environmental option for end-of-life electronic products. Returning used materials to the economy requires an investment of energy and will create by-products that may be environmentally damaging. For example:

- Organic pollutants:

  Chloro-fluoro carbons (CFCs):
  Although ozone depleting CFCs have now been eliminated from production, older appliances still in use may still contain these gases as a coolant and within insulation foams. It has been estimated that around 1,100 tonnes of these CFCs are released to the environment each year in the UK from within recycling processes, in spite of legal requirements for these gases to be treated prior to disposal (Poll, 1993; Niemeyer & Woldt, 1997).

  Poly-chlorination bi-phenyls (PCBs):
  It has been found that concentrations of PCBs (introduced above) in shredder residues fell substantially between 1988 and 1990 in the UK, from around 40-90 mg/kg to around 16 mg/kg (Poll, 1993). This is a direct consequence of the ban on PCB use introduced in OECD countries over a decade ago. A problem with reducing PCB content to zero is determining content in imported products from countries that have not implemented or properly enforced such legislation.

  Halogenated flame retardants:
  Recent research has shown that certain halogenated flame retardants are bioavailable, and can accumulate within the blood stream of workers in electronics dismantling plants (Sjödin *et al.*, 1999). This is of particular concern as some PDBEs are believed to be carcinogenic and to cause neuro-developmental toxicity (Hooper and McDonald, 2000).

  Dioxins:
  It has been reported that dioxins may be formed and released from small smelting furnaces (BifA, 1997) and shredding and granulating processes (Danish Environmental Protection Agency, 1997) when processing equipment containing PVC (poly-vinyl chloride).

[13] Illegally in the nearest convenient skip or waste ground, in municipal waste, in skip at work, through municipal collections or civic amenity sites, or though distributors or retailers. Although these disposal routes do not exclude reuse, the majority products entering these routes are disposed of through landfill or incineration, or sent for metals recovery.

The environmental impacts and costs of waste electronic products.

- Inorganic pollutants:

  Metals:
  Metals contained in printed circuit boards and cathode ray tubes can become mobilised in the environment through recycling processes. For example, metal rich dusts may become airbourne from granulation and smelting operations and contaminate surrounding land.

- Resource consumption:

  Energy use:
  It has been estimated that shredders and granulators used in the recovery of metals from wastes consume on average 0.1 MJ of energy per kg of waste processed (ICER, 2000: 24). This is dwarfed by the energy used in smelting and refining recovered metals. For example, in recycling it requires around 74 MJ per kg to smelt copper and 12.6 MJ per kg to smelt steel (EcoBilan, 1998). In addition, the collection and transportation of equipment for treatment and recycling will cause increased fuel consumption and pollution compared to disposal as waste due to longer transport distances between consolidation and recycling points.

As many categories of electronic products may remain in use over a number of years, materials restrictions will take several years to have full effect. Thus, where long-term environmental damage is caused, such as the release of bioaccumulative substances and ozone depletion, treatment of products at end-of-life is the only method of controlling release.

In recognition of the potential for environmental degradation from waste electronic products, some industry bodies have proposed electronics recycling standards (The Nordic Office and IT Organisations, 1998; ICER, 1997; CYCLE, 1995). The proposed EU Directive includes obligations both on recyclers and waste processors. However, these standards do not have provisions to guarantee that the recycling of electronics will be of net environmental benefit from a "life-cycle perspective". The work reported here allows the environmental burdens of various disposal options to be compared along with the associated costs using Life Cycle Assessment and Costing methods.

1.3 Summary

Increasingly, governments across the developed world are requiring that producers pay for the treatment and recycling of their waste products at end-of-life through the introduction of Producer Responsibility legislation. This approach is based on the polluter pays principle, in that there is an expectation that producers will be given financial incentives to design products with lower environmental impacts at end-of-life.

For electronic products, both the recycling and landfilling of WEEE can have substantial impacts on the environment. Using Life Cycle Assessment and Costing methods, this study examines the likely effectiveness of the proposed WEEE Directive, which enforces Producer Responsibility for electronics wastes. It also attempts to assess how the environmental impacts and costs of EOLM processes for WEEE can be reduced.

In the following section (Section 2), the current situation with respect to the disposal and

recycling of WEEE in Europe is reviewed. In Section 3, this is followed with a review of Life Cycle Assesment and Costing studies to date examining options for the recycling and disposal of WEEE. In Sections 4 and 5 the methodologies selected and used in this study are described in detail. The results and analysis, discussion, and conclusions of this study are presented in Sections 6 to 8 respectively.

2. Waste electronics: the current situation

As a background to the study, the current situation for the recycling and disposal of WEEE in Europe is discussed below. Considering the scope of the proposed WEEE Directive, this review covers three different issues:

- Quantities of arisings and disposal practices (in Section 2.1)
- The organisation and financing of EOLM processes under Producer Responsibility (in Section 2.2)
- The progress over the last 30 years in the field of "reverse logistics" on the management of recycling processes (in Section 2.3).

2.1 Quantities of arisings and disposal practices

In this section, the disposal of WEEE in Europe is reviewed including an overview of the quantities and distribution of waste arising in Europe, disposal routes used, and the composition and recycling of WEEE.

Quantities and distribution of arisings

In Europe, it has been estimated that at least 6.5 to 7.5 million tonnes of electronics waste are discarded each year (Ogilvie, 1997:15). A breakdown country by country, examining sales of electrical and electronic products in 1994 in Europe, is given in Fig. 2.1 and Table 2.1 overleaf. As this data is incomplete for 4 of the 15 EU Member States, the actual quantities of WEEE eventually discarded will be higher. In 1994, the largest proportion of electrical and electronic products (62%) was sold in only 3 of the 15 European Member States: Germany, the UK, and France. The Nordic countries Sweden and Finland accounted for only 5% of European product sales in 1994. However, population in these countries is widely distributed (with only 19 and 15 inhabitants per km^2 respectively). Under the proposed WEEE Directive, collection arrangements must be established to ensure all citizens have reasonable access to disposal facilities.

The quantities of WEEE discarded in Europe estimated by Ogilvie (1997) were calculated from data on market sales volumes, average product masses, and expected product lifetimes, as shown by the following formula:

$$\text{Quantity of products discarded yearly} = \text{Average product mass} \times \text{Sales estimate in year corresponding to expected lifetime of product}$$

Figure 2.1: Sales of electrical and electronic products with population density in Europe

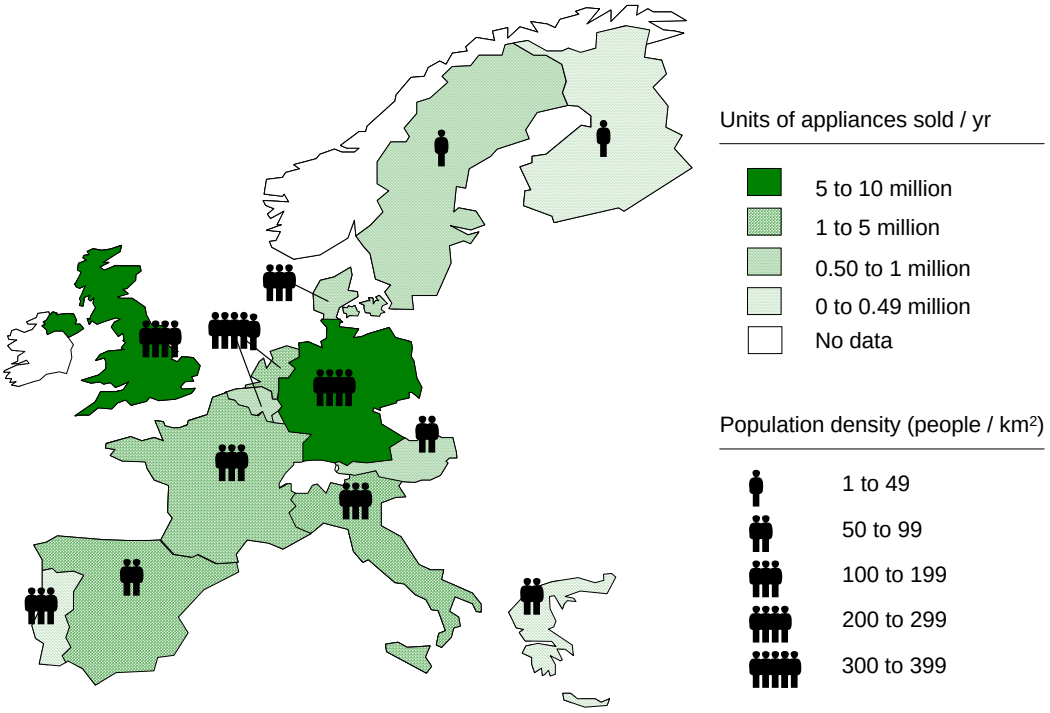


Table 2.1: Yearly sales of electrical and electronic appliances in Europe (1994)

All percentages by units sold	*White goods*	*Consumer electronics*	*Information technology*	***Total (units)***
Austria	19%	29%	52%	6,494,476
Belgium/Luxembourg	14%	29%	57%	8,600,848
Denmark	15%	19%	66%	6,307,995
Finland	*No data*	26%	74%	4,550,127
France	14%	28%	58%	48,542,648
Germany	17%	23%	59%	81,754,132
Greece	*No data*	100%	*No data*	2,441,221
Ireland	*No data*	*No data*	*No data*	*No data*
Italy	11%	38%	51%	35,064,489
Netherlands	13%	22%	65%	16,596,661
Norway	*No data*	*No data*	*No data*	*No data*
Portugal	*No data*	100%	*No data*	2,317,171
Spain	12%	37%	51%	24,763,443
Sweden	*No data*	23%	77%	8,929,701
Switzerland	*No data*	*No data*	*No data*	*No data*
UK	16%	24%	60%	56,356,752
Total	**14%**	**28%**	**58%**	**302.719,664**

Data sources for Fig. 2.1 and Table 2.1:

1. Ogilvie, S.M., R*ecovery of Waste from Electrical & Electronic Equipment: Economic & Environmental Impacts*, AEA Techology: Abingdon, 1997.
2. Harper Collins, *Collins Gem Encyclopedia*, Harper Collins Publishers: Glasgow, 1993.

Disposal routes (based on UK empirical data):

Empirical research conducted on householders in the UK by Cooper and Mayers (2000) investigated the variety of routes through which household appliances can be discarded. This research attempted to quantify the proportion of WEEE collected through these different routes from information provided by a sample of householders demographically and statistically representative of the UK population. There is no equivalent data that examines patterns of disposal on a European basis. From a total of 470,000 tonnes discarded per year[14]:

- Around 104,000 tonnes (22% by mass) of discarded appliances were reused, two thirds of which was donated to family or friends with most of the remainder being sold. Appliances most frequently reused were computers, hi-fi and stereo, microwave ovens, and video equipment.

- Around 328,000 tonnes (69%) of discarded appliances were taken to civic amentity sites by householders, collected as "bulky waste" by local authorities, or collected by retailers or recycling companies. Around 4% (20,000 tonnes) of this was returned to retailers for a discount on the sale of new products. Over 276,000 tonnes of this consisted of large white goods mainly destined for recycling. It is likely that much of the remaining 52,000 tonnes (mostly televisions, microwave ovens, home and garden tools, and vacuum cleaners) was incinerated (mainly small appliances) or ended up in a landfill.

- The remaining 29,200 tonnes (6%) of discarded appliances were collected as "ordinary waste" by local authorities (i.e. from dustbins, wheelie bins, or rubbish sacks) or left in a skip at the owners work-place or, illegally, on the nearest convenient skip or waste ground (the latter accounting for 3,330 tonnes).

The use and disposal of household appliances in the UK is depicted diagrammatically in Fig. 2.2 overleaf based on these results.

Significant differences were found on the disposal routes used for different products and by different sectors of society. For example:

- Smaller products were most frequently disposed of to landfill due to the ease of disposal in household kitchen bins, wheelie bins, and rubbish sacks.
- With lower socio-economic status, householders disposed of a significantly higher proportion of their waste to landfill and illegally (by leaving in the nearest convenient skip or waste ground). Householders of lower socio-economic status were also found to own a significantly higher proportion of second-hand products, and so bought fewer products new.

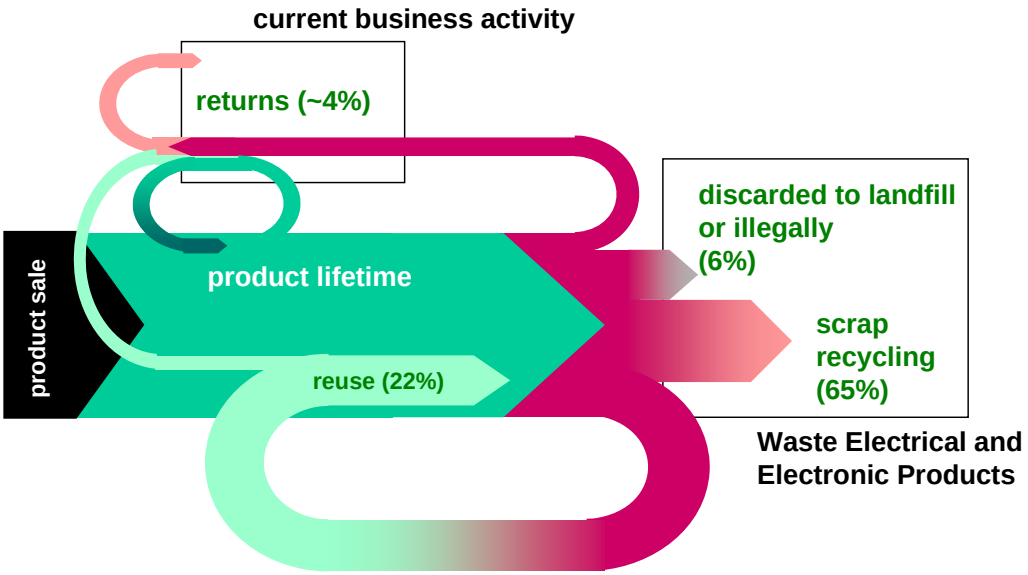
The composition and recycling of WEEE

Electrical and electronic products consist of a variety of materials that must be separated before recycling is possible. White goods, including washing machines and fridges and freezers, consist mainly of steel (at around 61% by mass on average, as shown in Table 2.2). In contrast, consumer electronic products consist largely of glass, ceramics, and

[14] The following points are extracted directly from Mayers & Cooper (2000: 9-10).

plastics (at around 65%). Information technology equipment consists largely of plastics and metals (at around 66%).

Figure 2.2: The reuse, recycling, and disposal of appliances by UK householders by mass



- Total quantity discarded: 470,000 tonnes per year.
- The remaining 3% of appliances were discarded through "other" routes.

Data source: Cooper, T., and Mayers, K., *Prospects for Household Appliances*, Urban Mines: Bradford, 2000

Table 2.2: Material composition of WEEE by product category

Product type All percentages by mass	*White goods*	*Consumer electronics*	*Information technology*	*Mean*
Steel	61%			22%
Non-ferrous	6%			2%
Copper	0%		8%	4%
Unspecified metals		16%	36%	21%
Plastics	9%	20%	29%	21%
Rubber	1%			
Insulation	2%			1%
Glass / ceramics	2%	45%	23%	18%
Concrete	12%			4%
Printed circuit boards			2%	1%
Wiring and cables		3%		1%
Hard and floppy disk drives				1%
Wood		3%		
Other	7%	12%		4%

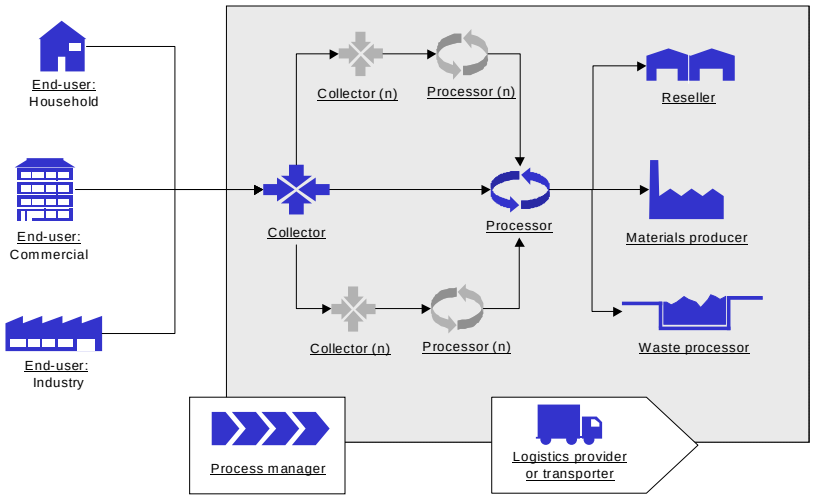
The material composition of different appliances in WEEE can also vary substantially. For example, hi-fi equipment does not usually contain the glass or wood contained in the cathode ray tubes and casings of televisions. For white goods, fridges and freezers do not usually contain the concrete contained as a balancing counter-weight in washing machines.

The recycling of WEEE is more complex than the recycling of conventional materials, such as steel, paper, and drinks cans, due to:

- The variety of routes though which WEEE may be discarded
- The variety of different materials they contain

The complexity of materials contained in electronic products requires initial processing before material recycling can be conducted. This can either be conducted through manual disassembly using simple hand and power tools, such as automatic screwdrivers, or through mechanical processing including shredding, granulation, and materials refining and classification. Following initial processing, the material and components from WEEE may be sent to production processes for recycling into new materials, for further specialist processing, or for disposal in incinerators or landfills as residual materials. A generic overview of collection, treatment, and recycling processes for WEEE is given in Fig. 2.3 below.

Figure 2.3: End-of-life management processes for WEEE



Product end-users: Organisations & individuals disposing of end-of-life products.

Collectors: Collecting from end-users directly or through drop-off points e.g. retailers.

Waste electronics processors: Electronics recyclers & subsequent specialist materials recyclers e.g. cathode ray tube recyclers.

Product and component resellers: Traders or brokers re-marketing and reselling refurbished products or components.

Material producers: Producers of finished materials using materials reclaimed from waste for use in new products e.g. copper smelters.

Waste processors: Waste management companies providing waste treatment and disposal services.

Logistics providers and transporters: Logistics providers & transporters providing transport links between all stages in the end-of-life management chain e.g. hauliers.

Process manager: Performing high-level integrated management functions e.g. waste management companies and producer consortia..

Source: Bettac, Mayers, and Buellens, 1998

Much of the materials within WEEE will not be fully recycled, but may be disposed of in landfill or through incineration, or may be burned or become part of the waste slag of metals smelting processes. For example:

- Printed circuit boards contain only around 17% recoverable metals on average by mass (BiFA, 1997). Remaining materials will be lost as shredder fluff, or burned or incorporated into waste siliceous slag from precious metals smelting.

- In most European countries, white goods are already recovered from waste for mechanical metals recycling. However, typically only steel is recycled at around 61% of appliances by mass, the remainder being disposed of to landfill or incineration.

Under current definitions in the proposed WEEE Directive, once WEEE is accepted to a recycling or production process it is considered to be "recycled", even though a large percentage may still be disposed of in landfill or incinerated. Definitions of recovery and recycling are only likely to be refined following review by the European Commission of recycling rates achieved in Member States. A more credible approach could be to set recovery and recycling targets for the different material fractions recovered from WEEE rather than for separate product categories. This approach, for example, has been adopted already within Belgium.

2.2 Producer Responsibility in practice

Producers may organise the take-back and recycling of their waste products either on an individual basis or through collective recycling schemes or consortia along with competitors in the same sector. Both of these approaches are described in further detail below.

A number of major producers of electronic goods have initiated their own treatment and recycling processes for WEEE. These processes are primarily used for commercial asset management, processing equipment returned from business operations such as:

- Ex-lease equipment
- Surplus production and obsolete stock
- End of line product
- Returns for repair
- Customer returns
- Ex-internal assets
- Product recalls

These processes have developed in response to:

- Increased customer pressure for asset management services and "environmentally responsible" disposal routes.
- The need for more control over second hand product markets.
- The need to prepare for Producer Responsibility legislation.

Hewlett-Packard, for example, has recycling centres at Böblingen in Germany, Grenoble in France, and Roseville in California. Some companies have sold their recycling operations and now subcontract these services. For example, in 1998 Philips sold their recycling plant at Eindhoven in the Netherlands to the international waste management company, Cleanaway.

Only in a few cases have producers been able to match collection targets proposed by the European Union[15] through individually organised recycling operations. For example:

- Xerox reclaimed 30% of their products by mass in 1993 (corresponding to 7,200 tonnes of returned copier equipment), and 50% by mass in 1995 through their recycling plants in the UK, France, and the Netherlands (Maslenikova, 1996; ENDS, 1996).

- In the early nineties, Siemens Nixdorf established a network of 42 collection points in Germany where customers could return their redundant or obsolete IT equipment. In 1995 a total of 5,400 tonnes of equipment was returned for processing at the Siemens Nixdorf recycling plant in Paderbourne. This represented around 30% of products sold by mass based on 1990 sales figures (Business and the Environment, 1995).

This anecdotal evidence demonstrates how in the early nineties, IT producers started to establish individual electronics treatment and recycling processes. This was mainly due to the large size of the commercial business to business market. The management of redundant IT equipment is a problematic issue for most companies, and the provision of product take-back services can be a useful addition to an IT producer's post-sales services (Mayers *et al.*, 2000).

Within the latter half of the nineties (from 1996 to 2000), many European countries implemented national Producer Responsibility regulations or policies ahead of the proposed WEEE Directive (as described in Section 1.1). In response producers have focussed on establishing "collective" recycling arrangements with their competitors.

In collective recycling schemes, the responsibility for organising treatment and recycling of WEEE discarded by consumers is shared amongst producers. A collective scheme may either subcontract third parties to collect, treat, and recycle their products, or may appoint one or more manufacturers to develop one or more recycling facilities in-house. For example[16]:

- In Switzerland, a collective scheme known as SWICO was established in 1994 for organising the treatment and recycling of IT goods. Although this was originally a voluntary scheme, Producer Responsibility legislation has been in place in Switzerland since 1998. The scheme sub-contracts twelve different recycling companies, each in a different region of Switzerland. Transportation from local collection points and retailers is organised by only one transportation company. SWICO finances the costs of logistics, treatment, and recycling operations by charging producers fixed fees per product sold to the Swiss market. In January 2002, SWICO will also begin recycling of consumer electronic products.

- In Germany, the "Power Tool Recycling Initiative" was set-up voluntarily in 1997 with the support of 24 different power tool and garden equipment producers. Recycling is conducted at the BOSCH Service Center in Willershausen, Germany. In

[15] At approximately 25%-35% by mass, based on a collection target of 4 kg per head (WEEE – May 2000: 46)

[16] Information obtained from private correspondence with recycling scheme managers during 1999-2001. These organisations are known and registered by their acronyms. An explanation of the meaning of the acronyms in the different national languages is not given and not relevant for the discussion.

the first year of operation (April 1997 to April 1998) almost 2,000 tonnes of products were collected from participating municipalities and retailers and recycled. The initiative operates on a non-profit basis, and producers finance the costs of logistics, treatment, and recycling costs for their own products. This recycling scheme is similar to proposals for IT products by the CYCLE scheme, also in Germany, and the Dutch ICT scheme for IT products described below.

- In the Netherlands, two collective systems have been operating in parallel since 1999, serving both consumer electronics and white goods producers (NVMP) and IT producers (ICT) to meet requirements of Producer Responsibility legislation introduced in 1998. These schemes both sub-contract treatment and recycling responsibilities to three to four Dutch recycling companies. Transportation and sorting of WEEE from municipal collection sites and retailers is organised by a collective consortium of waste management and logistics companies known as NVRD.

  NVMP finances recycling operations by means of a fixed visible fee charged to consumers at the point of product sale, and then paid to NVMP by producers. Similar schemes to NVMP have been established in Norway (Elektronikretur) and Belgium (RECUPEL).

  In contrast, ICT recovers its costs by charging producers for products returned bearing their own brand (plus a proportion of products with no brands or for which the original producer no longer exists – "orphan products").

- In July 2001, a scheme known as EL-KRETSEN was established to help producers comply with Swedish take-back law introduced in 2000. EL-KRETSEN finances the transportation and recycling of all categories of WEEE by charging producers in proportion to their market share for each product category. Recycling is carried out using four different third party recycling companies, with transportation arrangements made on the basis of week-by-week competitive quotations from various logistics companies. A similar scheme known as PRIMER has also been proposed to meet the requirements of the WEEE Directive in the UK.

The arrangement of financing responsibilities by collective schemes is shown generically in Fig. 2.4 overleaf. The function of recycling schemes is chiefly to organise the financing of treatment and recycling processes, and at an operational level to manage any necessary contracts with third party waste management and logistics companies.

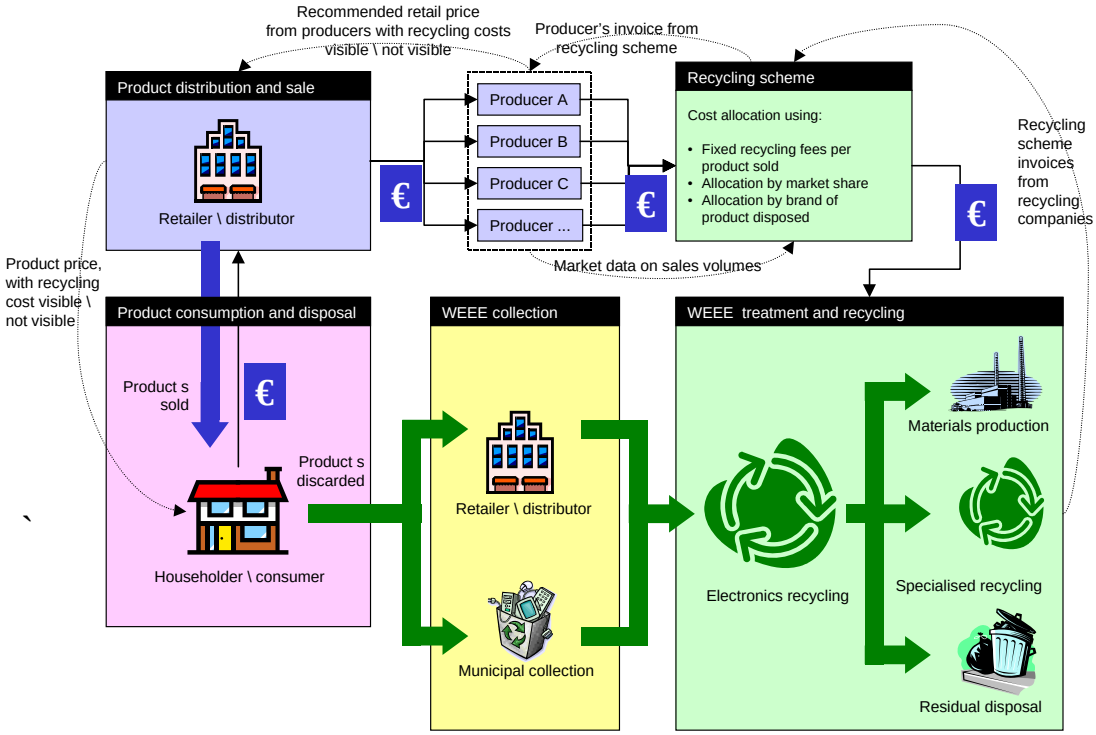
As reported here, many producers already manage treatment and recycling processes for electronic products in Europe. This is either on an individual basis or collectively with competitors. However, approaches taken to date have significant flaws in relation to the management of environmental impacts:

- Producers are not legally mandated to organise and finance the treatment and recycling of their own products sold following the introduction of legislation. Without such a requirement, Producers are not given the financial incentives to reduce the environmental impacts of their products at end-of-life as intended under Producer Responsibility.

- Recycling is not carried out to ensure reductions in environmental impact are achieved throughout the product lifecycle.

These two aspects are investigated in this study. Below, approaches under development for improving the economic and environmental performance of WEEE recycling and treatment processes in the area of reverse logistics are reviewed.

Figure 2.4: Financing of treatment and recycling by producers in collective schemes



2.3 Reverse logistics and the recycling of WEEE

Much is now understood on the organisation, dynamics, and management of product supply-chains through the study of *physical distribution and logistics management* [17]. Indeed, this relatively new discipline is now well supported by a large research community. Although some papers have been written on the logistics of recycling processes, research to date in this area has almost wholly been focussed on the logistics of the so-called "linear economy". This includes the production of materials from virgin resources, product manufacturing, and sale and delivery of finished goods to market, with the assumption that products are eventually discarded with no recycling or reuse.

In comparison, very little is understood about "reverse logistics": the flow of materials and products out of and back from the market for reuse and recycling (the logistics of the "circular economy"). This has lead one author to claim that even seemingly simple reverse logistics processes, e.g. the collection of used chemical drums from customers for reuse by suppliers, requires "*vastly expanded infrastructure and new management systems*" to ensure sufficient processing capacity and control of materials (Guitini, 1997: 81).

[17] As in: the *Journal of Physical Distribution and Logistics Management.*

In order to improve the development and organisation of waste management and recycling operations, various researchers are investigating the area of reverse logistics. These researchers have to date addressed three main overlapping themes: reverse logistics in supply chain management, the application of operational research methods in reverse logistics, and the logistics of waste management and recycling. These areas of research in developing EOLM processes for electronic products are evaluated below.

Reverse logistics in supply chain management

Various books and reports on reverse logistics describe activities and experiences of waste management and recycling in the distribution industry. For example, Guitini & Andel (1995) and Melbin (1995) provide various case studies on waste minimisation to illustrate progress in this area. In a later paper, Guitini (1997) outlines considerations for the management of returnable chemical drums, including inventory and accounting, recall procedures, quality checking, remanufacturing and repair, recycling, disposal, and product redesign. Kopicki *et al* (1993) and Stock (1992) provide information and resources for logistics professionals on how to set up waste management and environmental management activities in distribution.

These reports do not provide any specific insights into the development of effective Producer Responsibility legislation, or for improving *existing* recycling processes for household wastes not integrated into the supply chain, such as paper, drinks cans, and glass bottle recycling.

The application of operational research methods in reverse logistics

Various mathematical operational research methods have been developed to help solve and find cost-optimal and time-optimal solutions for reverse logistics problems. For example, algorithms[18] have been developed for optimising the cost of recycling facility location and product recycling (Krikke, 1998), the management of returnable packaging (Kroon & Vjrigens, 1994), and for planning component recovery systems (Veerakamolmal and Gupta, 1998).

Operational research methods are used to optimise specific operational processes, such as the disassembly of products of known construction and complex transport routing problems. They are used increasingly in research on waste management and recycling and are also used within the waste management industry, such as for collection scheduling. Operational research methods are examined further for use in this research within Section 4.2.

The logistics of waste management and recycling

Various empirical studies have been conducted examining the structure and organisation of recycling "channels". In distributive logistics, a channel is described as a vertical marketing or distribution system (Gill & Allerheiligen, 1981). The structure of a channel determines the sequence of stages, organisations, and processes in a logistical chain of distribution (or reverse distribution). In the case of product take-back and recycling, a channel can be defined as the route taken by a discarded product from a final end-user

[18] Algorithm: "*a logical arithmetical or computational procedure for solving a problem*" (Harper Collins, 1992: 13)

(customer), through collectors and end-of-life processors to final value-extraction, treatment, and disposal.

Through the investigation of recycling activities under development in the US during the late sixties and early seventies, Zikmund and Stanton (1971) were among the first to suggest that recycling processes should be considered as channels of reverse distribution. Subsequent empirical research includes studies on the "embryonic" recycling industry (Guiltnan & Nwokoye, 1974), plastics recycling (Pohlen and Farris, 1992), and Material Reclamation Facilities (MRFs) in waste management (Jahre, 1995). Comparison of these studies show how obstacles to the development of a "circular" economy, based on maximum use of recycled materials in place of virgin resources, have not been resolved over the last 30 years. Recycling issues raised in the research by Guiltnan and Nwokoye in 1974 were still relevant and raised again in research by Pohlen and Farris in 1992. This includes the need for:

- Increased co-operation between organisations within a recycling channel, which was first recognised within the literature on logistics management (as described by Christopher, 1992: 12-16)
- Government policy to address levels of recycling (as is now proposed for WEEE).
- Developing an end-market for recycled materials.

Despite any rhetoric to the contrary in the area of "reverse logistics", over the last 30 years there appears to be no research that has contributed substantively to support a transition to a circular economy with reduced environmental impacts. More recently, however, the application of operational research methods has offered new insights into specific problems in planning recycling processes and facilities. These methods are considered further for use in this study in Section 4.2.

2.4 Summary

The recycling of WEEE is more complex than conventional household waste recycling for glass, paper, plastics, and metals. This is because of the variety of routes through which household appliances may be discarded and the wide variety of materials appliances usually contain.

The first major development of electronics recycling processes in Europe began in the early nineties, mainly within the IT sector to handle equipment returned as part of business operations. With the introduction of Producer Responsibility legislation in European countries in the latter half of the nineties, a number of industry collective recycling schemes have been established. These schemes organise the recycling and financing of WEEE treatment and recycling in a number of different ways.

A limitation of national recycling laws implemented to date is that individual producers are not legally and financially responsible for the products they have placed on the market. Such a direct relationship is necessary to establish financial incentives that can influence product design (at least in theory). In addition, recycling is not carried out to ensure reduction in environmental impacts throughout the product life-cycle.

In the following section, Life Cycle Assessment and Costing studies to date conducted on the recycling and disposal of WEEE are discussed.

3. Life Cycle Assessment in the recycling of WEEE

Life Cycle Assessments, or LCA, can be used in determining Best Practicable Environmental Options (BPEO) in waste management (Barton *et al.*, 1999). For example, the UK Environment Agency now uses a customised Life Cycle Assessment software tool in determining BPEO in waste management (DETR, 1999). The use of Life Cycle Assessment is also gaining favour among policy makers in other areas of environmental policy development. Life cycle thinking and LCA forms the basis of the EU draft Integrated Product Policy and draft Directive on EEE (summarised in Section 1.1).

Various LCAs have been conducted on the recycling and disposal of WEEE. These are discussed in detail below.

3.1 Life Cycle Assessment (LCA) of WEEE

LCA has been used extensively within the electronics industry to examine the overall environmental impacts of electronic products and their components (for examples see Thomas, 1998; Nissen *et al.*, 1998; Brickman *et al.*, 1998). However, such studies do not assess the disposal stage in enough detail to evaluate the potential environmental impacts of different waste management and recycling options for WEEE.

Producer Responsibility itself is not intended to address the full life cycle of a product (from extraction and production, to use, recovery, and disposal, or "cradle-to-grave") as it largely excludes manufacturing and use. However, the adoption of a life-cycle perspective in the management of electronics waste would allow different product design and waste management options (including incineration and landfill) to be compared and considered together ensuring the best environmental options are identified. Studies investigating the environmental impacts of products at end-of-life alone are known as "gate to grave" studies. A selection of gate-to-grave Life Cycle Assessments have been reviewed below, mainly focussing on end-of-life electronic products.

The only comprehensive LCA study completed to date on WEEE investigated eight different electrical and electronic products[19], using three different end-of-life scenarios in the UK (Ecobalance, 1999). These three scenarios were:

1. The current UK situation (where, depending on product type, Ecobalance have assumed different proportions products landfilled, recycled, and reused)
2. 100% disposal to landfill
3. The situation under the second draft of WEEE Directive (WEEE - 27/07/98)

Interestingly, the methodology used combined LCA with Life Cycle Costing (LCC, as discussed further below in Section 3.2). However, there appear to be significant problems with the methods and assumptions used by Ecobalance, which undermine the veracity of the conclusions made. A detailed critique of the LCA assumptions used is given below, and of the LCC methodology used in the following section. The environmental

[19] Washing machines, personal computers, kettles, vacuum cleaners, lawnmowers, refrigerators, telephones, and televisions.

conclusions of this study were that:

- **Environmental impacts of landfilling WEEE**

  Current methods for disposing of WEEE have a lower potential impact on the environment than 100% landfilling for all impacts categories studied[20]. This finding is attributed to the offset environmental burdens assumed for new product production resulting from product reuse and production of materials using virgin resources resulting from increased recycling of plastics and steel. This finding is in contradiction with the results of this research, where electronics recycling faired better than 100% landfilling in only 9 out of the 16 impact categories studied (as described in Section 6.1.2).

- **Environmental benefits of the WEEE Directive**

  With the exception of refrigerators and TVs, which are discussed as a separate item below, results indicate that the EU WEEE Directive is likely to reduce the potential environmental impacts of WEEE over current practice in the UK substantially. As above, this finding is based on assumed environmental impacts offset from product reuse and from increased materials recycling. For the six remaining product categories[21], the highest potential environmental gains were found for eutrophication and non-renewable resource depletion:

  – *Eutrophication*
    Depending on product category, results indicate that eutrophication could be 5-30 times lower for the WEEE Directive compared to the current UK scenario, which had 21-55% lower recycling rates by mass. The work presented here in Section 6.X also shows that eutrophication is likely to fall with increased recycling rate. The potential for eutrophication of the basic metals recovery scenario investigated is around 50% higher than the maximum recovery scenario, [22] and the proportion of products recovered by mass 38% lower. This is due to lower emissions of nitrogen oxides from smelting of recovered metals relative metals from virgin resources.

  – *Non-renewable resource depletion*
    Non-renewable resource depletion was also much improved under the WEEE Directive scenario, although potential reductions varied widely between 1.7 and 870 times lower than the current UK scenario. Findings on the reduced potential for non-renewable resource depletion are consistent with results presented in Section 6.1.2, which show a 25% reduction between maximum recovery and basic metals recovery scenarios. This indicates that the recycling of WEEE is likely to be an efficient use of non-renewable resources.

  Despite agreement on findings for eutrophication and non-renewable resource depletion, results presented in this work do not support Ecobalance's conclusion that the WEEE Directive will reduce the potential environmental impacts of landfilling

[20] For a list of impact categories analysed by Ecobalance, see Section 4.5.3.
[21] Washing machines, personal computers, telephones, kettles, vacuum cleaners, and lawnmowers.
[22] Where maximum recovery = "plastics and PCBs recovered" scenario in section 5.3, and basic metals recycling = "plastics and PCBs landfilled".

and of current practice in the UK. In this research, the WEEE Directive scenario (corresponding to the "*plastics and PCBs recovered*" scenario) had the lowest environmental impact compared to other scenarios investigated for only 5 out of 16 categories studied (as presented in Section 6.1.2). The assumptions leading to Ecobalance's findings are evaluated following this summary of conclusions.

- **Findings for refrigerators and televisions**

For refrigerators and televisions, the Ecobalance study found some environmental impacts were higher in the WEEE Directive scenario than the current UK situation (as shown in Table 3.1 below). It is argued that these increased impacts result from the treatment of hazardous materials in the WEEE Directive scenario, such as CFCs from insulation materials and as a coolant from refrigerators, and the phosphate and metal rich coating from inside television tubes.

Table 3.1: Problematic impact categories for refrigerator and television

Product	Impact category	Units	Scenario result		
			100% landfill	Current UK	WEEE Directive
Refrigerator	CML – eutrophication (water)	g eq. PO_4	59.1	14.3	41.7
	CVCH water	litre	137	52.8	80,400
	Waste (hazardous)	kg	0.106	1.95	93.6
Television	CML – air acidification	g eq. H^+	159	60.9	71.9
	IPCC – greenhouse effect (direct, 20 years)	kg eq. CO_2	514	331	427
	CVCH water	litre	81,800	11,200	13,600

Source: Ecobalance UK and Dames & Moore, *Life Cycle Assessment and Life Cycle Financial Analysis of the Proposal for a Directive on Waste from Electrical and Electronic Equipment*. Final Report (ECO UK/C134). Department of Trade and Industry: London, 31 July 1999, p. 73, 80.

This argument does not explain these results satisfactorily. Under current practice in the UK, hazardous substances within waste TV's and refrigerators often are not removed and properly treated, even where legally required. For example, despite requirements for CFCs to be removed from waste refrigerators and treated, it has been estimated that 1,100 tonnes of CFC's are still released to the atmosphere from waste refrigerators every year (as previously explained in Section 1.2.2).

Hazardous waste generation is not an accurate indicator of environmental impact. For example, it does not indicate levels of toxicity and a high value could result from good practice in the treatment of hazardous materials. Differences in the results for aquatic toxicity (CVCH water), eutrophication, and the greenhouse effect are likely to be caused by inconsistencies and errors in the assumptions on reuse and the toxicity of WEEE sent to landfill, which underlie all product categories. These are discussed further in the critique below.

- **Environmental impacts of transportation**

Transport was found not to be a major determinant of the environmental impacts of

WEEE. A 50% reduction in transport distances caused a maximum change of only 3% in any environmental inventory or impact result. In contrast, this study indicated that transportation between consolidation and recycling points influenced the level eutrophication to a greater extent. An underestimation of assumed transport distances of 50% increased the potential for eutrophication by 15% (as presented in Section 6.1.2).

The low sensitivity of results to transport distances in the Ecobalance study is not explained. The most likely cause of this low sensitivity is the high level of environmental impact factored into the assessment for assumptions relating to reuse and new product manufacture.

- **Sensitivity analysis**

Through sensitivity analysis it was found that for PCs, environmental impact increased "*dramatically*" across all categories as the proportion disposed of in landfill increased. In addition it was found that the reuse of capacitors from washing machines could result in a 14% reduction in stratospheric ozone depletion (and a 5% reduction in environmental impacts across other categories).

These results indicate that the design of capacitors to allow extended life through reuse could be worthwhile in terms of reduced environmental impact at end-of-life. It also suggests that attention should be paid to which parts of a product should be recycled, rather than always recycling whole products. This view has also been argued by Legarth *et al.* (1995) for components containing trace and rare earth metals on printed circuit boards. In this study, three different recycling scenarios are included, which allows consideration of the environmental impacts of recycling different components.

Various conclusions were also made on the recyclability of products in relation to targets laid down in the WEEE Directive. These conclusions were not based on the outcomes of the LCA but on the study's assumptions taken from data provided by the Industry Council for Electronics Recycling (ICER). These conclusions are not evaluated here as they do not concern the environmental impacts of WEEE and are not based on the results of the LCA and LCC study.

Underlying the Ecobalance study were over 250 general assumptions on processes for the transportation, recycling, and treatment of WEEE and their related costs. A similar number of more specific assumptions were also made for each product category, covering specific end-of-life processing routes used and product composition. Many of these underlying assumptions appear substantially flawed, specifically:

- **Plastics recycling and energy recovery**

For all of the product categories studied by Ecobalance with the exception of televisions (which were assumed to contain less than recyclable 1% plastics), plastic recycling was found to contribute considerably to a positive result for the WEEE Directive scenario. Assumptions relating to materials recycling possibilities for plastics were however unrealistic. It was assumed that plastics contained in shredder residues would be separated by polymer type for reprocessing At present commercial recycling is not even undertaken for relatively clean supplies of sorted plastics from

commercial sources WEEE.

Future plastics recycling will be dependent of the elimination of brominated flame retardants in products, which must be otherwise be selectively treated rather than recycled, and economically on the use of a smaller number of plastic polymers in products. For products sold before the entry into force of the Directive, mixed plastics recycling is likely to remain economically unattractive and legally will be superseded by treatment requirements. In respect of new product development, the work presented here suggests that Producer Responsibility will not provide the necessary financial incentives encourage producers to design products with end-of-life in mind, such as to use a reduced number of polymers (explained in Section 6.2.2).

It is perhaps more likely that improved energy recovery technology for post consumer plastics will gain greater acceptance. For example, the UK government has now implemented a policy to build from 28 to 160 energy from waste facilities over the next decade (DETR, 1999: 25).

- **Functional unit**

A"functional unit" was used of one tonne of each product (such as one tonne of kettles). In reality, the specific composition of products within a waste stream will be mixed, and highly dependent on the disposal channel under consideration (as discussed in Section 5.5, Chapter 3, Vol. 1). This could have lead to errors in the allocation of environmental impacts between products, particularly for shredding and transportation, which handle mixed batches of equipment. In the work presented in Sections 5 to 8, the analysis of the environmental impacts of WEEE is made using a practical example of products returned through retailers in the UK, which is more realistic.

- **Effects of WEEE in landfill**

Components such as printed circuit boards and cathode ray tubes were assumed to have the same composition and environmental impacts as an "average" tonne of waste to landfill, as the material composition of these components were not considered in landfill modeling. This is likely to have lead to:

– A serious overestimation in the quantity of methane generated upon decomposition (and therefore Global Warming Potential). As Global Warming Potential was reported as the impact category where there were least gains for the environment from the WEEE Directive, this could lead a favourable result for 100% landfilling over the other scenarios.

– A serious underestimation of leachable metals content in the 100% landfill scenario (and therefore terrestrial ecotoxicity). The weaknesses in Ecobalance's assumptions on toxicity were also noted by the EC within the Explanatory Memorandum to the proposed WEEE Directive (WEEE – May 2000: 24). The potential for metals contamination is a major environmental concern over the disposal of printed circuit boards and cathode ray tubes in WEEE (Yang, 1993).

Given that a major environmental concern of the disposal of WEEE is the

potentially toxic substances they may contain, the omission of this data from the analysis brings into question the finding that eutrophication and resource depletion are likely to be greatest benefits of the WEEE Directive.

- **Product reuse**

The most significant flaws in the conclusions of the Eco-balance study are likely to arise from several mistakes in the underlying assumptions on reuse:

– *Scope of reuse activities*
Householder reuse activities such as donating or selling fall outside of the scope of the WEEE Directive. Any environmental benefits of product reuse by householders should therefore remain the same between current UK and WEEE Directive scenarios, and consequently cancel each other out. This is not the case for four out of the eight product categories studied.

The reuse of vacuum cleaners, lawnmowers, and washing machines was assumed to increase by 50-100% under the current UK and WEEE Directive scenarios (see Table 3.2). An explanation was only given for lawnmowers that this was due to current growth in second-hand markets. This growth is unrelated to the introduction of the WEEE Directive and so the levels of reuse assumed should not differ between the scenarios.

The reuse of refrigerators was assumed to fall to 0% under the WEEE Directive due to the need to treat Ozone Depleting Substances. This assumption is also in error, as no part of the proposed WEEE Directive aims to prevent the reuse of refrigerators by householders. No explanation was given to support this assumption.

– *Assumed levels of reuse*
There are serious discrepancies between the levels of reuse assumed for current UK and WEEE Directive scenarios and levels given by empirical research (Cooper and Mayers, 2000: 12). Product reuse is overestimated by around 30-100% for telephones, kettles, and televisions, and underestimated by around 50-100% for personal computers, vacuum cleaners, lawnmowers, and refrigerators (as shown in Table 3.2 below). The rate of reuse for washing machines was underestimated by 25% for the current UK scenario, and overestimated by 15% for the WEEE Directive scenario. The substantial environmental benefits claimed from product reuse are therefore weighted erroneously above or below levels that would be calculated using empirical data.

– *Environmental benefits of reuse*
If the scope of the WEEE Directive were to be expanded to include reuse, the assumption that this will offset the environmental impacts of new product production has been bought into question by empirical research on householder behaviour (reported in Chapter 3, Vol. 1, Section 5.7.4). This is due to the transfer of second-hand products from higher to lower socio-economic status households. In this research it is argued that product reuse serves to extend the useful lifetime of a product, but may not always substitute new product sales. In this context reuse should be considered in terms of a full product life-cycle assessment rather than the "gate to grave" assessment conducted by Ecobalance.

Table 3.2: Comparison of assumed rates of reuse

Product category	Ecobalance assumed % reuse †			Actual reuse in UK *
	100% landfilling	Current UK situation	WEEE Directive	
Washing machine	0%	10%	15%	13%
Personal computer	0%	36%	36%	70%
Telephone	0%	53%	53%	32%
Kettle	0%	33%	33%	16%
Vacuum cleaner	0%	4%	10%	25%
Lawnmower	0%	4%	10%	24%
Refrigerator	0%	10%	0%	22%
Television	0%	42%	42%	32%

* Cooper, T. and Mayers, K., *Prospects for Household Appliances*, Urban Mines: Bradford, 2000, 12.
† Ecobalance UK and Dames & Moore, *Life Cycle Assessment and Life Cycle Financial Analysis of the Proposal for a Directive on Waste from Electrical and Electronic Equipment*. Final Report (ECO UK/C134). Department of Trade and Industry: London, 31 July 1999, pp 109-154.

Overall, the errors on reuse outlined above bring into question all the environmental conclusions of the Ecobalance study, as for every product category the environmental benefits of product reuse were reported to have made a substantial contribution to findings. For example, this could partially explain Ecobalance's worse result for refrigerators, as reuse was not included in either the landfill or the WEEE Directive scenarios.

There are further problems with the method used by Ecobalance for Life Cycle Costing (LCC). The discussion of the Ecobalance study is continued in Section 3.2 below on LCC.

Other gate-to-grave LCA studies have also been conducted on the take-back of mobile phones as part of a scheme in the UK and Sweden (McLaren *et al.*, 1999), and on the disposal of plastic computer housing from IBM products in the USA (Brinkley *et al.*, 1994). Together these life-cycle studies reinforce the orthodox view of the hierarchy of waste management: that in descending order, product reuse, material recycling, and incineration energy recovery are preferable to disposal in landfill. Although these studies provide interesting conclusions, their findings are not generally applicable across different products and different waste management and recycling processes. McLaren *et al.* (1999) focussed specifically on energy consumed in disposal, recycling, and reuse, whereas Brinkley *et al.* (1994) only examined disposal options for plastic monitor housings, as opposed to the disposal of whole products.

Future studies examining the recycling of WEEE using LCA must make improvements in the quality and scope over existing gate-to-grave studies if their results are to be made robust enough to allow the best environmental options to be defined. The study completed in this research attempts to address the weaknesses to date, as discussed in detail later in the methodology section (Section 5).

3.2 Life Cycle Costing (LCC) of WEEE

Life Cycle Costing (LCC) has been developed for use in financial planning and decision-making. These accounting based approaches can be used to determine the total costs of a product throughout its life-cycle, including capital investment, production, distribution, use, maintenance, and disposal. Although there are no specific set methods for LCC, it involves the use of standard accounting:

> *"Financial Life Cycle Costing (LCC) methods are, in general, methods for cost accounting and include often only internal costs. Financial LCC seeks to identify all the costs incurred during the whole lifecycle of a particular product or system…Inclusion of lifecycle costs in accounting processes is relevant for firms undertaking pollution prevention planning, but also for firms, governments or agencies that are interested in improving decision making."* – Maas and Jantzem (1999: 21)

Life-cycle costing has been mostly used within the military and within the construction industry, where there are high levels of cost associated with capital expenditure, use, and maintenance throughout the product life-cycle (Maas and Jaantzem, 1999; Flannagan *et al.*, 1989). More relevant to the management of WEEE, LCA and LCC approaches have been used in tandem in the Ecobalance (1999) study described previously, and in a study by Guido *et al.* (1998).

Guido *et al.* (1998) examined the lifecycle of a television using the Dutch eco-indicator method[23] to derive a single score representing the level of environmental impacts at each stage in the life cycle. End-of-life was found to only constitute 1.6%-2.0% of the total eco-indicator score of the life cycle of a television, and 1.1% - 1.4% of its costs. Thus, it was suggested that:

> "*This tempts one to conclude that the current environmental focus on the end-of-life stage might better be aimed on other areas, where larger improvements can be realised*" – Guido *et al.* (1998: 192)

While this is an interesting proposition, it might equally be argued in contention that the proportions of overall life-cycle cost were commensurate with the overall environmental benefits attained, and therefore that electronics recycling is in some respects justified in terms of the relative balance of environmental impacts and costs. Single-score methods of environmental impact assessment were not used in the research presented here to allow sufficient analysis of the different environmental impacts resulting from each scenario. Furthermore, valuation and aggregation of impact categories into one impact score was not necessary for the analysis.

Further problems were found with the methodology and approach used within the Ecobalance (1999) LCC study on WEEE:

- **Systems boundary expansion**

  Results of the LCC analysis are difficult to interpret as the methods used result in substantial financial miscalculations. This is due to the use of an LCA method known as systems boundary expansion in the LCC study. Systems boundary expansion is used to ensure comparisons between different recycling and waste management

[23] The eco-indicator method is a system of deriving a single score to represent the environmental impacts of the life cycle under study. The latest version of this method is given in Goedkoop and Spiensma (2000)

scenarios are equivalent. This is achieved by adding the environmental impacts of processes producing materials from virgin resources to scenarios deficient in materials production volumes compared to recycling scenarios. Whilst this can be justified for environmental LCAs, the financial benefits of materials recycling should only be considered by comparing the profitability of the different waste management scenarios. For example, it is not necessary to know the costs and revenues of producing iron from virgin resources compared to production from recovered materials to calculate the financial benefits or profitability of different recycling and waste management scenarios.

- **Results analysis**

  Although the Ecobalance study evaluated both cost and environmental impact, no attempt was made to bring the results of the LCC and LCA together to determine Best Practicable Environmental Option for the products studied.

Under Producer Responsibility, electronics producers will need to assure a certain level of environmental performance for product collection, treatment, and recycling processes whilst attempting to minimise their costs. In investigating the environmental impacts and costs of product EOLM, the use of LCC combination with LCA can provide a useful analytical approach:

> "*As financial LCC will generate more extensive, accurate and detailed information on internal (environmental) costs and enables a more integral assessment of the system under study, it is recommended to include a life cycle perspective in cost calculations.*" – Maas and Jantzen (1999:95)

The potential benefits of the WEEE Directive should be examined in more detail from a life cycle perspective, using LCA and LCC methods.

3.3 Summary

Under Producer Responsibility legislation for WEEE, producers will need to assure their EOLM processes achieve a certain level of environmental performance. As a business necessity they will also attempt to finance and organise these processes in a cost efficient manner.

Life Cycle Assessment is a useful tool for evaluating the overall environmental impacts and costs of waste management and recycling processes. The results of existing LCA and LCC studies provide only limited insight into the relationships between drivers of environmental impact and cost in the management of WEEE. As discussed above, these studies are either limited in scope or require substantial improvements in assumptions and methods used.

To date, EcoBalance (1999) has conducted the only comprehensive investigation of the environmental impacts and costs to producers of the proposed WEEE Directive, using LCA and LCC. This study concluded that the recycling of WEEE as proposed by the EC will have reduced environmental impact compared to the current UK situation and the option to discard 100% of products in landfill. However, as described above, errors apparent in the LCA assumptions and LCC methods used undermine the veracity of

these findings significantly.

Within this research, LCA combined with LCC is also used to conduct an environmental and financial assessment of the likely effectiveness of the proposed WEEE Directive. Further details of the methods used, which attempt to address weaknesses in studies completed to date, are described in detail in Section 5.

In the following section (Section 4), a range of possible research methods are evaluated for use in this research.

The environmental impacts and costs of waste electronic products.

4. Research methodology selection

Possible approaches for use in investigating and managing the environmental impacts and costs of EOLM processes are reviewed in this section. As described in Section 1, the aims of this research were to:

- Determine the likely environmental impacts and cost implications for producers of the proposed Producer Responsibility legislation for Waste Electrical and Electronic Equipment (WEEE).
- Investigate the potential for reducing the environmental impact of End-of-Life Management (EOLM) processes cost effectively for WEEE

The suitability of methods for use in this research were evaluated against four criteria, as follows:

1. Impact and cost allocation
   Must be capable of attributing costs and environmental impacts to well-characterised streams of waste materials or EOLM processes, such that any potential improvements can be identified and achieved. In addition, should allow the environmental impacts and costs of each separate stage and sub-process within EOLM to be determined, including product collection, processing, and revalorisation.

2. Applicability
   Must be generically applicable to different waste electronics disposal or recycling scenarios, and not be exclusive to any particular EOLM process. That is, it should be applicable irrespective of the types of product collected, sources of waste equipment, collection methods used, and treatment and recycling technologies involved.

3. Scope
   Must allow holistic assessment of the entire EOLM process from the point of collection until final materials recovery, treatment, and disposal, such that one stage is not optimised at the expense of another.

4. Compatibility with management systems
   Given that this project was undertaken at HP, that has a strong culture of quality management, an important criteria was compatibility of the selected method with management systems based on continuous improvement. This is also important due to the use of continuous improvement within existing environmental management systems such as ISO 140001 (ISO, 1996).

There are many methods of financial and environmental assessment described within literature on environment, financial accounting, and waste and logistics management. ***Only methods addressing a combination of the selection criteria listed above were selected for review (as described in more detail in Sections 4.1-4.4).*** These fall into four different types of approach:

- Dynamic systems modelling

The environmental impacts and costs of waste electronic products.

- Operational Research methods
- Management accounting
- Life Cycle Assessment and Life Cycle Costing

In section 4.5, the selection of the specific methods used in the work presented here (LCA, and LCC based on logistics management accounting) is explained.

4.1 Dynamic systems modelling

Dynamic systems modelling can be used to determine the behaviour of a system over time. Its suitability against the four criteria defined above is evaluated in Table 4.1 below. This method has been used extensively both in modelling processes in environmental engineering and in planning product distribution systems.

Dynamic modelling has been used in environmental engineering to model both the effects of pollutants in the environment and the effectiveness of waste management and emission treatment processes. For example, it is commonly used to model the depletion of oxygen in rivers from sewage discharge and to model sewage treatment processes (for examples see; Masters, 1991: 131-134; Hanaki *et al.*, 1985: 585-634; Andrews, 1983: 113-172).

One study on electronics recycling uses dynamic modelling in combination with LCA to examine the energy consumed during the life cycle of a mobile phone (McClaren, 1999). Three different end-of-life policy scenarios were investigated, including:

1. Precious metals recovery only
2. Precious metals recovery and component reuse
3. Precious metals recovery and component reuse, including phones held in storage

The study concluded that the take-back and recycling of mobile phones could be viewed as environmentally beneficial in terms of overall energy consumption, particularly with regards to component reuse. It also concluded that substantial return rates were required to lower overall system energy requirements.

Dynamic systems modelling has been used in the study of manufacturing systems for over 40 years (a field of research known as industrial dynamics), and can be useful in identifying opportunities for continuous improvement (Towill, 1996: 40). For example, one recent study used a dynamic model to determine an optimal set of control parameters to reduce the amplification of supply and demand through feedback in industrial supply chains (Disney *et al.*, 1997).

In spite of its widespread use in environmental research and research on logistics management, dynamic system modelling was not selected because it fulfilled only 3 of the 4 research methodology selection criteria (as shown in Table 4.1 below). The behaviour of electronics recycling systems over time is not an aspect investigated in this research.

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Table 4.1: The suitability of dynamic systems modelling against criteria for research method

Criteria	Evaluation	Criteria fulfilled
1. Impact and cost allocation:	Cannot be used to attribute environmental impacts and costs to different EOLM processes. This is because dynamic systems modelling is a method used to investigate system behaviour and feedback over time, and not to determine environmental impact or cost allocation.	No
2. Applicability:	Could be used to simulate any EOLM process or scenario provided sufficient data.	Yes
3. Scope:	Can be used to model an EOLM process from cradle to grave, and can be used in combination with LCA and LCC. McClaren *et al.* (1999) provide an example of such a method used to assess energy consumption in electronics recycling and reuse.	Yes
4. Compatibility with management systems	Given different scenarios this method can be used to determine appropriate management strategies in continuous improvement. For example, this method can be used to investigate reasons for system instability and failure in distribution planning and re-engineering of manufacturing processes.	Yes

4.2 Operational Research (OR) methods

Operational Research (OR) is commonly used in designing product distribution systems, and in finding cost and time optimal solutions to specific problems in manufacturing and logistics management (as summarised in Section 2.3). OR methods are used to determine the optimum permutation or combination for a given process or system against predefined criteria, where there are many different sequences of options possible. For example, OR can be used in solving vehicle routing problems, facility location problems, and in delivery scheduling in distribution.

There has been much research on the application of OR methods in reverse logistics. For example, operational research methods have been used in:

- Optimising product design for disassembly (Veerakamolmal and Gupta, 1998; Krikke *et al.*, 1998; Bullinger *et al.*, 1998: 4-6)
- Minimising the impact of transport on the environment through optimised routing (Bullinger *et al.*, 1998: 9)
- Facility location and recovery network design in recycling (Kooi *et al.*, 1996; Krikke, 1998)

OR methods were not used in this research as they only fulfilled three of the four research methodology selection criteria (see Table 4.2 below). The optimisation of waste electronics treatment and recycling processes at an operational level is an important area of research, but is not investigated here.

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Table 4.2: The suitability of dynamic systems modelling against criteria for research method

Criteria	Evaluation	Criteria fulfilled
1. Impact and cost allocation:	The methodology required here must be capable of determining the *most appropriate* allocation of costs and environmental impacts to different stages of an EOLM process. This requires qualified judgements as opposed to quantitative optimisations as performed by OR methods.	No
2. Applicability:	The algorithms used in OR can be used in combination and new algorithms can be developed to optimise a variety of problems within waste management. OR methods can therefore be developed and applied to different EOLM processes.	Yes
3. Scope:	Can be applied to any stage of an EOLM process. For example, a number of algorithms have been developed by Krikke (1999) for collection of waste electronics, disassembly processes, and recycling facility location.	Yes
4. Compatibility with management systems	OR methods could be particularly suitable for optimising EOLM proceses against given environmental and financial criteria, and therefore could be useful in objective-based decision making and continuous improvement.	Yes

4.3 Management accounting

Accounting methods are considered here due to the their importance in business and financial management, including within the electronics recycling industry. For example, accounting methods are also used in research on logistics management (Christopher, 1992) and life cycle costing (Maas and Jantzem, 1999).

There are three different types of management accounting method, the use of which will depend on the time period relevant and the objectives of the accounting exercise:

- Total Cost Accounting (Mills and Robertson, 1999: 233-272)
- Variable or Activity-Based Costing (Innes and Mitchell, 1996)
- Non-routine costing (Mills and Robertson, 1999: 199-232)

These three management accounting approaches have the general advantage that they are commonly used within management and are applicable to all types of business or business operation. They are also all compatible with continuous improvement approaches. Thus they all fulfil the second and fourth requirements for an EOLM system given above. Each of these approaches is evaluated below in relation to the remaining selection criteria (1 and 3).

4.3.1 Total Cost Accounting (TCA)

TCA is used in long-term financial planning to evaluate the financial feasibility of large-scale investment projects, based on Net Present Value (NPV) techniques (Mills and

Robertson, 1999: 233-272; Shillinglaw, 1963). NPV techniques are used to determine the value of money received in the present compared to money received in the future, based on the principle that the value of money in the future is discounted (by a given rate) against the value of money in the present.

Most LCC studies to date are based on TCA, as they have been used to evaluate large-scale construction and military hardware development projects with high investment needs and high costs over long product lifetimes (Maas and Jantzem, 1999). In forward logistics management, TCA has been further developed for use in long-term planning and investment in distribution infrastructure (Christopher, 1992; Ray *et al.*, 1980).

TCA was not selected, as it does not fulfil the first of the research method selection criteria on impact and cost allocation (as shown in Table 4.3). The principal disadvantage of TCA is that it is used to evaluate *lifetime* costs and not *lifecycle* costs, and investment-related decisions are not an aspect investigated in this research. Other existing accounting methods already provide more suitable approaches for use in investigating the commercial viability of EOLM processes, as described below.

Table 4.3: The suitability of Total Cost Accounting against criteria for research method

Criteria	Evaluation	Criteria fulfilled
1. Impact and cost allocation:	Only addresses some financial aspects of EOLM, such as rates of product obsolescence, asset depreciation, and asset salvage values. Cannot be used to allocate costs to separate EOLM processes, or to each stage within a waste management channel.	No
2. Applicability:	Commonly used within management and applicable to all types of business or business operation.	Yes
3. Scope:	TCA could be used to holistically evaluate the overall financial performance of different EOLM processes over-time.	Yes
4. Compatibility with management systems	Can be used during the initial strategic planning stage of continuous improvement.	Yes

4.3.2 Variable or Activity-Based Costing (ABC)

The ABC method, or variable cost accounting as it is less commonly known, is typically used within manufacturing and engineering to aid short-term operational and process orientated decision-making and planning (Mills and Robertson, 1999). More specifically, ABC can be used to calculate the total variable cost attributable to a given production line or process. It is particularly useful in financial analysis when process costs are dependent on a combination non-volume related cost drivers, arising from shared processes (Innes and Mitchell, 1996). Examples of such costs include material handling, procurement, installation, maintenance, quality control, machinery, and fitting cost overheads arising within a production facility. ABC could be used in electronics recycling to compare the costs and efficiency of different material separation processes, such as manual disassembly (where labour rates are flexible), automated disassembly, and mechanical shredding.

Although ABC methods are important in evaluating the behaviour of a process's operational costs in relation to processing volumes, they cannot be used to apportion or

evaluate *non-variable*, *irregular*, or *indivisible* costs, including fixed historic costs and occasional future costs. Examples of such costs include management headcount, capital investment, and process refurbishment. This means that ABC methods are incapable of providing analyses that remain relevant over extended timeframes. As one author has argued:

> "*The danger in using ABC lies in too readily assuming that it provides a panacea which will solve all of the problems associated with the provision of costing information to management. It should be recognised that ABC is not a general purpose system whose outputs are suitable, without thought or modification, for use in all areas of control, performance, assessment and managerial decision-making...Whilst ABC has the particular advantage of providing an indication to management of long-term product costs, it must be remembered that it is over this time perspective the shortcomings of historic cost will be accentuated*" – Innes and Mitchell (1990: 59)

As ABC cannot be used to evaluate non-variable process-related costs, used alone it does not fulfil requirements on impact and cost allocation, and scope (as shown in Table 4.4). However, these two requirements are met when ABC is used in conjunction with non-routine costing methods (described below), that include procedures for allocating and evaluating non-variable costs.

Table 4.4: The suitability of Activity Based Costing against criteria for research method

Criteria	Evaluation	Criteria fulfilled
1. Impact and cost allocation:	As Activity Based Costing cannot be used to evaluate non-variable process-related costs, it cannot be used to disaggregate the *overall* cost of an EOLM processes to individual unit processes, or attribute irregular common or shared costs relating to processing activities.	No
2. Applicability:	Commonly used within management and applicable to all types of business or business operation.	Yes
3. Scope:	As Activity Based Costing cannot be used to evaluate non-variable process-related costs, it cannot be used to provide a holistic assessment of the overall financial performance of an EOLM process.	No
4. Compatibility with management systems	Can be used during the initial strategic planning stage of continuous improvement.	Yes

4.3.3 Non-routine costing

Non-routine costing is used to evaluate the financial implications of completing a particular series of tasks in achieving a predefined objective. Non-routine costing methods are essentially based on ABC, and do not employ the NPV techniques used in TCA (described in Section 4.3.1). However, they differ substantively from ABC in two ways:

- They focus on the commercial viability of management objectives and decisions as opposed to the operational costs of production processes
- They include procedures for the allocation and attribution costs which vary to different extents with volume and over different time-scales, recognising that most costs have both fixed and variable elements (HDL, 1997: 17)

Where LCA is used to determine the environmental impacts attributable to particular products, non-routine costing methods can be used to do the same for costs. However, no LCC studies using non-routine costing were found in the literature. This is surprising given the use of non-routine costing in cost allocation, and provides opportunity for research such as that completed in this study.

Two relevant methods are described below used in accounting and in logistics management:

- Cost-Volume-Profit Analysis (CVPA): used in product development and planning to determine the relative profit contributions of different products (Mills and Robertson, 1999: 199-232; HDL, 1997:17-56). The CVPA approach is most applicable for use in forward distribution and marketing to compare the profitability of different products.

- Mission Costing (MC): Proposed within the logistics literature, and developed to evaluate the commercial viability of different distribution channels used in distributing different products or services to market (Christopher, 1992; Barret, 1982). For example, the MC method could be used to evaluate the profitability of different service delivery channels in a fast-food restaurant (such as take-away, eat-in, or home delivery), including the differential costs of ingredients, packaging, preparation, and service in each case.

As shown in Table 4.5, non-routine costing methods fulfil all of the research methodology selection criteria given above. The Mission Costing method appears particularly interesting, as its focus on the commercial viability of channels of distribution is particularly suitable for the evaluation of EOLM processes or "channels". For simplicity, the term "EOLM processes" is used throughout this report instead of "EOLM channels". MC approaches are used in financial analysis within the waste management industry under the titles of "*job costing*", "*flow sheeting*", and "*project costing*" [24]. These methods are used in industry to determine the commercial viability of providing different waste management and recycling services to customers.

Table 4.5: The suitability of Non-Routine Costing against criteria for research method

Criteria	Evaluation	Criteria fulfilled
1. Impact and cost allocation:	Can be used to attribute both fixed and variable costs to different EOLM processes, and to different stages or sub-processes within an EOLM process.	Yes
2. Applicability:	Commonly used within management and applicable to all types of business or business operation.	Yes
3. Scope:	Can be used to evaluate holistically the overall commercial viability of an EOLM process.	Yes
4. Compatibility with management systems	Can be used during the initial strategic planning stage of continuous improvement.	Yes

[24] Based on discussions with one of the UK's leading waste management companies and a European precious and base metal smelter (1999).

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The MC methodology has some striking similarities to LCA. Both approaches can be used to evaluate chains of industrial activity by cross-tabulating inventories of costs (MC and LCC) or environmental impacts (LCA) across functional boundaries (throughout a company's distribution channel or from "cradle-to-grave"). In addition, both approaches are used to evaluate a specified level of product or service functionality. In Mission Costing each service is described by a clearly defined service-related "mission"[25], which is assessed in terms of profitability. In lifecycle assessment, a unit of functionality (service) is defined for each product or service (such as pages printed for printers, or mass of waste processed in waste management), which is then assessed in terms of its environmental impact.

4.4 Life Cycle Assessment and Costing

Research using LCA and LCC to date investigating the treatment and recycling of WEEE has been discussed in detail in Section 3. In summary, these methods are used to evaluate the environmental impacts and costs of products from cradle to grave. The combination of LCA with LCC fulfils all the research methodology selection criteria outlined above (as shown in Table 4.6).

Despite increasing use of LCA within decision-making, practitioners often criticise LCA as a tool too complex and specialised to be of use in product development, production, and distribution. LCA is necessary if the overall environmental impacts of a product from raw material extraction to final disposal are to be understood. Decisions taken affecting the life cycle of a product without such information could lead to errors in environmental management. For example, the environmental burdens of a product could be shifted to other stages in the product lifecycle rather than being reduced overall.

Table 4.6: The suitability of LCA and LCC against criteria for research method

Criteria	Evaluation	Criteria fulfilled
1. Impact and cost allocation:	Used to determine the total environmental impacts and costs that can be attributed to a stated functional unit of a product or service. Also allows data to be summed and disaggregated for each stage of EOLM.	Yes
2. Compatibility:	Applicable to all products, and therefore different EOLM processes.	Yes
3. Scope:	Based on a holistic assessment of an entire life cycle of a product, or EOLM process.	Yes
4. Compatibility with management systems:	Can be used to identify improvements in product design which could contribute to a company's environmental performance.	Yes

With the increasing number of LCA software tools available (such as the EcoBilan TEAM software used in this research; EcoBilan, 1998), LCA studies are becoming increasingly practicable. In addition, there have been attempts to integrate LCA methods into environmental management systems such as ISO 14001 (Ferrone, 1996). For

[25] In MC, the "mission" is the objective of a channel of distribution. It is a statement that summarises the specific product that is to be provided, the market to be serviced, and service levels to be achieved (Barret, 1982).

example, Product Oriented Environmental Management systems (POEMs) have been adopted by many companies in the Netherlands under voluntary agreements with the government (Rocha and Brezet, 1999) [26]. Although as yet the effectiveness of these tools in reducing the life cycle environmental impacts of products has not been investigated, the development and use of LCA within environmental management is important and increasingly practicable.

In conclusion, LCA and LCC provide a useful analytical framework for investigating EOLM processes. However, to be compatible with management practices employed within industry, LCA and LCC should be integrated where possible within continuous improvement. One of the objectives of this research is to investigate opportunities to reduce the environmental impacts and costs of EOLM processes for WEEE. These opportunities could be taken up within continuous improvement

4.5 Method selection

The suitability of each of the methods described above is summarised against the four evaluation criteria given at the beginning of this section in Table 4.7 below. The only methods that fulfil all four criteria are LCA coupled with LCC, and MC. As LCC and MC are compatible, these were the methods chosen for use in this research.

The main problem with the other approaches evaluated is that they do not provide suitable procedures by which costs or environmental impacts can be allocated to different stages or processes within EOLM. All of the approaches examined could be used as a tool in achieving continuous improvement and would be compatible between different treatment and recycling scenarios. The use of LCA in continuous improvement is currently a growing area of academic interest, and therefore provides useful insights into the effectiveness of such approaches (as discussed in Section 7.4).

Table 4.7: Evaluation of methods for use in EOLM

Method	**Allows aggregation and disaggregation of data**	**Compatible between EOLM scenarios**	**Provides holistic assessment**	**Compatible with continuous improvement**	**Criteria fulfilled**
Dynamic modelling	No	Yes	Yes	Yes	3/4
Operational Research (OR)	No	Yes	Yes	Yes	3/4
Total Cost Accounting (TCA)	No	Yes	Yes	Yes	3/4
Activity Based Costing (ABC)	No	Yes	No	Yes	2/4
Mission Costing (MC)	Yes	Yes	Yes	Yes	4/4
LCA & LCC	Yes	Yes	Yes	Yes	4/4

[26] Information provided by the Dutch Ministry of Environment, March 2001.

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4.6 Summary

This section has evaluated a range of methods for use in this research, from dynamic systems modelling, operational research, management accounting, to LCA and LCC. Four research methodology selection criteria have been outlined, covering needs for environmental impact and cost allocation, applicability, scope, and compatibility with management systems.

LCA and LCC together with the non-routine management accounting method, Mission Costing (MC), were the only methods fulfilling all four criteria. Consequently, these methods are used in this research to complete an environmental and economic analysis of the likely environmental impacts and costs to producers of the proposed WEEE Directive (the results of which are presented in Section 6). In the following section (Section 5), the research methodology is described in detail.

5. LCA and LCC methodology

Following the evaluation of research methods in the preceding section (Section 4), this section provides comprehensive details of the LCA and LCC study methodology. In Section 5.1, the printer trade-in case study is outlined. In Sections 5.2 to 5.5 the four separate stages of LCA and LCC are described:

1. Goal and scope determination:
   Setting of the study goals and LCA and LCC system boundaries.

2. Inventory of environmental burdens and costs:
   Quantification and tabulation of life-cycle environmental burdens and costs.

3. Impact characterisation and normalisation:
   Calculation of overall life-cycle environmental impacts and costs in relation to common basis of comparison. Valuation or weighted comparison of environmental impact categories was not necessary and not undertaken in this study.

4. Improvement assessment:
   Analysis of relevance of results to goals of the study.

The results of the research are presented and discussed the following Sections 6 and 7.

5.1 The HP printer trade-in example

During April 1999, HP conducted a printer trade-in with the Dixons Stores Group (DSG). This was used as a case study for the LCA and LCC investigation. During the trade-in, printers were exchanged for a discount on selected new HP models by householders at both DSG high-street and out-of-town stores across the UK. These returned printers were then collected and consolidated at the DSG returns warehouse in Stevenage, and at HP's subcontracted distribution centre at Basingstoke. The trade-in conformed with the requirements in the proposed WEEE Directive, which specify that waste appliances returned to retail outlets on the purchase of new by consumers must be recycled free of charge by producers. In terms of the EOLM processes involved, it was also similar to the disposal of waste appliances at municipally organised collection points.

The printers collected were sent to a recycling facility near Portsmouth for processing (Intex Computers Limited). Working HP products (33% of products by mass) were refurbished and resold either directly, through second-hand equipment brokers, or through maintenance and repair companies. The remaining products (67% by mass) were sorted and dismantled into various material streams (as shown in Plates 5.1 to 5.7 overleaf), and sent for further treatment, recovery, and recycling. The results of the trade-in are presented in Table 5.1 two pages overleaf. The processes used for the collection, treatment, and recycling printers in the trade-in are shown in Fig. 5.1, also two pages overleaf.

Plates 5.1 to 5.7:
The processing of end-of-life printers

Plate 5.1: Traded-in printers at "goods in"

Plate 5.2: Printers for refurbishment

Plate 5.3: Plastic casings for shredding

Plate 5.4: Shredded casings for energy recovery

Plate 5.5: Printed circuits for recycling

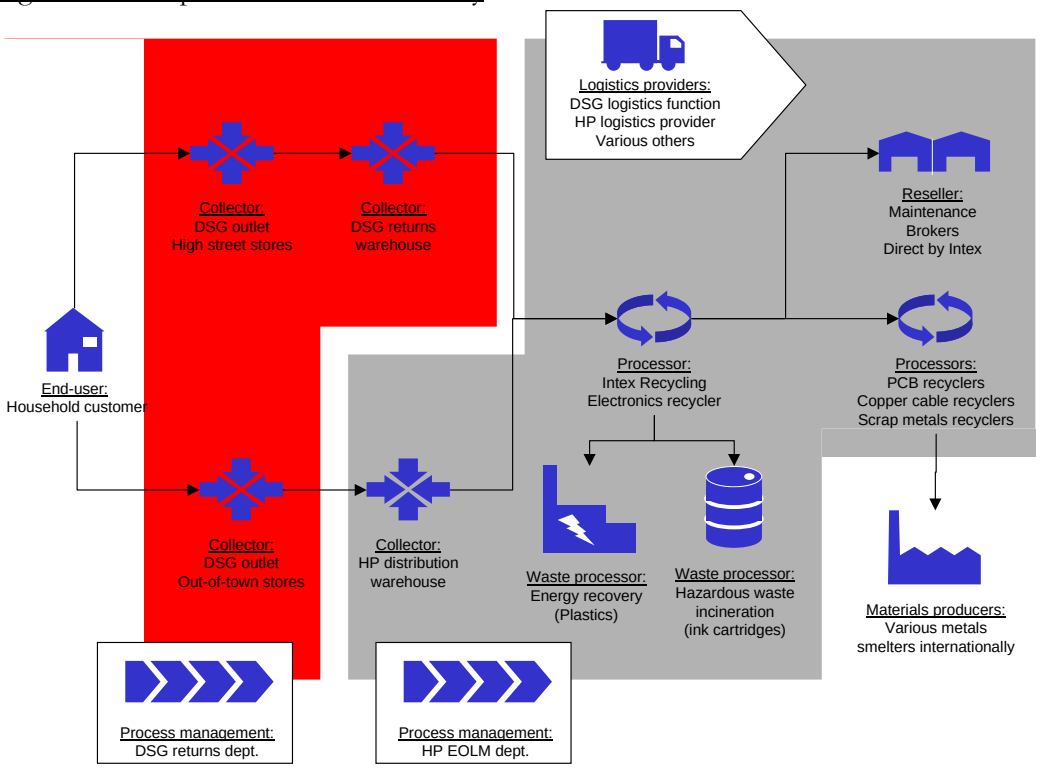
Plate 5.6: Copper cabling sorted for recycling

Plate 5.7: Steel casing for recycling

Table 5.1: Printer trade-in results

	Inkjet printers	Laserjet printers	Dot matrix printers	Fax machines	Totals
Number collected (units)	1,969	133	1,129	30	3,261
No. of brands (units)	27	32	59	16	75
No. of models (units)	125	79	-	28	-
Total mass (kg) of printers received	-	-	-	-	21,642
Total mass (kg) of printers recycled	4,098	2,044	7,783	155	14,080
Total mass including packaging (kg)	4,250	2,071	8,105	164	14,590

Figure 5.1: The printer trade-in case-study

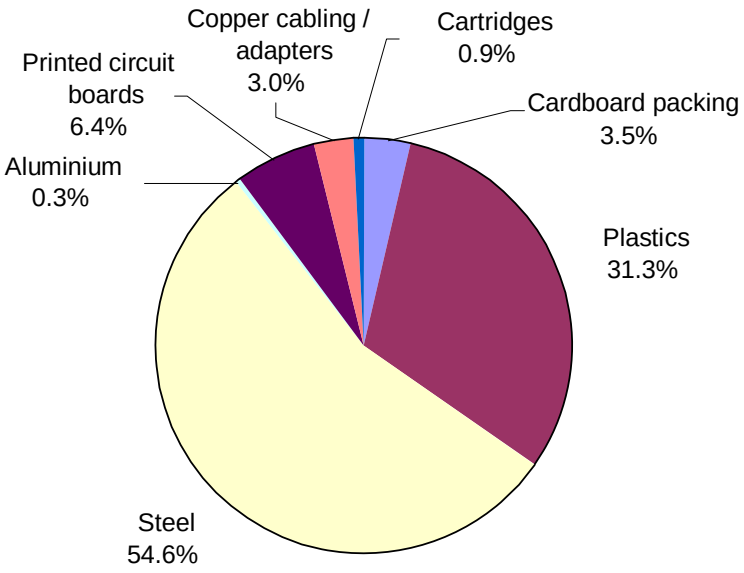


In total 3,261 printers were received during the trade-in period, which constituted over 21.6 tonnes of equipment. Products returned included over 75 different brands, and included 59 different brands of dot matrix printers[27], 125 models of inkjet printers, 79 models of laser printers, and 28 models of fax machines. The results include a wide range of printer types, models, and brands, as might be collected for treatment and recycling following the implementation of the proposed WEEE Directive.

The overall composition of the returned printers is shown in Fig. 5.2 overleaf, which shows that around 85% of the products collected by mass were composed of plastics and steel. This compositional data is necessary to determine the quantities of materials entering treatment and recycling processes and their respective environmental impacts and costs.

[27] Dot matrix printers counted by brand due to difficulty in identifying model type.

Figure 5.2: The materials composition of printers collected (by mass)



Total mass sent for recycling = 14,590 kg

5.2 Study goal and scope

As the first step in LCA and LCC, the goal and scope of printer trade-in study were determined. This involved the definition of the:

- Study goals (described in Section 5.2.1)
- Product or service to be studied (definition of functional unit, described in Section 5.2.2).
- Stages to be included in the assessment (setting of systems boundaries, described Section 5.2.3).
- Minimum data quality requirements for financial, environmental, and process-related data (described in Section 5.2.4).

For the purposes of LCA, the printer trade-in process is considered as a gate-to-grave life-cycle (explained below). For the purposes of the MC accounting method used in LCC (introduced in Section 4.3.3), the printer trade-in process is considered as a logistics channel (albeit a reverse logistics channel).

5.2.1 Study goals

The two goals of the printer trade-in study were introduced at the beginning of Section 1:

- Determine the likely environmental impacts and cost implications for producers of the proposed Producer Responsibility legislation for Waste Electrical and Electronic

Equipment (WEEE).

- Investigate the potential for reducing the environmental impact of End-of-Life Management (EOLM) processes cost effectively for WEEE

Four scenarios were selected to evaluate different rates of recovery and recycling (as shown in Table 5.2 below), with recovery rates ranging between 61% and 99% by mass for recycling and recovery scenarios, and 0% for landfilling. The "*plastics and PCBs recovered*" scenario was consistent with requirements for IT products in the EC's first WEEE Directive proposal, which set minimum targets of 75% for recovery and recycling and 65% for recycling by mass. All recycling and recovery scenarios are consistent with treatment requirements of the proposed WEEE Directive, which entails the removal of printed circuit boards, toner cartridges, and plastics potentially containing brominated flame retardants for separate treatment.

Table 5.2: Waste management and recycling scenarios investigated for the printer trade-in

Scenario	Description	Sent for materials recycling$^{\Psi}$ (by mass)	Sent for energy recovery$^{\Psi}$ (by mass)	Total recovered and recycled$^{\Psi}$ (by mass)
Plastics and PCBs[28] recycled (maximum recycling and recovery):	All components sent for recycling, energy recovery (in the case of mixed plastics), or treatment$^{\varphi}$. This scenario represents the actual printer trade-in undertaken, which corresponded to requirements proposed by the WEEE Directive.	67.8%	31.2%	99.0%
Plastics landfilled (maximum recycling, no energy recovery):	Plastic components landfilled, all remaining components sent for recycling or treatment$^{\varphi}$. Scenario assessed in terms of environmental performance and cost as a potential alternative to the maximum recovery scenario.	67.8%	0%	67.8%
Plastics and PCBs lanfilled (partial recycling, no energy recovery):	Printed circuit boards and plastics landfilled, all remaining components sent for recycling or treatment$^{\varphi}$. Scenario assessed in terms of environmental performance and cost as a potential alternative to the maximum recovery scenario.	61.4%	0%	61.4%
100% landfilling (no recycling or recovery):	All printers disposed of in landfill. Scenario assessed in terms of environmental performance and cost as a potential alternative to the maximum recovery undertaken, and used as a baseline case to normalise comparisons between scenarios.	0%	0%	0%

Ψ : Out of around 14.6 tonnes of equipment sent for recycling and recovery.
φ : Hazardous waste treatment e.g. high temperature incineration for printer cartridges

5.2.2 Definition of functional unit:

In LCA and LCC, it is necessary to define the product or service under investigation, as explained below.

[28] Printed circuit boards

The functional unit used in LCA for the printer trade-in

Within LCA, a *quantitative* "functional unit" is selected to define the product or service under investigation. It is important to ensure the functional unit used adequately defines the problem area to be investigated. The Ecobalance (1999) study on WEEE used a hypothetical functional unit of 1 tonne of each category of WEEE studied. This was not an adequate functional unit as the specific composition and quantity of arising WEEE will vary significantly between different sources. For example, in the UK the majority of larger domestic white appliances are disposed of through civic amenity sites, local authorities, and distributors, whereas the majority of smaller domestic appliances are disposed of as municipal waste (Cooper and Mayers, 2000). In comparison, the functional unit used in this study was the total quantity of mixed printer products collected and sent for treatment and recycling during the period of the trade-in.

Definition of the aim (mission statement) of the printer trade-in used in MC

As explained in Section 4.5, the MC accounting method was used to conduct the LCC investigation. In MC, the service (or functionality) provided by a logistics channel is described *qualitatively* by defining a statement of its "mission". Put simply, the mission statement of a channel is a summary of its purpose and aims. Four steps are outlined as part of the initial "Mission Identification" stage in MC:

1. Identification of customer requirements through market research and investigation
2. Segmentation of the market into distinct groups of customers with different requirements.
3. Specification of the levels of service to be provided to each market segment
4. Definition of mission statements for each logistics channel used for supplying products and services to each market segment

Market based approaches (particularly looking at end-user market segmentation) have an important role to play in the development of both logistics service (Christopher, 1992; Murphy & Daley, 1994) and recycling programme strategies and requirements (Howenstine, 1993; Zikmund and Stanton, 1971):

> *"If it is possible to establish the cost of supplying the various levels of service to the various market segments, i.e. to cost the physical distribution missions, the potential exists to establish the level of service which yields the highest net benefit (profit) to the company, since both the revenue and the cost implications of changes in level of service may be quantifiable."* – Barret, 1982: 10

> *"There is reason to believe that great recycling potential exists in virtually every demographic group if its resources, needs, capabilities, and concerns are understood. But instead of tailoring campaigns for specific communities, municipalities [have] often applied one recycling programme city-wide: for simplicity, to avoid charges of discrimination, and because of a lack of reliable information about the needs of different groups. Market segmentation can help to identify and prioritise the needs of potential recyclers in diverse communities."* – Howenstine (1993: 89).

The domestic and commercial market for product disposal services has been investigated in this research in Vols. 3 and 4, Part 1. The results of these studies reveal that the market for end-of-life management services can be segmented according to the type of products collected, end-user (customer) group involved, and the specific collection and disposal

services provided. Table 5.3 provides a summary of the printer trade-in with respect to these factors.

Table 5.3: Summary of the market addressed by the printer trade-in

Service differentiation factors	**Service description**
End-users:	• All UK consumers
Products:	• Mixed obsolete desktop printers
Services:	• Collection through all DSG retail outlets selling selected new printer range • Maximum resale of HP printers • Material recycling and recovery of non-resellable printer components • Treatment of hazardous parts not recycled or resold

To complete the first step of MC, the aim (or mission statement) of the printer trade-in was defined based on these factors:

> *"To provide a collection and disposal route for the resale of selected printer types, ensuring material recycling and energy recovery of non-resellable printer components, and controlled treatment and disposal of non-recyclable printer components for printers traded-in by consumers at UK retail outlets participating in the trade-in promotion."*

In summary, the functional unit used in the LCA was the total quantity of printer products collected and processed during the trade-in, whereas the purpose or function of the trade-in is described by the above aim.

5.2.3 LCA and LCC system boundaries:

To determining the scope of an LCA and LCC investigation, the product or service life-cycle (or EOLM process) under study must be defined by setting system boundaries. The systems boundaries used in this study are described below.

Boundary setting in LCA

Due to the need for a diverse range of information on environmental burdens from all stages of a product or service life cycle, LCA has detailed requirements for boundary setting[29]. Firstly, both "*foreground*" and "*background*" life cycle boundaries must be decided upon (Barton *et al.*, 1996). In addition, when assessing and comparing different waste management and recycling options, "*gate-to-grave*" and "*expanded*" life cycle boundaries should also be determined, as described below.

Foreground and background system boundaries:

Within an LCA, the "*foreground system*" includes all process steps for which a primary or direct causal link can be established between a product lifecycle and its environmental

[29] For example, 376 different environmental burdens were identified in the "*plastics and PCBs recovered*" scenario (included in the inventory data presented in Appendix 3).

impacts. In comparison, "*background systems*" include process steps with secondary or indirect environmental impacts (Barton *et al.*, 1996), such as energy production. Within an LCA on waste management, the foreground system should include all processes of direct concern in waste management, and the background system all activities in the general economy supplying services to the waste management system.

Gate-to-grave system boundary:

Life Cycle Assessment studies examining the environmental impacts of different waste management options are generally known as "gate-to-grave" studies. In such studies, the manufacturing and use stages are considered to be the same between different EOLM channels. Therefore, these stages effectively cancel each other out, and can be considered to be outside of the overall system boundary or "out of scope" (Barton *et al.*, 1996). Policy makers in the UK are increasingly using this type of LCA in determining Best Practicable Environmental Options in waste management (DETR, 1999). The "gate-to-grave" system boundary for the printer trade-in corresponded to the overall system boundary, including all foreground and background processes used for the collection, treatment and recycling of the printer products collected, and the expanded systems boundary (discussed below).

Expanded systems boundary

Where different material recycling and waste management options are considered, there may be differences in the quantities of secondary raw materials recovered between scenarios. Therefore, in order for such scenarios to remain functionally equivalent, it is necessary to supplement them with the equivalent quantities of primary raw materials produced from virgin sources. This approach, known as the Systems Boundary Expansion Method (ISO, 1998), has become common practice in LCA studies in waste management (Finnveden and Ekvall, 1998). Boundary expansion is the one of the first steps in the allocation of the environmental burdens in LCA (ISO, 1998: 11).

The consideration of product reuse within an expanded systems boundary requires further attention. In previous gate to grave studies on WEEE (McClaren, 1999; Ecobalance, 1999), it has been assumed that product reuse effectively substitutes for the production of new products. Therefore, these studies included the environmental impacts of product production in the expanded boundary to account for avoided burdens.

The environmental impacts of product reuse should only be investigated from the perspective of the total life cycle of a product. This enables factors such as the extent to which product reuse actually substitutes for the resale of new products, the energy used by a product through its life cycle, and the eventual disposal or recycling of the product itself to be given proper consideration. Within this study, product production was not included in the expanded boundary. However, the environmental burdens of product refurbishment and delivery to equipment resellers were included as part of the foreground system, as they were an integral part of the EOLM channel under consideration. This was appropriate given that the original WEEE Directive proposal only set requirements for the treatment, recovery and recycling of WEEE.

In Figs. 5.3 and 5.4 the use of these system boundaries is shown generically for both recycling and recovery, and disposal in landfill. The system boundaries used in the printer trade-in study are presented Fig. 5.5.

Figure 5.3: Life cycle systems boundaries for electronics recycling scenarios

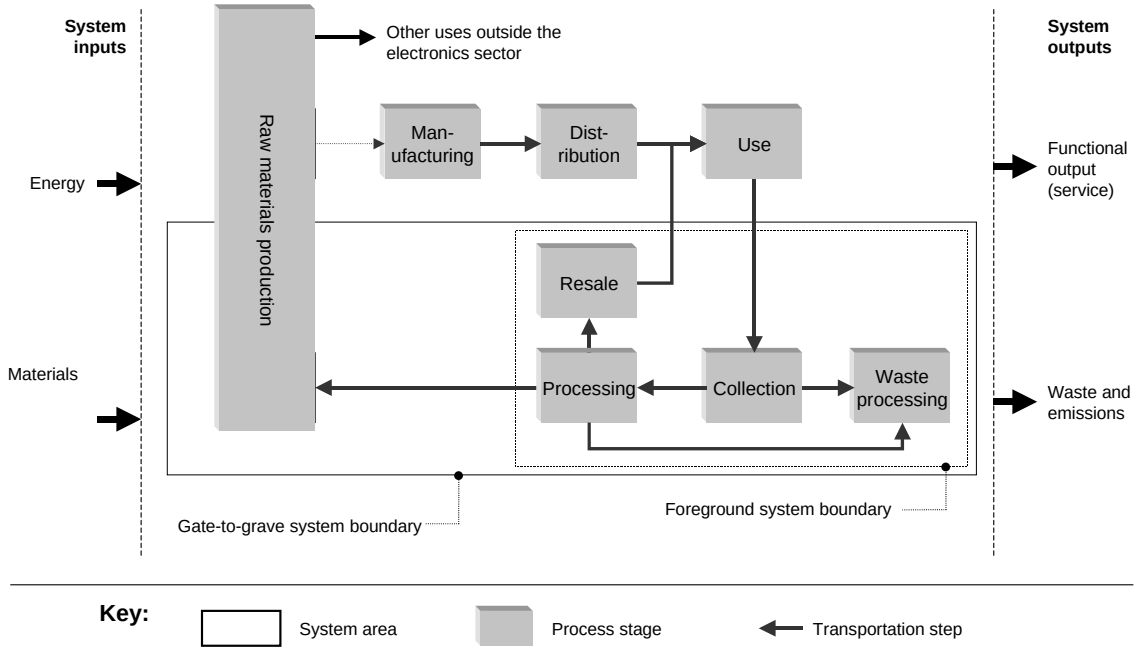
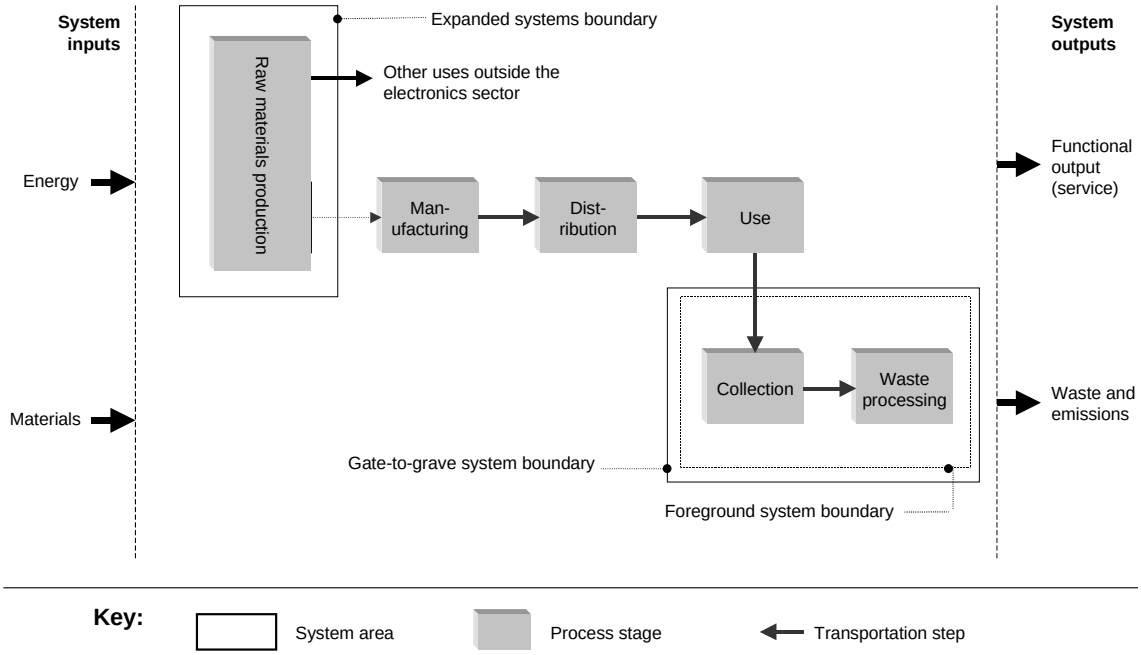
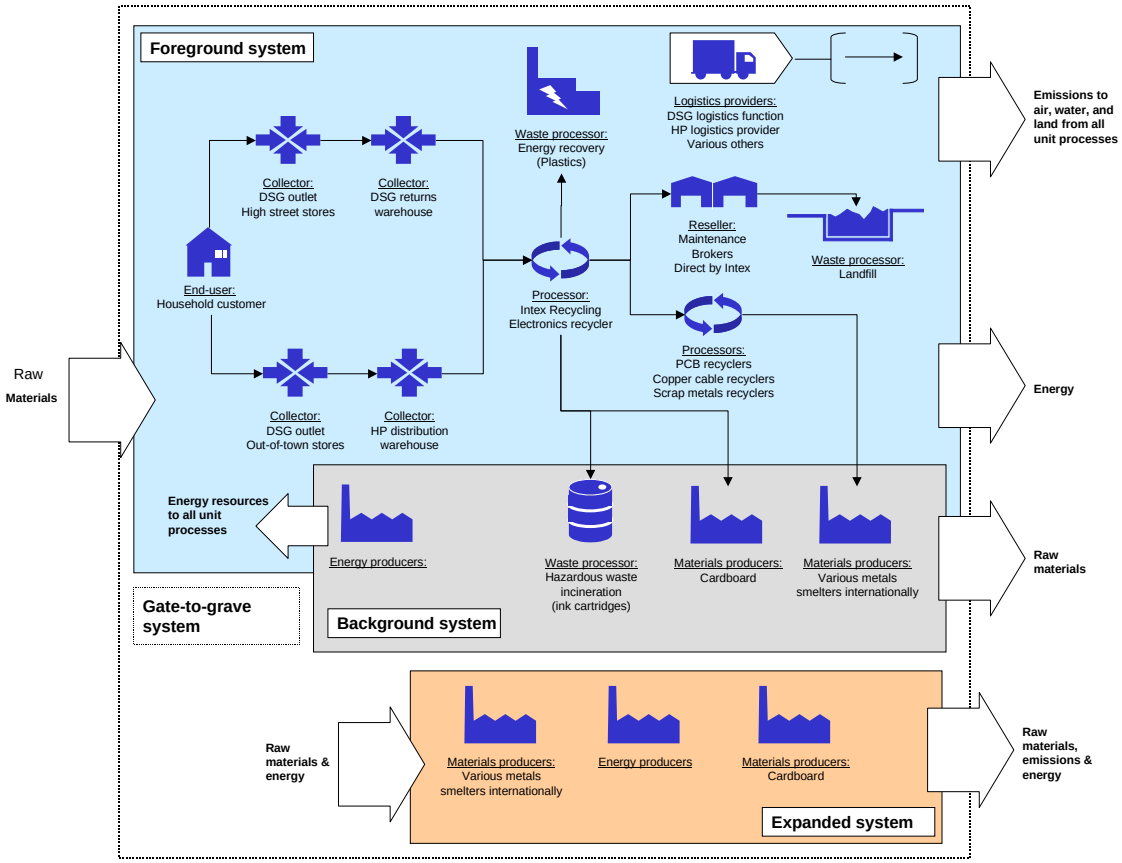


Figure 5.4: Life cycle systems boundaries for electronics landfilling scenarios



The environmental impacts and costs of waste electronic products.

Figure 5.5: LCA system boundaries for the HP printer trade-in



Boundary setting in the LCC financial assessment

With respect to MC, the scoping of the printer trade-in process was relatively straightforward. All stages within a channel which have costs *attributable* [30] in respect to the aim of logistics channel under investigation must be included in the MC analysis. Therefore, the scope of this MC included all actors and stages directly controlled by HP as part of the printer trade-in process (as depicted in Fig. 5.1 in Section 5.1). The costing of the trade-in included the collection of printers from either the point of collection from DSG out-of-town stores UK-wide, or the DSG returns warehouse in Stevenage, through to final product resale, materials recycling, or treatment and disposal. Thus, the LCC was designed to reflect a producer's EOLM costs under the proposed WEEE Directive.

5.2.4 Minimum data quality and reporting requirements

To ensure that the results of this study were reliable and meaningful, minimum data quality requirements were defined as part of the initial scoping exercise. Data quality requirements covered all the categories of data used:

[30] An attributable cost is defined as "*the cost per unit that could be avoided on average if a product or function were discontinued entirely without changing the supporting organisational structure*" (Shillinglaw, 1963: 80). See section 5.5.3 for more details.

- Data reported on costs and revenues
- Data on the material composition of products and components
- Data calculated and used on the environmental burdens of the printer trade-in
- Data reported on the quantities of materials processed

In addition, reporting requirements were set to ensure the validity of data reported on the quantities of equipment processed and any associated costs and revenues. The data quality and reporting requirements used in this study are explained in detail below.

Data quality requirements used for LCA data

Due to the level of uncertainty with environmental data, data quality is important in LCA to ensure confidence in the study results for use in decision-making. Minimum data quality should be established and disclosed concerning (ISO, 1998: 11; Smet and Stalmans, 1996):

1. Representativeness and relevance to the study
2. Coverage and completeness
3. Accuracy (degree of precision)
4. Compatibility and consistency of data from different sources
5. Reproducibility
6. Transparency

The LCA data quality requirements used in the printer trade-in study are described under these headings in Table 5.4 overleaf. These minimum requirements were determined from the extent of data available within the printer trade-in study, and the data quality required for the validation of the research results. The main problems with the quality of the data used in this study were found to be:

- Completeness:

  There was a lack of data available for various processes, including mining of nickel and palladium, gold production, and emissions from printed circuit board shredding. The effect of these data omissions on the validity of results is discussed in section 7.1.2.

- Accuracy:

  Statistically, the standard deviation and the degree of variance were not known for any of the data collected during the review of processes used in the printer trade-in, or reported in the literature. Limitations on the resources and time available, and on commercial confidentiality, prevented statistically representative samples being collected during site visits.

The implications of these data deficiencies are considered further in the discussion of results presented in Section 7.1.2. In areas where data was not available or not of sufficient quality, estimates were used, and included as assumptions of the study (listed in Appendix 1). The sensitivity of the results of the study to inaccuracy of these estimates was tested through sensitivity analysis presented the results section (Section 6.1.3)

Table 5.4: Minimum LCA data quality requirements for the HP printer trade-in

Data quality criteria	Foreground data	Background data
LCI data included:	– Consolidation – All processing steps – All landfill steps – PCB: refining – Plastics incineration – High temperature incineration – Resale	– Electricity production – Transport – Combustion of coal – Combustion of natural gas – Metals smelting – Cardboard production & recycling
Representativeness:	– Actual process data used – All data under 5 years old	– Country specific data used for energy consumption. – All data is material and process specific – All data under 5 years old
Nature of data:	– Data either measured, calculated, or taken from referenced published sources – Where estimates are used, sensitivity analysis allows for 50% error, such as for unknown transport distances	LCI databases: – BUWAL (1996) – Doka (1996) – Ecobilan (1998)
Completeness:	– Landfill excludes the burdens to air and water from energy consumption – Shredding of Printed Circuit Boards excludes direct atmospheric process emissions due unavailability of data	– Production data for copper, nickel, palladium, steel plate, and aluminium ingots in expanded boundary all exclude mining – Aqueous emissions unavailable for Silver. – Gold production data unavailable
Accuracy (degree of precision):	– Weighted means used in most cases (variance unknown) – Medians used where minimum and maximum values given. – Credibility of reports provided by third parties verified by independent financial audits and periodic cross checking of weights and inventories reported with those taken at consolidation points	– Based either on experimental measurements, or actual process mass balance data reported in the literature.
Consistency:	– Consistency check completed using LCI software in TEAM	– Consistency check completed using LCI software in TEAM
Reproducibility:	– Data checked by independent consultants TME – Initial and final data check completed using Excel spreadsheet	– Data checked by database suppliers, Ecobilan – Initial and final data check completed using Excel spreadsheet
Transparency:	– All inventory data and impact calculations disclosed.	– Transparent LCI data for all unit processes – Data provided with notes on coverage

The environmental impacts and costs of waste electronic products.

Reporting requirements for process-related data and costs used in LCC

In addition to minimum data quality requirements, various controls were made on the reporting of process-related and financial data:

- Independent financial auditors (Dunn & Bradstreet) were used to verify the annual financial accounts of main sub-contractors.
- Process related reports were verified against reports on units collected from transportation and logistics companies.
- All products, pallets, and containers were labeled and numbered for reporting purposes.
- Based on open-book accounting, data was reported in detail on the costs, revenues, and volumes of materials processed at different stages of the printer trade-in.
- A number of on-site visits were made to ensure process control and reporting requirements were fulfilled, utilising Hewlett-Packard's quality and environmental auditing activities.

These steps were undertaken to minimise uncertainty over any financial reports used or invoices paid.

With the goals, scope, and data quality and reporting requirements defined, the Environmental Impact and Cost Inventory stage of the LCA and LCC are described in the following section (Section 5.3).

5.3 Inventory of environmental burdens and costs

For the inventory stage in LCA and LCC, the total environmental burdens and costs of the printer trade-in were identified, tabulated, and totaled. This involved three steps: process identification and dissagregation, data collection, and data allocation and reporting. These steps are detailed further below.

5.3.1 Process identification and disaggregation

Firstly, the life-cycle processes and sub-processes contributing to the overall environmental impact and cost of the printer trade-in were identified. As production, distribution and waste management processes may be common to different products and waste streams, disaggregation is necessary to identify causal relationships between a product life-cycle and its environmental burdens and costs. This is addressed by the *process disaggregation step* in LCA, and a similar *sub-system identification step* in MC (ISO, 1998: 54; Azapagic and Clift, 1999: 358,366; Barret, 1982: 21):

> "…*dissagregation is an essential part of formulating a suitable system model, which can then be used to solve the allocation problem by physical causality*" – Azapagic and Clift (1999: 358)

In adapting LCA methodology to waste management, various researchers have argued that unit waste management and recycling processes and the composition of waste streams require separate consideration (Kremer *et al.*, 1998; Barton *et al.*, 1996). This is because different waste streams are likely to have entirely different impacts on the environment, even if processed in the same way. To demonstrate this point, Kremer *et al* (1998) used the example of the incineration of plastics from "technical consumer goods". Substantial differences where found between the environmental burdens of one tonne of waste with an average composition, and waste containing 10% plastics. For example, the plastic containing waste was found to produce more than double (2.46 times) the amount of Carbon Dioxide in the cleaned flue gas than waste of average composition (Kremer *et al.*, 1998: 54). Barton *et al.* (1996) included a general list of processes and waste categories for use in LCAs on waste management, however these do not include the processing of electronics products.

Within this study, consideration was given to environmental burdens at both the process and waste composition level. The composition of the collected printers was described in Section 5.1. The processes used in the treatment and recycling of all categories products collected and recycled by HP from internal use and business customers are listed in Table 5.6. These processes were identified through site visits and audits, telephone enquiry, and periodic reports from recycling service providers. Finally, the specific processes used in the printer trade in were identified and the range of potential environmental burdens and impacts listed, as shown in Appendix 2.

Table 5.6: EOLM processes used by HP's for processing redundant IT equipment (1998-2000)

- **Management:**
  - Administrative tasks
  - Customer account management tasks
  - EOLM channel management tasks
- **Sorting**
- **Transportation:**
  - Car, van, lorry, ship, train
- **Storage:**
  - In-door
  - Out-door
- **Refurbishment:**
  - Testing
  - Repair
- **Product dismantling**
- **Printed Circuit Board processing:**
  - Shredding and granulation
  - Density separation
- **Plastics processing:**
  - Shredding
- **Cathode Ray Tube processing:**
  - Granulation
  - Washing of glass
- **Glass recovery**
  - Use as flux in chemical industry
  - Used within ceramic tile production
- **Metals refining:**
  - Crushing
  - Granulation and shredding
  - Density separation
- **Metals production:**
  - Mining
  - Smelting
- **Waste processing:**
  - Landfill
  - Incineration with energy recovery
- **Hazardous waste processing**
  - High temperature incineration
  - Landfill
  - Chemical treatment

5.3.2 Data collection

Following process dissagregation, data was collected on the environmental impacts and costs of each unit sub-process involved in the printer trade-in. The data used was collected from a variety of sources meeting the minimum quality criteria specified in Section 5.2.4 above, i.e:

Data on environmental burdens:

- The available literature
- Process review and audit

- Management and financial reports
- Published Life Cycle Assessment databases

Data on process costs and volumes:

- Supplier invoices based on open-book accounting
- Actual charges quoted by service providers
- Management and financial reports based on open-book accounting.

The specific list of data sources used is summarised in Table 5.7 overleaf. In areas where data was not of sufficient quality, estimates were used and included in the assumptions of the study, which are listed in Appendix 1. The composition of products and materials collected during the printer trade-in was calculated from reports and assays. In addition, compositional data was also compared with data available from within the literature, and from information provided within Material Data Safety Data sheets available from manufacturers.

Where processes within a life-cycle are common to a number or products (or waste streams) other than that under study, the allocation of environmental impacts and costs must be diven careful consideration. In the following section, the allocation of environmental burdens and costs within the printer trade-in is discussed, completing the life cycle inventory stage of LCA and LCC.

5.3.3 Allocation of environmental burdens costs

The use of different allocation methods between studies can lead to substantially different results in LCA and LCC (ISO, 1998). In this section the allocation of environmental impacts and costs in the printer trade-in is explained.

Allocation of environmental impacts

The first step of allocation involves the allocation of environmental burdens in the expanded boundary, explained in Section 5.2.3 above. The second step of allocation involves allocation of environmental burdens to foreground and background processes within the life-cycle. During this second step, particular consideration must be given to the allocation of environmental burdens of *co-product* or *common* processes, which are used for more than one purpose or function.

Within the literature on LCA, practitioners often base much of their results on assumptions that the environmental burdens of co-product processes can be allocated on the basis of single measures, such as mass. For example, the Ecobalance (1999) LCA study on WEEE (summarised in Section 3) assumed that, by mass, the landfilling of components contained in the appliances studied would have the same environmental burdens as municipal waste of average composition. Using mathematical modeling, some studies have shown that this approach can lead to significant errors in LCA:

> "*In the field of waste disposal processes, the application of 'simple' rules of allocation (for example allocation of resource consumption and emissions to individual waste fractions proportional to mass or calorific values) often leads to non-sensical partial results with a considerable effect of the overall result*" – Kremer *et al.* (1998: 47)

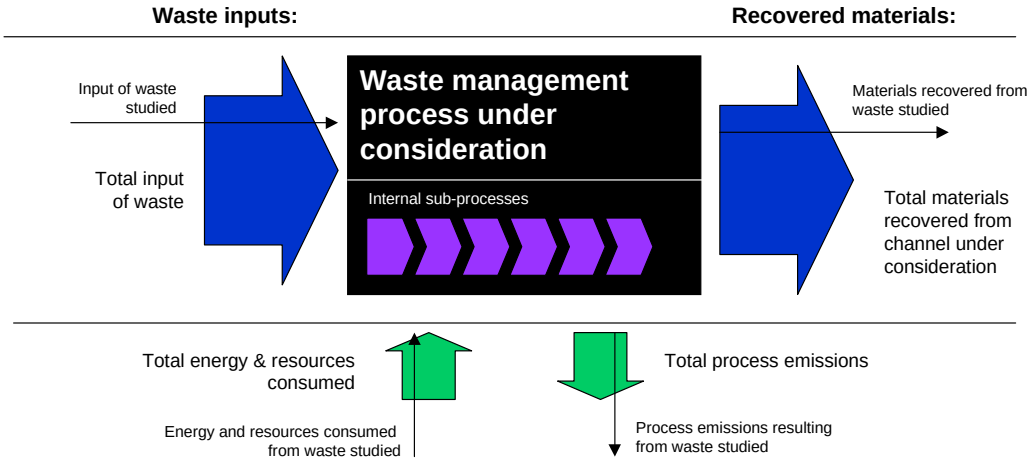
Table 5.7: Data sources used for building the life-cycle inventory

Process	Description	Data sources
Collection	Retail outlets	Process review and audit DOE (1994)
	Warehouse consolidation	Process review and audit Management and financial reports DOE (1994)
Processing	Product recycling and refurbishment	Process review and audit Management and financial reports BiFA (1997) Metals Bulletin Monthly (1996)
	Circuit board shredding	ICER (2000)
	Scrap consolidation	Process review and audit
Waste processing	Hazardous waste incineration	Process review and audit
	Energy recovery from plastics	Process review and audit BUWAL (1996)
	Landfilling	Actual charges quoted by service providers Yang (1993) SP (1998: 40-41) White *et al.* (1995: 271-301)
Reselling	Includes only delivery to resellers	Process review and audit See transportation
Production	Metals smelting	Process review and audit Legarth (1995) BUWAL (1996) Doka *et al.* (1996)
	Cardboard production	BUWAL (1996: b) Doka *et al.* (1996)
	Energy production	Doka *et al.*(1996) IEA (1995-1996)
Transportation	All modes	Process review and audit Doka *et al.* (1996) ProGIS (1999) Microsoft Autoroute Express (1995)

> "*…in some cases it may be correct to allocate the burdens on the basis of a simple physical quantity; however, the choice of allocation parameter must be based on the physical causation involved, and not chosen arbitrarily.*" – Azapagic and Clift (1999: 366)

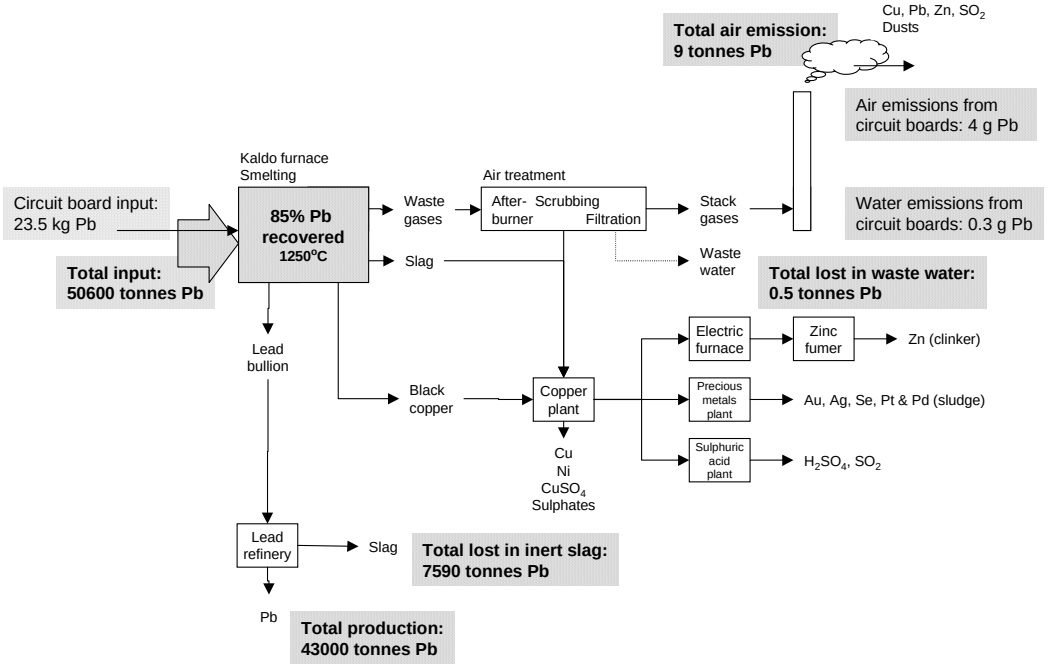
The environmental burdens of common or co-product processes can be more precisely allocated in proportion to the specific inputs of waste and materials (Kremer *et al*, 1998: 47; Azapagic and Clift, 1999: 366), as shown generically in Fig. 5.6 below.

Figure 5.6: The allocation of environmental burdens in waste management LCAs



Various co-product or common processes were used within the printer trade-in process. For example, printed circuit boards were smelted together with secondary ore concentrates and metallic catalysts to produce a variety of base, precious, and rare earth metals. The allocation of atmospheric lead emissions in proportion to the lead input from printed circuit boards during smelting is shown diagrammatically as an example in Fig. 5.7 below. The total annual lead emissions from precious metals smelting are 9 tonnes to the atmosphere and 0.5 tonnes in waste water, and 7,590 tonnes in inert slag. The total emissions of lead to the atmosphere and in waste-water from printed circuit board recycling was calculated as a proportion of the lead input to the smelter from printed circuit boards in relation to total lead input by mass.

Figure 5.7: Allocation of environmental burdens in printed circuit board smelting



Data provided in tonnes per year by Boliden smelter in Sweden (1995-2000).

In addition, although the printers received in the trade-in were disassembled separately, they were stored and sorted alongside redundant computer products from many other sources. Energy used in heating and lighting was allocated by the capacity of the disassembly facility utilised for the trade-in (in terms of available floor-space). Energy used in plastics shredding was calculated directly from process data.

Allocation of costs

Using MC, the costs of the printer trade-in were allocated according to their *avoidability*. Should activities related to the logistical channel under study cease, any cost that can be avoided is considered to be attributable (including if the cost is only partially avoidable). The allocation of costs by avoidability in MC is equivalent to the allocation of environmental burdens by *physical causality* in LCA (Azapagic and Clift, 2000: 36). According to Barret (1982: 18-25), the avoidability of a cost is related to its variability over time, its degree of divisibility, and its traceability to the logistics channel studied. Using these criteria, MC classifies costs as either short-run variable, semi-fixed, totally fixed, and non-attibutable:

- Short-run variable: *Traceable with respect to the mission statement of a logistics channel and fully divisible.*

  Expressed as unitary costs, such as the costs of product assembly per unit. For example, within the printer trade-in, the cost of waste disposal in landfill was a short-run variable cost, allocated on a cost per tonne basis.

- Semi-fixed: *Traceable with respect to the mission statement of a logistics channel, but only partially divisible.*

  Expressed on the basis of the activity, which if ceased, would result in the avoidance of that cost. For example, in this study transportation costs were semi-fixed in nature, and were not merely a direct function of mileage. This was because transportation costs were composed of a range of different costs and cost drivers, including the costs of vehicle hire, loading and unloading, fuel, and driver time. As a result, transport costs were allocated on a cost per trip basis, broken down by number of pallets for shared loads. Examples of other semi-fixed costs included management costs, which were unitised over different periods of time (cost per hour, day, man-month, or year), and warehouse facility costs that were allocated on the basis of occupancy.

- Totally fixed: *Traceable with respect to the mission statement of a logistics channel and indivisible: directly attributable*

  Expressed on a total cost basis, such as plant hire costs. The trade-in involved no totally fixed costs, due to a HP policy to establish EOLM processes that did not require fixed investment, and which could respond flexibly to changing process volumes.

- Non-attributable: *Non-traceable and unavoidable in respect of the mission statement of a logistics channel for the period under study.*

  An example of non-attributable costs in the printer trade-in was the cost of the senior management team within HP, including the UK board of directors. Due to separate internal accounting of these costs within HP, no basis of cost avoidance could be established in relation to printer trade-in activities.

The allocation of costs in the printer trade-in is summarised in Table 5.8 below. In the following section, the characterisation of the environmental burdens into environmental impact categories is discussed.

Table 5.8: The attribution of end-of-life costs by common End-of-Life Management activities

End-of-Life Management activities	**Totally variable**	**Semi-fixed**	**Totally fixed**	**Attribution factors**
All costs must be traceable with respect to missions	Divisible by units	Divisible by level of activity	Indivisible	
Management and administration	X	X		Total headcount allocated Man months / hours utilised Consultancy / agency rate
Transport		X		Number of collections Number of pallets collected Number of kg collected
Sorting	X	X		Man months / hours utilised Weight of materials received Number of products received
Storage		X		Number of pallets stored m^2 of warehouse utilised
Product dismantling	X	X		Man months / hours utilised Number of units dismantled by product type
Product refurbishment	X	X		Man months / hours utilised Number of units refurbished by product type and fault code
Materials processing	X			Weight of materials processed Type of materials processed
Waste disposal	X			Weight of materials disposed Type of materials disposed
Commissions		X		Percentage of sales revenue
Profit share		X		Percentage of net profit

5.4 Impact assessment and normalisation

The impact assessment and normalisation stage of LCA and LCC involved the calculation of the overall environmental impacts and net cost of the printer trade-in. To

determine the level of impact on the environment from the environmental burdens calculated in the life-cycle inventory and simplify interpretation (ISO, 1997: 8), *classification* and *characterisation* steps are explained in Section 5.4.1. The calculation of the net cost of the printer trade-in from cost and revenue data is described in Section 5.4.2. Finally, the normalisation of environmental impacts to allow the magnitude of impacts between categories and net cost to be compared is discussed in Section 5.4.3.

5.4.1 The characterisation of environmental impacts in the printer trade-in.

Methodologies for environmental impact assessment within LCA are at varying stages of development, and there are no commonly accepted methods for consistently and accurately calculating and weighting environmental inventory data and determining environmental impacts (ISO, 1997: 8; Cowell, 1998: 18). Previous LCA studies on WEEE have used a variety of different environmental impact categories to characterise environmental burdens. For example, in the Ecobalance (1999) study, the following categories were used:

- Waste hazardous (kg)
- Waste total (kg)
- Total Primary Energy (MJ)
- Air Acidification (g eq. H+)
- Eutrophication (water)
- Critical Volumes[31] - Air (m3)
- Critcial Volumes - Water (litre)
- Depletion of non renewable resoures
- Greenhouse effect (direct, 20 years)
- Depletion of the ozone layer (high)

In contrast, a study conducted by Brickman *et al* (1998) on the lifecycle of televisions used a different selection of similar impact categories (for which the units used were not given):

- Global Warming Potential (Greenhouse effect)
- Ozone Depletion Potential
- Natural Resources Depletion Potential
- Atmospheric Acidification Potential
- Nutrification (Eutrophication) Potential
- Total Primary Energy
- Particulate Matter (air)
- Carbon monoxide (air)
- Total Hydrocarbons (air)
- Total Metals (air)
- Total Suspended Solids (water)
- Total Metals (water)
- Total Hazardous Waste

[31] The Critical Volumes method measures toxicity based on the total volume of air or water required to dilute toxic emissions to concentrations in which they comply with emissions control laws.

- Total Non-Hazardous Waste

Most notably, the potential for photochemical oxidant formation was excluded from these studies, with no justification given in either case. Other studies have opted for single indicative measurements of environmental impact, such as energy use by McClaren (1999) and the eco-indicator score by Guido *et al.* (1998).

Within this study, characterisation methods were selected on the basis of reviews and recommendations in the LCA literature by Cowell (1998: 19-39, 224-245), Baisnée *et al.* (1994: 23-28), Finnveden (1994) and available within the Ecobilan TEAM software tool (EcoBilan, 1998). The characterisation methods used are described further below.

- Depletion of non renewable resources

  There are three methods available for classifying resource depletion potential, based on (in order of sophistication):

  1. Total size of resource reserve
  2. Total size of resource reserve in and rates of resource depletion
  3. Total size of resource reserve, rates of resource depletion, and resource scarcity

  As the third method was not available within the Ecobalance TEAM software, the second method was used based on the total economic reserve size * yield (EcoBilan, 1998: Finnveden, 1994: 61-65). Results are given as a reciprocal measure of the number of years current reserves are expected to last (yr^{-1}). As such, reserve depletion is considered in terms of rate of depletion and not resource scarcity. The printer trade-in study focussed solely on non-renewable resource depletion.

- Global Warming Potential (GWP)

  GWPs are measured in grams (g) equivalent of carbon dioxide, and have been calculated by the International Panel on Climate Change (IPCC) for a number of greenhouse gases for 20, 100, and 500 time frames (Houghton, 1996). This LCA study used these timeframes to characterise the GWP of the printer trade-in, using IPCC data available within Ecobilan (1998).

- Stratospheric Ozone Depletion Potential (ODPs)

  Similar to GWPs described above, ODPs have been calculated by the World Metereological Office (WMO) for a range of Ozone Depleting substances in g equivalent of CFC-11. However, these potentials exclude the complex effects of substances such as methane, nitrous oxide, carbon monoxide, which are not yet fully understood (Cowell, 1998: 31). For evaluation of the printer trade-in, both high and low ODPs were investigated for an indication of minimum and maximum effect, based on the WMO data within Ecobilan (1998).

- Acidification

  Acidification is calculated in g equivalent of H^+. To account for both direct precipitation and acidic leaching through groundwater, both minimum and maximum values should be used. However, only data for air acidification was available within

the Ecobalance TEAM software. Therefore, results on acidification represent the "minimum" scenario, as the effects of indirect acidification are not considered. Air Acidification was characterised based on the "ETH" method (ETH, 1996) within EcoBilan (1998).

- Photochemical oxidant formation potential

  Photochemical oxidant formation potentials have been calculated for a range of Volatile Organic Carbons (VOCs) based on increased ozone concentration on a g. equivalent basis with ethylene. As the level of impact will depend upon photochemical oxidant formation potential values used, the background concentrations of nitrogen oxides, and the time period used to calculate ozone formation, minimum and maximum values have been used, based on WMO methods available within EcoBilan (1998).

- Eutrophication

  Impact assessment factors for eutrophication are quantified in g. equivalent of phosphorous from atmospheric and aquatic emissions, including the effect of COD (Chemical Oxygen Demand). As there is likely to be a nutrient limiting factor to organic growth in eutrophic ecosytems, Cowell (1998, 35-36) suggests that classification values based on N and P limited environments should be used. However, only a total measure was available within the Ecobance TEAM software using the "CML" method (Heijungs, 1992a; Heijungs, 1992b). Therefore, the results for eutrophication represent the total potential for eutrophication of the printer trade-in channel, which will be limited by the availability of N and P upon decomposition.

- Human and eco-toxicity

  The lack of data and consideration of human and eco-toxicological environmental impacts appears to be common in LCA studies on waste management, as Finnveden and Ekvall (1998) have noted from an evaluation of LCA studies on the recycling and disposal of waste paper. There are a variety of approaches to characterising toxicity in terms of effects on eco-systems and human health. In summary:

  > *The less sophisticated and earlier methods are based only on the toxicity of the substance in question, namely the Critical Volumes approach as used in the Ecobalance (1999) study described above.*
  >
  > *More advanced methods include factors such as the fate of the substance in question, the influence of background conditions, and geographical and time issues. These methods are based on environmental modelling and fate analysis (such as the USES method) and empirical evaluation and verification (such as the CST method).*

  Due to the high degree of uncertainty with toxicity assessment methods, Cowell (1999: 244) recommends that both empirical and mathematical modeling methods should be used in the evaluation of toxicity effects. For evaluation of the printer trade-in the "USES 1.0" method (Guinée *et al.*, 1996) was used in combination with the "CST" method (Jolliet and Crettaz, 1996; Jolliet, 1996; Jolliet, 1994: 133-142) as a means of validation and comparison between results. Due to the high degree of

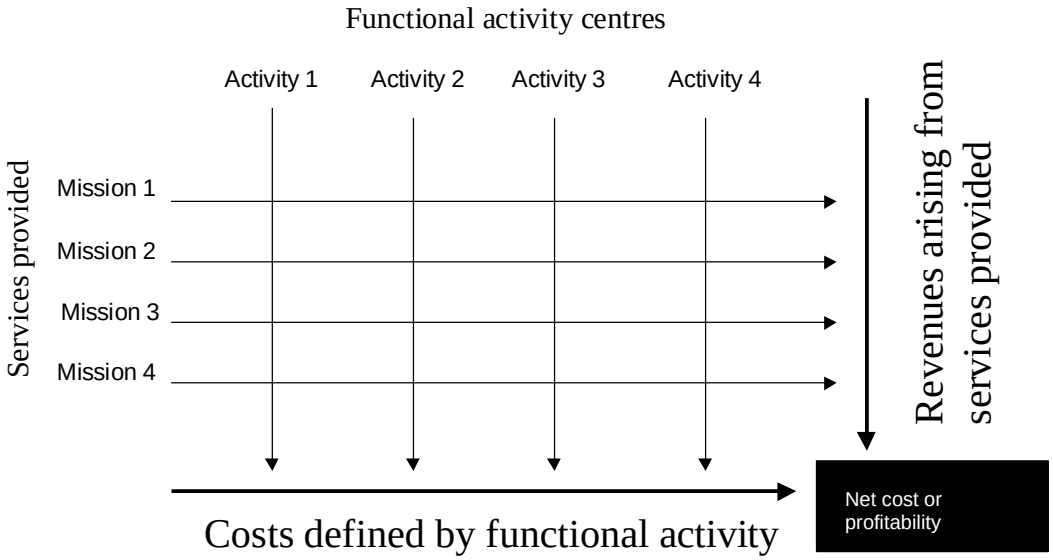
uncertainty in scientific understanding in this area, results should at best only be considered as indicative of toxicity potential.

5.4.2 Determination of net costs of the printer trade-in.

The net cost of the printer trade-in was calculated from the sum of its associated revenues, minus the sum of its attributable short-run variable, semi-fixed, and fixed costs. HP paid the remaining net cost of the trade-in.

The final stage in MC is to tabulate results of each logistics channel under review, such that they can be contrasted and compared together. This stage was not used in the printer trade-in, as only one process was studied. This tabulation also allows net revenues and net costs to be calculated, and the overall commercial viability of each logistics channel to be compared. The completion of an MC calculation allows analysis of the costs of each stage or "*function*" or within a logistics channel and also the costs of different logistics channels to be cross-compared (as shown in Fig. 5.8 below).

Figure 5.8: Balancing costs and revenues in Mission Costing



5.4.3 Normalisation of environmental impacts and costs.

Finally, the "*100% landfilling*" scenario was used to compare and normalise the recycling and recovery scenarios. This ensured that comparisons were made on a functionally equivalent basis, which is their relative environmental performance in comparison to landfill. It was not necessary to conduct a valuation of environmental impacts to define the likely effectiveness of the proposed WEEE Directive, as the results presented from the printer trade-in (in Section 6) were sufficient for analysing the original objectives set by the EC for the proposed WEEE Directive. The use of different approaches to valuation is discussed briefly in Section 7.4.

The environmental impacts and costs of waste electronic products.

5.5 Improvement assessment

For the valuation and improvement assessment stage of LCA and LCC, the study results are analysed and interpreted, and conclusions drawn relevant to the goals of the study. Where cross-comparisons were made between different impact characterisation results, this is on the basis of the relative magnitudes of impact on society or elsewhere in the life-cycle.

Finally, if the results of the printer trade-in LCA and LCC study are to be used in the policy development, ISO 14040 guidelines recommend that they are subject to an independent peer review process. The veracity of the study presented will be subject to independent academic review as a submission to the EngD thesis. The analysis of results draws relevant general conclusions on areas of policy development that should be investigated further by future research.

5.6 Summary

This section has described in detail the LCA and LCC methods used in evaluating the printer trade-in. This included the study goal and scope, LCA and LCC inventory calculation, impact characterisation and normalisation, and valuation and improvement assessment. The detailed results of the printer trade-in in terms of both environmental impacts and costs in Section 6, and discussed in Section 7. Finally, the study's conclusions are presented in Section 8.

6. Results

The results of the LCA and LCC investigation of the printer trade-in (described in the previous section) are presented and analysed below. This includes:

- A stage-by-stage analysis of the environmental impacts and costs of the printer trade-in.
- A comparison of the environmental impacts and costs to producers of different recycling and recovery scenarios in relation to landfilling.
- The results of a sensitivity analysis.
- An analysis of the effects of price discounting on EOLM costs under Producer Responsibility.

The results are analysed both in terms of the likely effectiveness of the proposed WEEE Directive and in terms of opportunities to minimise the costs and environmental impacts in the management of WEEE. The implications of these results and of the level of data quality attained are discussed in the following section (Section 7).

6.1 Analysis of environmental impacts using LCA

LCA results showing the environmental impacts of the printer trade-in are presented and evaluated below. This includes an analysis of impacts resulting from different stages of the printer trade-in (in Section 6.1.1), a comparison of the different printer trade-in scenarios (in Section 6.1.2), and the results of a sensitivity analysis (in Section 6.1.3).

6.1.1 LCA stage by stage comparison

The distribution of environmental impacts of the printer trade-in ("*plastics and PCBs recovered*" scenario)[1] varies over different stages of the gate-to-grave life cycle (as shown in Table 6.1 overleaf). Results for the collection, processing, and materials production stages are evaluated below. The environmental inventory data used in the analysis can be found in Appendix 3.

Collection

In relation to other the stages of the printer trade-in, collection only accounts for a low proportion of overall environmental impacts. Collection accounts for only:

- 11% of the potential for eutrophication, caused mainly by the release of over 8kg of nitrogen oxides to the atmosphere from transportation and electricity generation processes.
- 4-5% of photochemical oxidant formation potential, resulting from the release of 0.8kg of hydrocarbons to the atmosphere (mainly from transportation).
- 4% of the potential for air acidification, resulting mainly from the release of 8kg of nitrogen oxides to the atmosphere (as above for eutrophication).

[1] This scenario is used for this stage-by-stage comparison as it had the highest level of recycling and recovery, and represented the actual printer trade-in conducted.

- 3-4% of the potential for terrestrial ecotoxicity from the release of 28g of zinc to the atmosphere from energy production processes.
- 2% of global warming potential (from IPPC values at 20, 100, and 500 year timeframes), resulting from the release of 840kg of CO_2 to the atmosphere. Transportation accounts for around 70% of these emissions, the remaining occurring as a result of power generation for heating and lighting in warehousing facilities.

Collection accounts for less than 1% of the other environmental impact categories investigated (see Table 6.1 below for a list of these categories).

Table 6.1: Stage-by-stage comparison of printer trade-in environmental impacts ("*plastics and PCBs recovered*" scenario)

Environmental impact category	Units	% impact from collection	% impact from processing	% impact from materials production	% impact from management and administration	Total impact
CST-Aquatic Eco-toxicity	%eq. Zn water	0%	95%	5%	-	3.1E+04
CST-Human Toxicity	% eq. Pb air	0%	60%	39%	-	1.0E+07
CST-Terrestrial Eco-toxicity	% eq. Zn air	5%	33%	63%	-	1.4E+03
EB(R*Y)-Depletion of non renewable resources	% yr-1	1%	77%	21%	-	9.6E+02
ETH-Air Acidification	% g eq. H+	4%	22%	74%	-	4.6E+03
CML-Eutrophication	% g eq. PO4	11%	28%	60%	-	9.4E+03
IPCC-Greenhouse effect (direct, 100 years)	% g eq. CO2	2%	66%	32%	-	3.9E+07
IPCC-Greenhouse effect (direct, 20 years)	% g eq. CO2	2%	65%	33%	-	4.1E+07
IPCC-Greenhouse effect (direct, 500 years)	% g eq. CO2	2%	66%	31%	-	3.8E+07
USES 1.0-Aquatic Ecotoxicity	% eq. 1-4-dichlorobenzene	0%	92%	8%	-	1.4E+05
USES 1.0-Human Toxicity	% eq. 1-4-dichlorobenzene	0%	14%	86%	-	2.9E+08
USES 1.0-Terrestrial Ecotoxicity	% eq. 1-4-dichlorobenzene	3%	47%	50%	-	2.0E+09
WMO-Depletion of the ozone layer (high) ϕ	% g eq. CFC-11	0%	8%	92%	-	2.8E+00
WMO-Depletion of the ozone layer (low) ϕ	% g eq. CFC-11	0%	8%	92%	-	1.6E+00
WMO-Photochemical oxidant formation (high) φ	% g eq. ethylene	5%	50%	45%	-	1.5E+04
WMO-Photochemical oxidant formation (low) φ	% g eq. ethylene	4%	66%	30%	-	4.9E+03

ϕ High and low values based on minimum and maximum possible values from World Meterological Organisation data included in the EcoBilan TEAM software tool (EcoBilan, 1998).
φ High and low values based on minimum and maximum possible values from World Meterological Organisation data included in the EcoBilan TEAM software tool (EcoBilan, 1998), assumed background concentrations of nitrogen oxides, the time period used to calculate ozone formation.

Processing

The processing stage accounts for a large proportion of the environmental impacts of the printer trade-in. These impacts are caused mainly by the consumption of electricity and natural gas in warehousing facilities, the shredding and granulation of plastics and printed circuit boards, and the incineration of plastics for energy recovery:

- Based on the CST and USES methods, processing is responsible for between:
  - 92% to 95% of the aquatic ecotoxicity potential
  - 33% to 47% of the terrestrial ecotoxicity potential
  - 14% to 60% of the human toxicity potential

  This is caused mainly by emissions of mercury, cadmium, and zinc to water, air, and land from incineration. For example, around 6g of cadmium is released in wastewater from the incineration of plastics.

- Many of the foreground and background processes utilised during processing involve combustion of non-renewable resources, including electricity generation and heating, transportation, and incineration. Consequently, the processing stage of the printer trade-in accounts for:
  - 77% of the potential for depletion of non-renewable resources.
  - 65-66% of the global warming potential.
  - Between 50% and 66% of the overall potential for photochemical oxidant formation based on low and high cases.

For each of the remaining environmental impact categories investigated (as shown in Table 6.1 above) processing accounts for less than 30% of the total impact of the printer trade-in.

Materials production

During materials production, recovered steel, aluminium, and metals within printed circuit boards are smelted into raw materials. This stage also accounts for a large proportion of the environmental impacts of the printer trade-in. Overall, materials production is accountable for:

- 92% of the potential for ozone depletion, caused by the release of 0.13g of Halon during the smelting of Copper and Steel

- Based on the CST and USES methods, between:
  - 39% and 86% of the potential for human toxicity
  - 50% and 63% of the potential for terrestrial ecotoxicity

  This is mostly due to metal emissions to the atmosphere (63g of lead, 24g of zinc, 2g of nickel, and 1g of chromium) during the smelting of steel recovered from the traded-in printers.

- 74% of the potential for air acidification, due to the release of 80kg of SO_2 and 29kg of NO_2 to the atmosphere during the smelting of recovered steel and copper.

- 60% of the eutrophication potential, caused mainly by the smelting of steel which results in 25kg of NO_2 being released to the atmosphere (around a quarter of the atmospheric nitrogen dioxide emissions calculated for the trade-in).

- Between 30% to 45% the potential for photochemical oxidant formation, due to the release of 6kg of hydrocarbons to the atmosphere during the smelting of recovered and steel and copper.

For the remaining categories, the materials production stage of the printer trade-in accounts for only one third or less of environmental impacts (as can be seen in Table 6.1 above).

In summary, collection only accounts for 0% to 11% of the total environmental impacts of the printer trade-in, depending on impact category. Transportation and energy use within collection facilities are main cause of environmental impacts at this stage. The environmental impacts of processing and material production predominate. Within the processing step the incineration of plastics and energy consumption accounts for a high proportion of the environmental impacts. In contrast, steel and copper smelting processes account for most of the environmental impacts during materials production.

(*please see continuation of this section overleaf*)

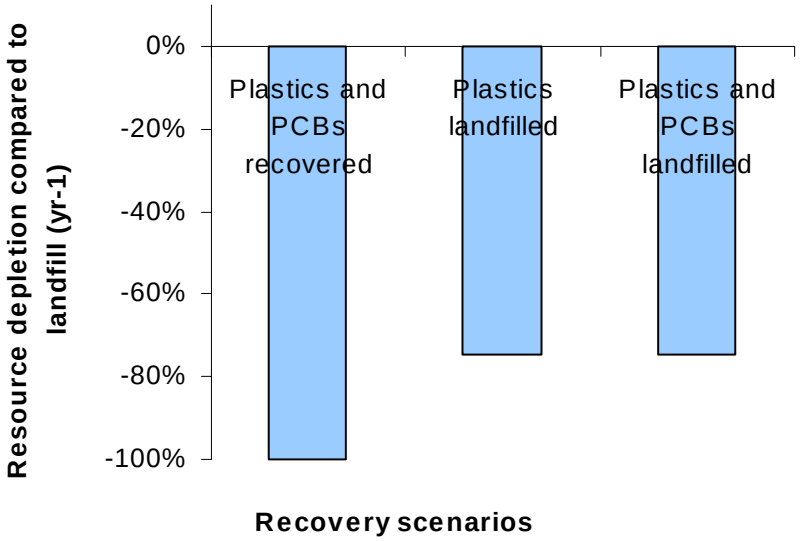
6.1.2 Comparison between EOLM scenarios

This section examines three different recovery and recycling scenarios against the option to discard all printers collected in landfill (as explained in Section 5.2.1).

Non-renewable resource depletion

The non-renewable resource depletion potential of the "*plastics and PCBs recovered*" scenario is almost 100% lower than "*100% landfilling*" (as shown in Fig. 6.4). This corresponds to a resource depletion potential for "*100% landfilling*" of over 2 million yr^{-1} and for "*plastics and PCBs recovered*" of only 955 yr^{-1}. For other scenarios the reductions in resource depletion achieved are less substantial compared to "*100% landfilling*" at around 75%. As the classification method used (available reserves by yield) does not account for resource scarcity, the resource depletion potentials of scenarios in which printed circuit boards (which contain several scarce metals) are landfilled[2] are probably understated.

Figure 6.4: Depletion of non renewable resources



0% = 2,080,000 yr^{-1}

Where yr^{-1} is a reciprocal measure of the number of years currently known reserves are expected to last.

For the "*plastics and PCBs recovered*" scenario, the proportion of resource depletion resulting from the consumption of non-renewable energy resources is 72%. This 72% can be substituted with energy from alternative sources, such as wind and energy. In comparison, resource depletion caused by consumption of non-renewable energy resources with "*100% landfilling*" is much lower at only 2%.

For printer products, whether substitutable energy-related resources are considered or not, recycling and recovery could result in substantial reductions in non-renewable resource depletion in comparison to landfilling.

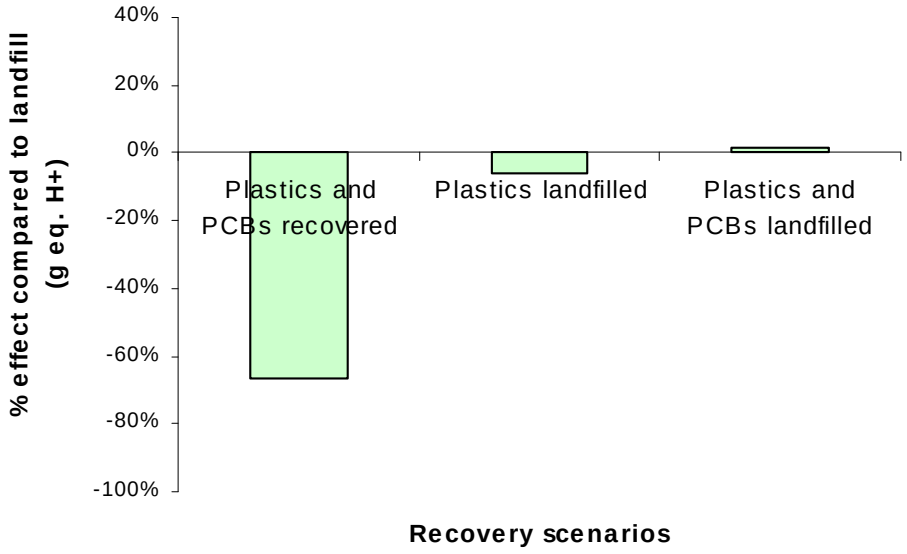
[2] "*Plastics and PCBs landfilled*" and "*100% landfilling*".

Air acidification

The "*plastics and PCBs recovered*" scenario results in around 65% less air acidification than "*100% landfilling*" (as shown in Fig. 6.5). This is mainly due to the substitution of energy derived from sulphur containing fossil fuels with energy recovered from the incineration of plastics, as air acidification increases by almost 60% when plastics are landfilled and not recovered. If printed circuit boards are also landfilled and not recycled, air acidification increases to around 2% above the "*100% landfilling*" scenario.

The recovery and recycling of printers can reduce the potential for air acidification relative to disposal in landfill substantially, where it includes energy recovery from plastics.

Figure 6.5: Air Acidification



0% = 14 g eq. H^+

Photochemical oxidant formation

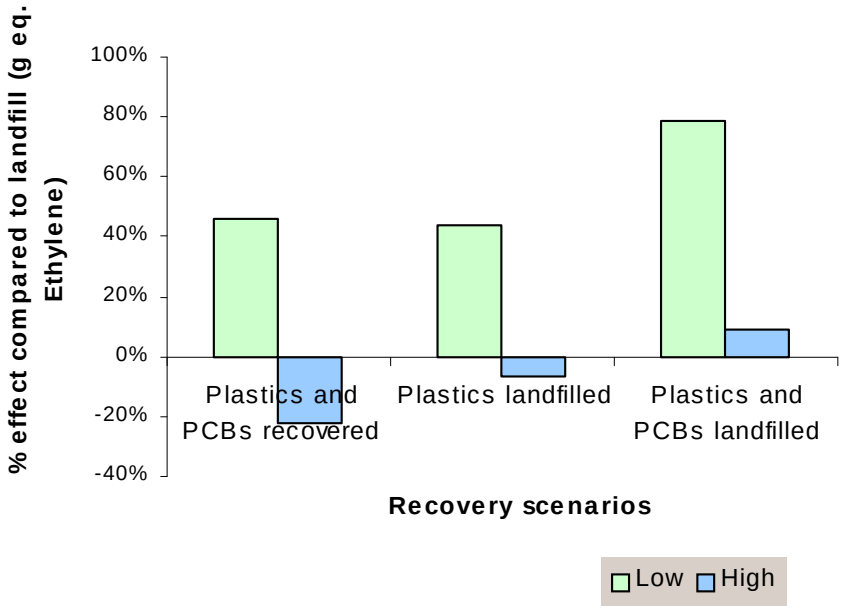
The recycling and recovery of materials from printer products does not result in a net benefit for photochemical oxidant formation in all cases compared to "*100% landfilling*" (as shown in Fig. 6.6):

- For the "*plastics and PCBs recovered*" and the "*plastics landfilled*" scenarios, results for photochemical oxidant formation vary widely, ranging from 10%-20% lower to 40% higher than "*100% landfilling*" based on high and low cases. The "*plastics and PCBs recovered*" scenario has a photochemical oxidant formation potential of 5kg to 15kg equivalent of ethylene, compared to "*100% landfilling*" at 3kg to 20kg equivalent.

- In the "*plastics and PCBs landfilled*" scenario, the potential for photochemical oxidant formation is 10% to 80% worse than "*100% landfilling*" based on low and high cases.

This corresponds to an increase in photochemical oxidant formation potential of 2 to 3kg equivalent of ethylene over landfilling (with 3kg to 20kg equivalent).

Figure 6.6: Photochemical oxidant formation



For "low", 0% = 20 g eq. ethylene, for "high", 0% = 3 g eq. ethylene.
High and low values based on minimum and maximum possible values from World Meterological Organisation data included in the EcoBilan TEAM software tool (EcoBilan, 1998), assumed background concentrations of nitrogen oxides, the time period used to calculate ozone formation.

Depending on the emission conditions and characterisation values used, the recovery and recycling of printers can substantially increase the potential for photochemical oxidant formation when compared to landfilling. This is largely due to the release of 6kg of Volatile Organic Compounds (VOCs) to the atmosphere from the cleaning of printer casings for refurbishment. The use of VOC-free cleaning agents could reduce the photochemical oxidant formation potential of the "*printers and PCBs recovered*" scenario by 35% to 60% (based on high and low cases). In this case, the photochemical oxidant formation potential of recycling and recovery scenarios would become favourable in relation to "*100% landfilling*".

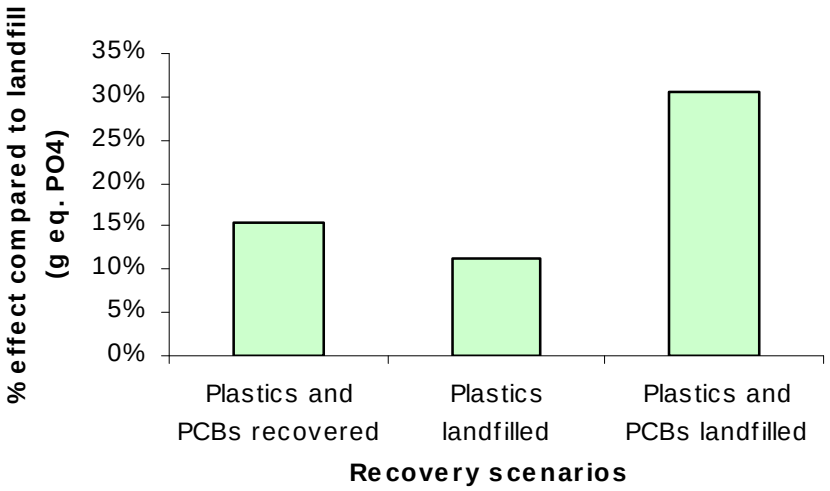
Eutrophication

For all scenarios, printer recycling and recovery results in a net increase in the potential for eutrophication in relation to "*100% landfilling*" (as shown in Fig. 6.7). For the "*plastics and PCBs recovered*" scenario, the potential for eutrophication is around 15% worse, whereas the "*plastics landfilled*" scenario is 10% worse, and the "*plastics and PCBs landfilled*" scenario 30% worse.

The increased potential for eutrophication with recovery and recycling is due to emissions of nitrogen oxides from steel smelting and the increased requirement for transportation over landfilling. The scale of operations required for electronics recycling means materials have to be transported long distances from local collection points, via

intermediate processing points, to international materials production facilities before they are eventually recycled.
Reductions in eutrophication potential could be achieved by landfilling and not recycling steel and copper. However, this would result in parallel increases in the consumption of non-renewable resources, and ecotoxicity. The recycling of steel and copper resulted in net reductions in environmental impacts for these impact categories of around 40% to 80% compared to landfilling (see relevant analyses above and below). Additional reductions in eutrophication would have to address the means of transportation used, for example, by using more fuel-efficient engines or by using rail transportation. Opportunities for a reduction in the overall distance travelled may also be possible.

Figure 6.7: Eutrophication



0% = 8 g eq. P

Global warming potential

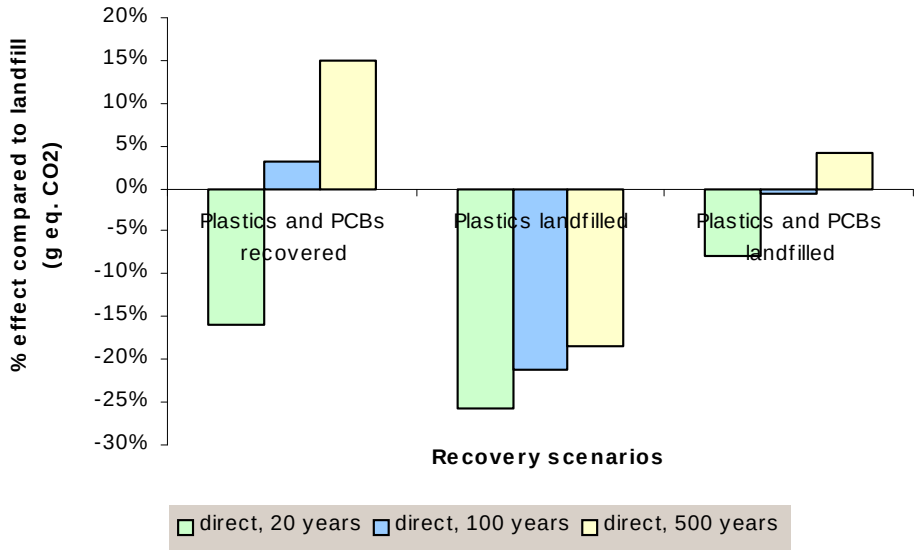
The potential effects of global warming vary over different time scales (as shown in Fig. 6.8). Reductions in Global Warming Potential over a 20 year period are likely to be assigned a higher priority than over a 100 to 500 year period, as priorities are defined by government policies generally targeted at the current generation. The aim of sustainable development is to ensure that future generations are not disadvantaged for the benefit of current generations. It is therefore relevant to consider the short *and* long-term effects of global warming:

- All recovery scenarios have less global warming potential than "*100% landfilling*" over a 20-year time frame (from 8% to 26% lower). This corresponds to a 4 to 13 reduction in tonnes equivalent of CO_2.

- Only in the "*plastics landfilled*" scenario is there an overall benefit in terms of global warming over 20, 100, and 500 year time frames, which have between 18% and 26% less global warming potential than "*100% landfilling*". This corresponds to a reduction

in the summed global warming potential[3] of this scenario of 27 tonnes equivalent of CO_2 compared to 121 tonnes from 100% landfilling.

Figure 6.8: Global warming potential



For "20 years", 0% = 49 t eq. CO_2
For "100 years", 0% = 38 t eq. CO_2
For "500 years", 0% = 33 t eq. CO_2

- For the "*plastics and PCBs recovered*" and the "*plastics and PCBs landfilled*" scenarios, global warming potential is reduced over a 20-year time frame by 16% and 8% respectively (corresponding to a 8 and 4 tonnes equivalent reduction of CO_2 compared to total emissions of "*100% landfilling*" at 49 tonnes). Over a 500-year timeframe the results of these scenarios are 15% and 4% worse than landfilling. This corresponds to a 5 and 1 tonne increase above 33 tonnes of CO_2 equivalent from "*100% landfilling*". Over a 100 year time frame, results for these scenarios are similar to "*100% landfilling*", with a 3% increase and 1% reduction in global warming potential respectively.

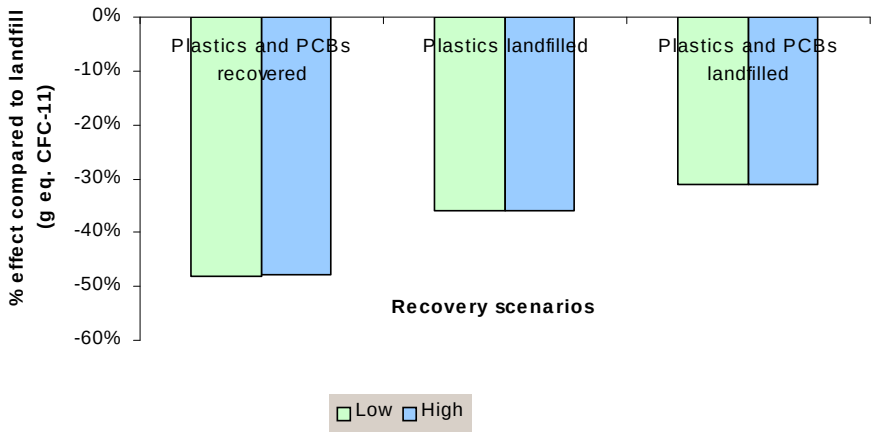
In terms of global warming potential, the best approach would be not to recover energy from plastics incineration (as in the "*plastics landfilled*" scenario). Electricity generation in the UK produces only 172g of CO_2 per MJ, compared to 293g of CO_2 per MJ from the combustion of mixed plastics[4] in energy recovery facilities (BUWAL, 1996: Doka *et al.*, 1996). The recycling of PCBs is favourable in comparison to production from virgin resources due to emissions of fewer greenhouse gases. For other recovery scenarios, the potential for global warming is likely to be lower compared to "*100% landfilling*" over the next 20 years, but higher over a longer period.

[3] Summed over 20, 100, and 500 year timeframes
[4] Including equal proportions of polythene, poly-vinyl chloride, polypropene, and polystyrene.

Ozone depletion potential

All of the recovery and recycling scenarios have a lower potential for ozone depletion than "*100% landfilling*" (as can be seen in Fig.6.9 below), from almost 50% lower for the "*plastics and PCBs recovered*" scenario to around 35% lower for "*plastics and PCBs landfilled*". However, this comparison is based on a low overall impact of "*100% landfilling*" of 3g to 5g equivalent of CFC-11 based on low and high cases (explained further below). The release of ozone depleting gases arises from background metals production processes. For example, in the "*plastics and PCBs recovered*" scenario, just under 92% of ozone depleting substances were emitted during the recycling of scrap steel.

Figure 6.9: Depletion of the ozone layer



For "low", 0% = 3 g eq. CFC-11
For "high", 0% = 5 g eq. CFC-11
High and low values based on minimum and maximum possible values from World Meterological Organisation data included in the EcoBilan TEAM software tool (EcoBilan, 1998).

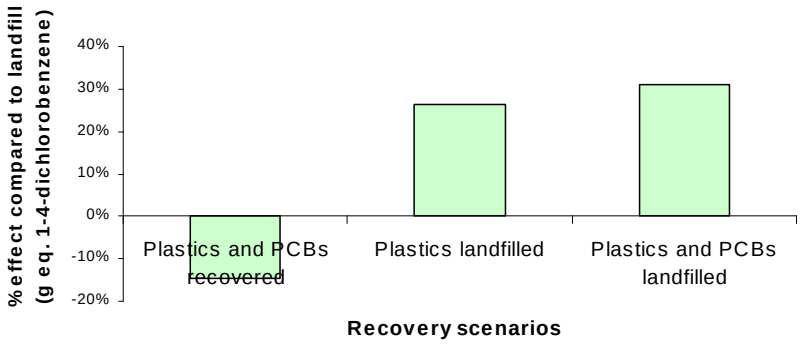
Although ozone depletion potential is lower with increased materials recovery and recycling. This is not considered a major environmental impact in any scenario due to the relatively low level of impact. For example, in 1991 it was estimated that around 1,100 tonnes of CFCs were released to the atmosphere from the recycling of refrigerators and freezers in the UK (Poll, 1993: 27). At present, around 345,000 tonnes of such products are recycled each year in the UK (ICER, 2000: 28). Based on 1991 results, without adequate treatment the recycling of refrigerators could have 20-40 times greater potential for CFC emissions by mass recycled than the printers in the "*plastics and PCBs recovered*" scenario.

Human toxicity

In the "*plastics and PCBs landfilled*" and "*plastics landfilled*" scenarios, the potential for human toxicity increases in relation to "*100% landfilling*" by 5% to 31% based on the CST and USES methods (as shown in Figs. 6.10 and 6.11). With the "*plastics and PCBs recovered*" scenario, results based on the USES method (which models toxicity effects mathematically) suggest that human toxicity is reduced by 15%. In comparison, the CST method (which models toxicity effects using empirically derived data) suggests the opposite with increases in human toxicity of 30%.

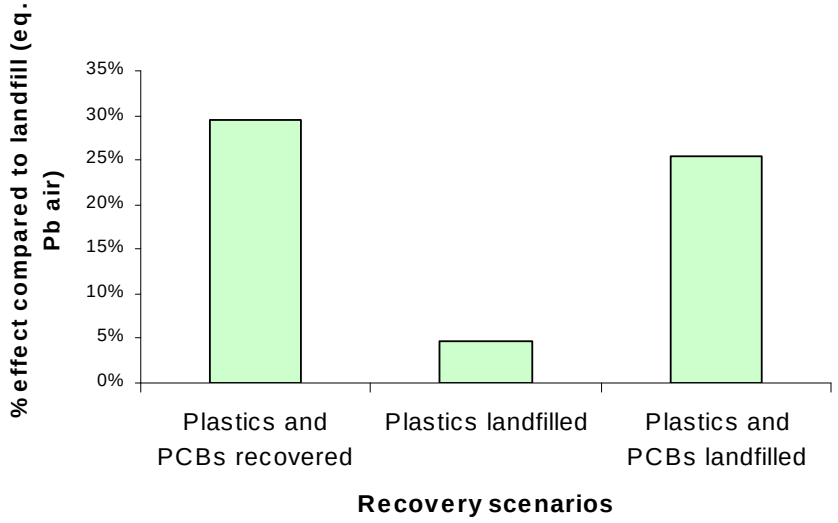
The potential for human toxicity in the recycling and recovery scenarios is attributable mainly to metallic emissions from metals smelting and the incineration of plastics. Differences in results between methods are due to different weightings for the toxicity of atmospheric lead emissions. Atmospheric lead emissions calculated using the CST method in the "*plastics and PCBs recovered*" scenario account for 36% of the potential human toxicity of the printer trade-in, compared to less than 0.1% using the USES method. In the "*100% landfilling*" scenario, toxicity effects are attributable to the leaching of metals from printed circuit boards.

Figure 6.10: Human toxicity (USES 1.0)



0% = 7 E+06 eq. 1-4-dichlorobenzene

Figure 6.11: Human toxicity (CST)



0% = 4 E+05 eq. Pb air Eco-toxicity

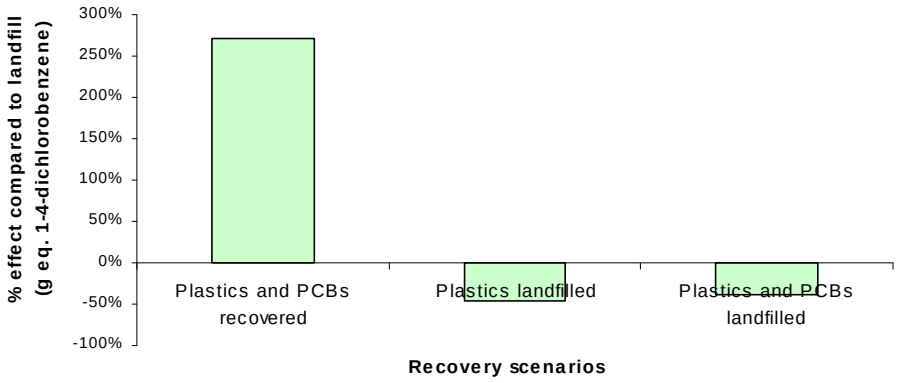
Human toxicity effects are different depending on the specific components and materials recovered from WEEE, and do not vary in proportion recycling rate between scenarios. In 5 out of the 6 analyses conducted, the potential for human exposure to toxic metals was higher than with landfilling.

Ecotoxicity

The potential ecotoxicity of the printer trade-in is evaluated below using both USES and CST methods to determine both aquatic and terrestrial toxicity for each scenario (as shown in Figs. 6.12 to 6.15).

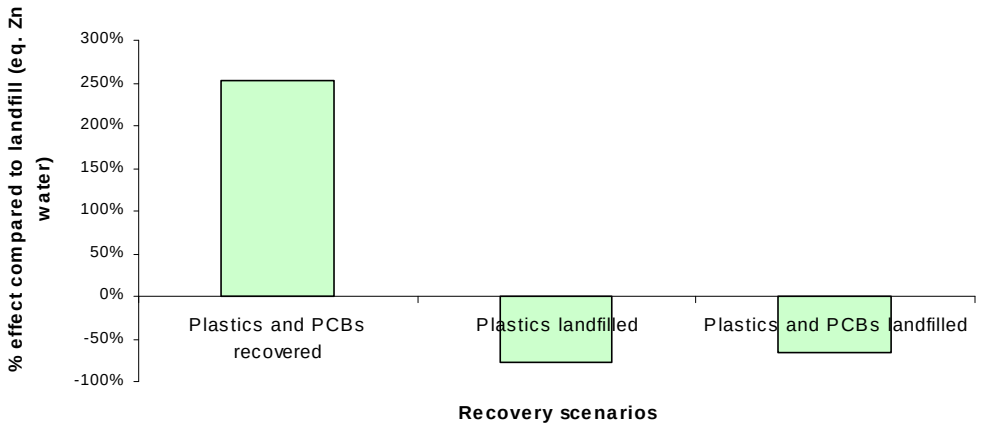
The "*plastics and PCBs recovered*" scenario has the greatest potential to cause aquatic toxicity (see Figs. 6.12 and 6.13) at around 250% to 270% more than that of "*100% landfilling*". This is largely due to the precipitation of atmospheric emissions and aqueous emissions from gas scrubbing during the incineration of plastics for energy recovery. For the "*plastics landfilled*" and "*plastics and PCBs landfilled*" scenarios, the potential for aquatic toxicity is between 40% and 80% less than that of "*100% landfilling*" using both USES and CST methods.

Figure 6.12: Aquatic ecotoxicity (USES 1.0)



0% = 3 E+04 eq. 1-4-dichlorobenzene

Figure 6.13: Aquatic eco-toxicity (CST)

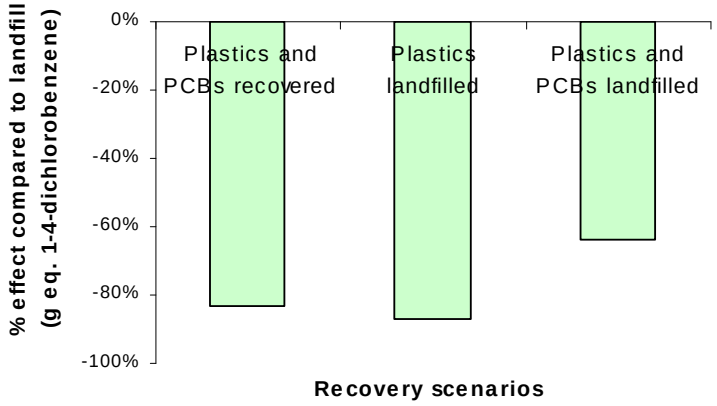


0% = 7 E+03 eq. Zn water

For all recovery and recycling scenarios, the potential for terrestrial ecotoxicity is from 60% to 87% lower than that of "*100% landfilling*" using both USES and CST characterisation methods (as shown in Figs. 6.14 and 6.15). This is due to the leaching of metals from printed circuit boards contained in printers in landfill. Thus the introduction of the WEEE Directive is likely to result in substantial reductions in the potential for terrestrial ecotoxicity.

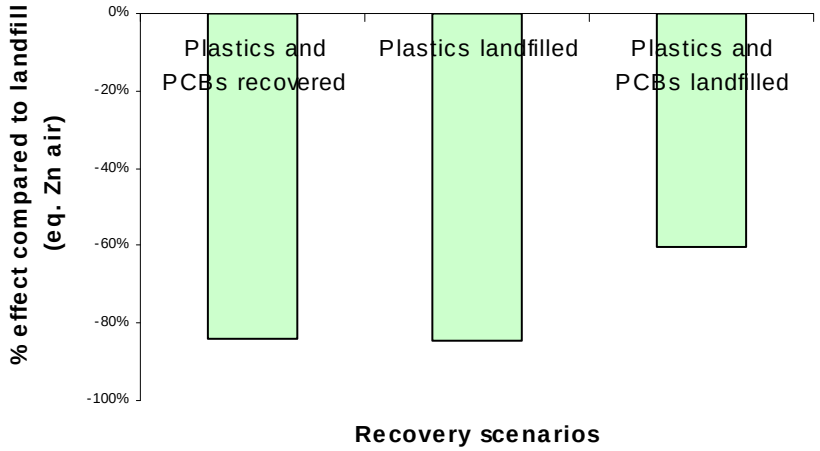
In terms of ecotoxicity, the "*plastics landfilled*" scenario appears to be the better option compared to "*100% landfilling*".

Figure 6.14: Terrestrial eco-toxicity (USES 1.0)



0% = 4 E+09 eq. 1-4-dichlorobenzene

Figure 6.15: Terrestrial eco-toxicity (CST)



0% = 1 E+03 eq. Zn air

Overall comparison of environmental impacts

For comparison, all the results presented above are shown in Fig. 6.16 overleaf. Based on these results, a ranking of each scenario is presented in Table 6.2 below. These results show clearly that increased recovery and recycling does not necessarily lead to reductions in environmental impact. The "*plastics and PCBs recovered*" scenario has the highest recovery and recycling rate at 99%, but has the lowest level of environmental impact in only 6 out of the 16 impact assessment results. In contrast, "*100% landfilling*", with a recovery and recycling rate of 0%, has the highest level of impact also in only 5 out of 16 impact assessment results. Conversely the "*100% landfilling*" scenario actually has the lowest level of impact in 3 out of the 16 results, and the "*plastics and PCBs recovered*" scenario has the highest level of impact in 5 out of 16 results.

Differences in the environmental impacts between scenarios were related to the specific materials and components recovered or recycled, rather than the rate of recycling by mass. The merits of each scenario are compared further in Section 7.3 along with implications for policy-makers in Section 7.5.

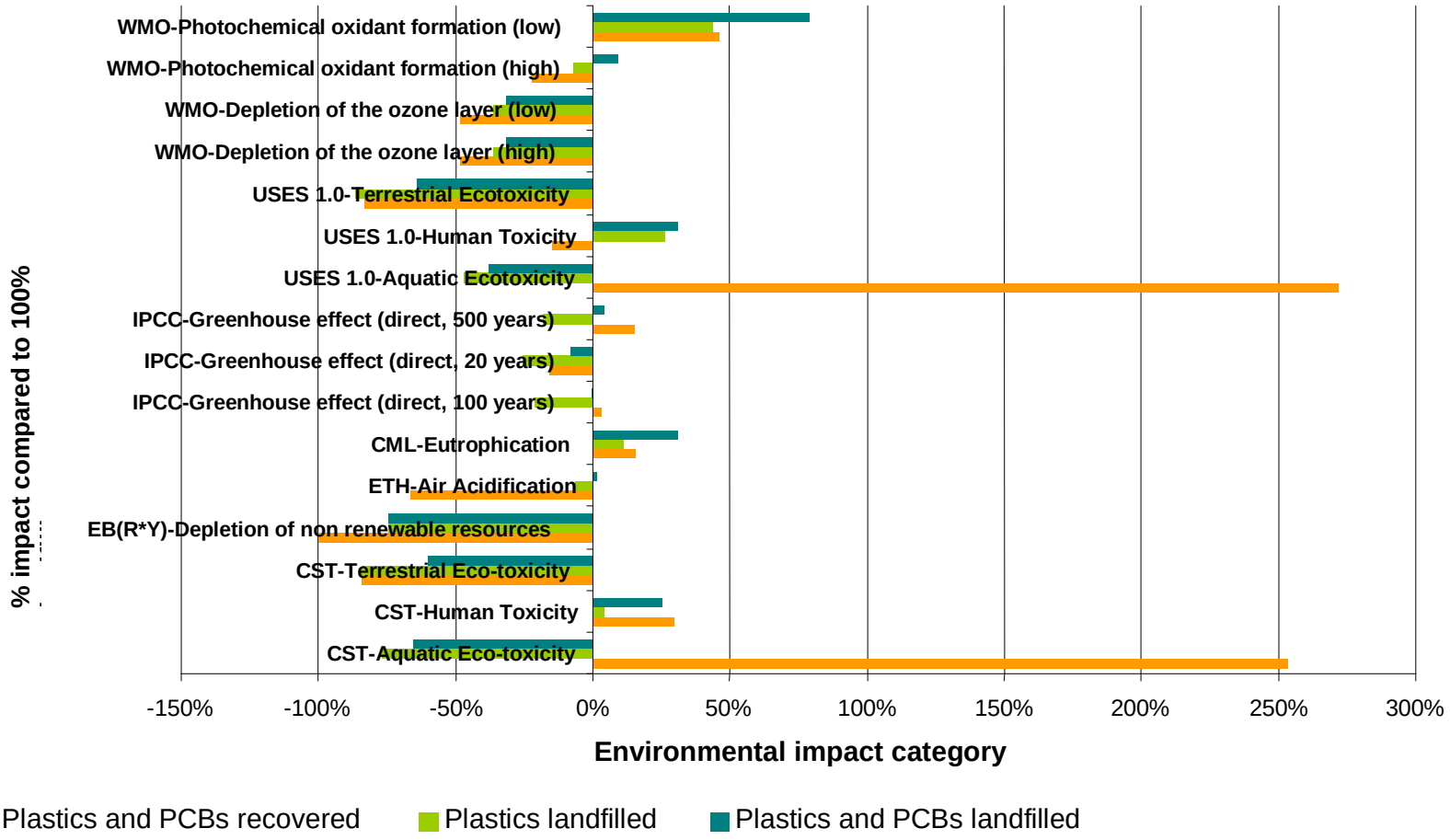
Table 6.2: Ranking of scenarios by environmental impact category

Environmental impact category	*Plastics and PCBs recovered*	*Plastics landfilled*	*Plastics and PCBs landfilled*	*100% landfilling*
Recycling and recovery rate (% by mass)	**99.0%**	**67.8%**	**61.4%**	**0.0%**
EB(R*Y)-Depletion of non renewable resources	1	2	3	3
ETH-Air Acidification	1	2	4	3
WMO-Photochemical oxidant formation (low)$^{\varphi}$	3	2	4	1
WMO-Photochemical oxidant formation (high)$^{\varphi}$	1	2	4	3
CML-Eutrophication	3	2	4	1
IPCC-Greenhouse effect (direct, 20 years)	2	1	3	4
IPCC-Greenhouse effect (direct, 100 years)	4	1	2	3
IPCC-Greenhouse effect (direct, 500 years)	4	1	2	3
WMO-Depletion of the ozone layer (high)$^{\phi}$	1	2	3	4
WMO-Depletion of the ozone layer (low) $^{\phi}$	1	2	3	4
USES 1.0-Human Toxicity	1	3	4	2
CST-Human Toxicity	4	2	3	1
USES 1.0-Aquatic Ecotoxicity	4	1	2	3
CST-Aquatic Ecotoxicity	4	1	2	3
USES 1.0-Terrestrial Ecotoxicity	2	1	3	4
CST-Terrestrial Eco-toxicity	2	1	3	4
No. of categories with rank of 1	***6/16***	***7/16***	***0/16***	***3/16***
No. of categories with rank of 4	***5/16***	***0/16***	***5/16***	***5/16***

ϕ High and low values based on minimum and maximum possible values from World Meterological Organisation data included in the EcoBilan TEAM software tool (EcoBilan, 1998).

φ High and low values based on minimum and maximum possible values from World Meterological Organisation data included in the EcoBilan TEAM software tool (EcoBilan, 1998), assumed background concentrations of nitrogen oxides, the time period used to calculate ozone formation.

Figure 6.16: Overall comparison of environmental impacts



6.1.3 Sensitivity analysis

In this section, the results of sensitivity analyses are presented[5]. These analyses are used to test the validity of the research assumptions by varying input variables substantially (for example by ±50%). A full table of results is included in Appendix 4. It has not been possible to test the statistical significance of differences between these analyses, as the variance for each result was not known (as explained in Section 5.2.4 on data quality). The factors in the analysis with the greatest sensitivity to change or error are summarised below for both the "*plastics and PCBs recovered*" and "*100% landfilling*" scenarios:

1. Copper content of cable overestimated by 50%

   Reducing the assumed copper content of cable by half (from 90% to 45%) causes reductions in environmental impact from 8% to 45% across all categories in the "*100% landfilling*" scenario. Particularly noticeable reductions in environmental impact include:

   - Photochemical oxidant formation potential, which would be 22% to 45% lower based on low and high cases.
   - Non-renewable resource depletion potential, which would be 37% lower.
   - Eutrophication potential, which would decrease by 26%.

   Some of the environmental impacts of the "*plastics and PCBs recovered*" scenario would also be reduced:

   - Ozone depletion potential, which would be reduced by 32%, based on best and worst cases.
   - Air acidification potential, which would be reduced by 19%.

   A copper content of 90% for cables is a reasonable assumption due to the generally high density of metals relative to plastic polymers. Reduced levels of environmental impact are due to the lower quantities of copper smelted in all scenarios. There may be opportunities for the development of cleaner product technologies if cables could be developed without losses in the required level of conductance but using less copper. This supports the contention that prevention of substance use is beneficial to the environmental impacts of a product throughout the life cycle.

2. Unknown transportation distances underestimated by 50%

   As explained in Section 6.1.1, the most significant environmental impact of transportation at the collection stage is eutrophication. Sensitivity analysis reveals that the eutrophication potential of the trade-in would increase by 16% with a 50% underestimation of *estimated* transport distances (as opposed to those that were specifically known). This result would increase the eutrophication potential of the "*plastics and PCBs recovered*" scenario by 2% (from 16% up to 18%) relative to landfilling (in g equivalent of PO_4).

[5] Analyses investigated: (1) storage space used in disassembly, (2) energy consumption in collection centres, (3) fuel used for heating in collection centres, (4) shredder material separation efficiency, (5) copper content in cable, (6) faulty printers landfilled following refurbishment, (7) underestimation of unknown transport distances. These analyses are defined in more detail in Appendix 1.

3. Use of oil-based heating in collection centres in place of natural gas

   Use of oil for space heating as opposed to natural gas during the processing of WEEE would result in a 12% increase in ozone depletion potential compared to "*100% landfilling*". This finding is of relatively low importance as the overall potential for ozone depletion is low (as discussed in Section 6.1.2 above). The increase in ozone depletion potential caused would not be sufficient to favour the landfilling over the recycling and recovery scenarios.

For all remaining analyses, variation in the level of environmental impacts ranges between only 9% lower or 6% higher than with "*100% landfilling*". Any errors in the assumptions used are unlikely to affect the findings of the study. For example, differences between Global Warming Potential for each scenario ranged from only 25% below to only 15% above "*100% landfilling*". However, sensitivity analysis only affected global warming potential results by 1-2% at worst. In the following section, the financial costs of each scenario of the printer trade-in are compared and evaluated.

6.2 Analysis of scenario costs using LCC and price discounting

In this Section, the financial costs of each stage of the printer trade-in are evaluated (in Section 6.2.1) and the recycling and recovery scenarios under study are compared to landfilling considering both cost and environmental impact (in Section 6.2.2). In addition, the effects of price discounting on a product's take-back costs are considered (in Section 6.2.3).

6.2.1 Stage by stage comparison of printer trade-in costs

In Table 6.3, the costs of each stage of the printer trade-in are shown. A full inventory of costs is given in Appendix 5. Overall, the printer trade-in recovered 62% of its costs, mainly through product resale. Examining this data, it can be seen broadly that the distribution of end-of-life costs of the collected printers is not related to the distribution of end-of-life environmental impacts. In spite of the relatively high environmental impact of material production (described in Section 6.1.1), this stage only accounts for around 10% of the total costs of the trade-in. Most of the costs of the trade-in occur during product collection (17%) and processing (60%), whereas most of the environmental impact occurs as a result of processing and material production. Management and administration accounts for around 12% of the costs of the trade-in, this includes reporting of the materials treated and recovered.

Table 6.3: Comparison of printer trade-in costs stage by stage

	Collection	Processing	Material production	Channel management	Total
Cost (£)	17%	61%	10%	12%	£18,100.00
Revenue (£)	-	-	-	-	£11,200.00

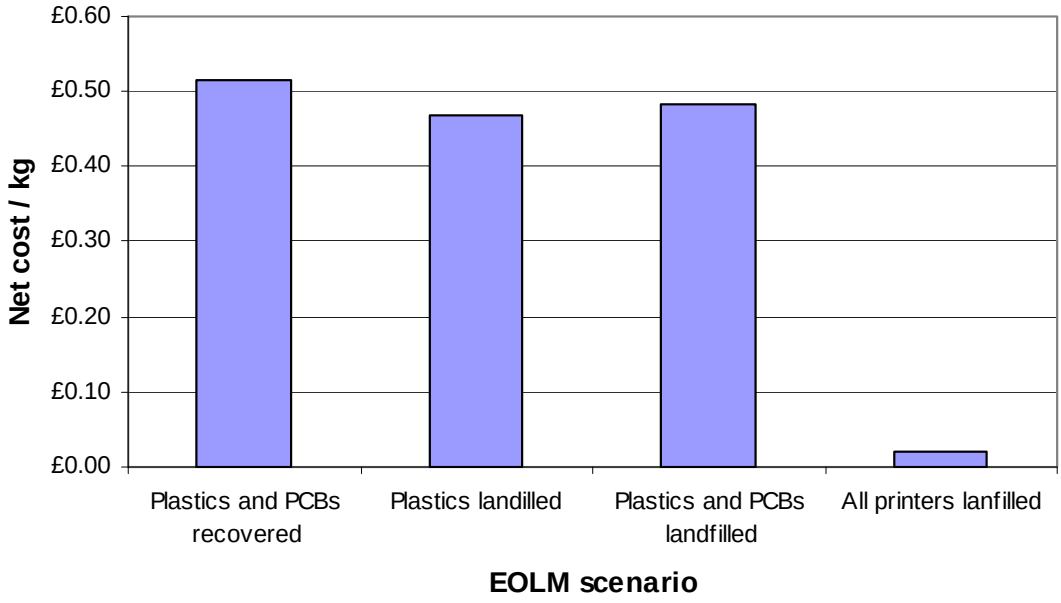
Decreasing the labour intensity and increasing the efficiency of manual disassembly processes could reduce the net costs of the printer trade-in substantially (as processing

accounts for 60% of costs). For example, the net costs of processing could be reduced by increasing volume to gain increased returns on scale, or by increasing the specialisation and streamlining of the disassembly process. These cost reductions would make recycling more economically feasible, but would have little affect on the environmental impacts calculated for the printer trade-in.

6.2.2 Comparison of scenario environmental impacts and costs

The net costs of recovery and recycling as required to meet the proposed requirements of the WEEE Directive[6] vary between £0.47 for the "*plastics landfilled*" scenario to £0.52 per kg for the "*plastics and PCBs recovered*" scenario (as shown in Fig. 6.16). In comparison, the estimated costs of "*100% landfilling*" are only around one twentieth of recycling and recovery costs at £0.02 per kg (around 50% of which is to pay for UK landfill tax).

Figure 6.16: Net scenario recycling and recovery cost



Comparing environmental impacts and costs between the different stages and scenarios of the printer-trade in reveals that any action taken to reduce the environmental impacts of recycling and recovering WEEE is unlikely to guarantee a corresponding change in recycling and treatment costs:

- Only in 4 out of the 16 impact categories investigated did the level of cost increase in-step with the level of environmental impact (as shown in Figs. 6.17 [a] to 6.17 [c]). These were aquatic eco-toxicity (using USES and CST methods), human toxicity (using the CST method), and global warming potential (over 500 years). The potential for resource depletion actually decreases from 68% to 61% with an increase in EOLM costs from £0.47 to £0.48 per kg, but then increases up to 99% with an increase in cost to £0.52 per kg. For the remaining impact categories, environmental

[6] Requiring at least that products are disassembled such that parts containing hazardous substances can be removed for treatment.

impacts generally increased with rise in costs from £0.47 to £0.48 per kg, and then showed the opposite trend and decreased with a further rise in EOLM costs from £0.48 to £052 per kg. These results reflect that the level of environmental impacts and costs are dependent on the specific materials and components recovered and recycled between scenarios. Moreover, the results indicate that there is no direct correlation between EOLM costs and environmental impacts.

- Although collection accounts for nearly 17% of the total printer trade-in cost, compared to processing and revalorisation, the environmental impacts of collection are relatively low (between 0% and 11% depending on impact category). Although materials production accounts for only 10% of the printer trade-in costs, it accounts for between 39% and 86% of human toxicity (depending on the assessment method used), and between 50% and 63% of terrestrial eco-toxcity.

- The relatively small difference in recycling and recovery costs of only £0.47-£0.52 per kg between scenarios cover differences in rates of recycling and recovery of nearly 40%.

Figure 6.17 (a): Environmental impacts by cost

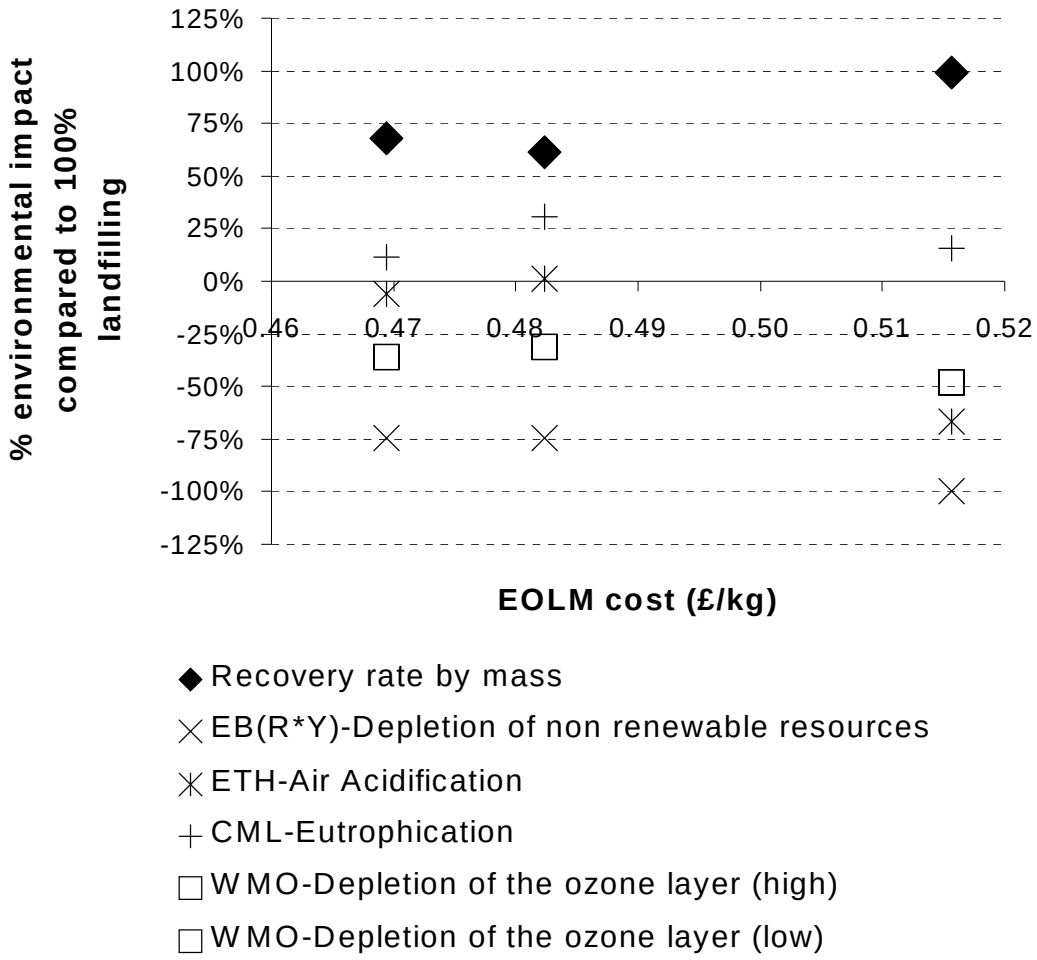


Figure 6.17 (b): Environmental impacts by cost

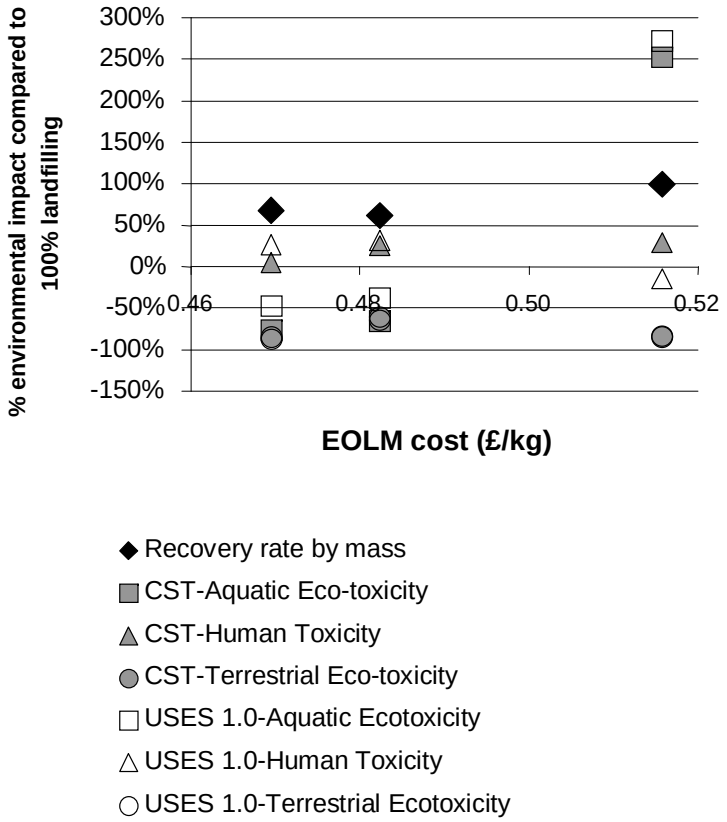
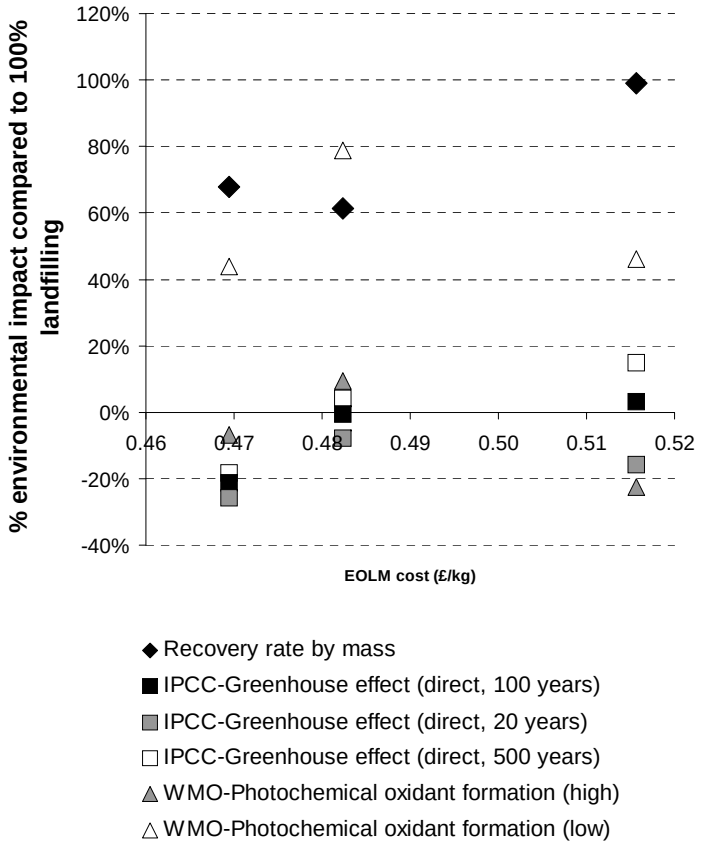


Figure 6.17 (c): Environmental impacts by cost



These results indicate that the costs of collecting, treating, and recycling WEEE are not directly related to the overall level of environmental impact. Without such a correlation Producer Responsibility will not provide the financial incentives necessary to encourage producers to design products with reduced environmental impacts at end-of-life. This is because any environmentally beneficial features designed into products are not assured to reduce product end-of-life costs for producers. This is a major flaw for the application of Producer Responsibility to WEEE.

The average cost of treatment and recycling can be compared to the cost of new products sold at the time the trade-in was conducted (from £49.99 to £244.00). Therefore, under future WEEE legislation product prices would have to increase by around 4% to 7% to cover recycling costs, depending on the printer model. The likely effectiveness of Producer Responsibility for WEEE is evaluated in light of these findings in the discussion of results in the following section (Section 7.2).

6.2.3 Discount rates and present value (PV):

Financial investments made by producers for product design changes in the present, with the aim of reducing future product recycling and treatment costs, *could* have a higher and more certain rate financial of return if put into alternative investments. In financial accounting and decision-making future cash flows are discounted against the present (Jackson, 1996: 94-95; Common, 1988: 183-187). This reflects that all investments have elements of risk that can be evaluated as opportunity costs (as introduced in Section 4.3.1).

To determine the effectiveness of Producer Responsibility legislation in stimulating design changes for electronic products, the affect of discounting on future product treatment and recycling costs should be considered (Mayers and France, 1999: 60). Based on net costs calculated for the printer trade-in ("*PCBs and plastics recovered*" scenario), Present Values (PV) are calculated for a range of product categories with different life spans[7] in Table 6.4 below, using the following formula (Common, 1988: 184):

$$PV = \frac{V_t}{(1+r)^t}$$

Where:

PV = present value
V = final value
r = discount rate
t = time (years)

The discount rates used for each product type are 0.05 and 0.15 per year, in order to reflect a broad range of possible scenarios. Products with the shortest life spans (4 years) have an PV which is 50%-80% of their potential future treatment and recycling costs

[7] Product categories selected (shown in Table 6.3) with similar materials and component types to printers, mainly consisting of mixed plastics, printed circuit boards, iron and steel, and aluminium. Life spans range from 4 to 9 years until discarded.

(depending on the discount rate used). In contrast, products with longer life spans such as Hi-fis and stereos (at 9 years) have a PV of only around 25%-50% of the future treatment and recycling costs. The practice of discounting future costs in financial

accounting will substantially diminish any incentives for producers to adapt the design of their products, in particular products with a longer life span.

Table 6.4: Discounted cash flows in EOLM

Product category	Small work and personal care appliances Toys Mobile phones and pagers	Computers and peripherals Telephones, faxes, and answephones Radio and personal radio, stereo and CD	Home and garden tools Video	Vacuum cleaners and carpet cleaners	Hi-fi and stereo
Average life span (until discarded) †	4	6	7	8	9
PV (discount rate of 0.05)	£0.42	£0.38	£0.36	£0.34	£0.32
% reduction	**19%**	**26%**	**30%**	**44%**	**47%**
PV (discount rate of 0.15)	£0.27	£0.20	£0.17	£0.14	£0.12
% reduction	**48%**	**62%**	**68%**	**73%**	**77%**
Total cost (100%)					£0.52

All cost figures compared to an average cost / kg of £0.52, based on the "*plastics and PCBs recovered*" scenario.
† Source: Cooper, T. and Mayers, K. "*Prospects for household appliances.*" Urban Mines Limited: Bradford, 2000, p.10.

6.3 Summary

In this section the results of the LCA and LCC of the printer trade-in case study have been described in detail. This included an analysis of environmental impacts and financial costs on a stage-by-stage basis, and for different recycling and recovery scenarios in relation to landfilling. It also included the results of seven different analyses to determine the sensitivity of the results to the assumptions used.

Overall, the processing stage accounts for the highest proportion of the costs of the trade-in (60%), due to the high cost of labour in product sorting, disassembly, and refurbishment. However, transportation, energy consumption during processing, plastics incineration, and steel and copper smelting processes account for the highest proportion of environmental impacts. Opportunities for reducing the environmental impacts of WEEE have also been identified. In many cases, trade-offs must be made between different environmental impacts, as there can be antagonistic effects between impact categories.

Most fundamentally for this study, results indicated that incentives for producers to adapt the design of their products are likely to be disrupted due to:

- Discounting of future EOLM costs by producers.
- The lack of relationship between a product's end-of-life costs and environmental impacts.

Also, based on the results of the printer trade-in, it cannot be assumed that the recovery and recycling of waste electronic products will always have lower environmental impacts than landfilling. For the "*plastics and PCBs recovered*" scenario, it was found that non-renewable resource depletion was reduced by almost 100% relative to landfill, and air acidification by around 65%. In contrast, the increased transport requirements of recycling and recovery increased the potential for eutrophication by around 15% relative to landfilling. In other areas, such as for photochemical oxidant formation, toxicity effects, and global warming, recycling and recovery were sometimes better and sometimes worse relative to landfilling depending on emission factors and the relative weighting of environmental burdens within the characterisation methods used.

The argument that increased recovery and recycling of WEEE will not always reduce its environmental impact compared to landfilling is also supported by results ranking scenarios by impact category. For example, the "*plastics and PCBs recovered*" scenario has the highest rate of recovery and recycling compared to the other scenarios at 99%. However, only in 5 out of the 16 categories studied does this scenario achieve the lowest level of environmental impact compared to the other scenarios. In contrast, the "*100% landfilling*" scenario has the lowest level of environmental impact in only in 5 out of the 16 categories investigated, but does not include any recovery or recycling.

In the following section (Section 7), the implications of these results are discussed.

7. Discussion of results

The EC has based its original proposal on certain assumptions that:

- The environmental performance of all economic operators involved in the life cycle of electrical equipment will be improved through increased treatment and recycling, in particular operators directly involved in the treatment of WEEE (COM[2000] 347: Article 1).
- Producer Responsibility will give producers economic incentives to adopt the prerequisites for the "sound waste management" of WEEE through product development and design (WEEE, 10.05.2000 - 6).

The validity of these assumptions have not yet been properly tested on the basis of scientific and empirical research. Although Ecobalance (1999) attempted to determine the overall environmental impacts and costs of the proposed WEEE Directive using LCA and LCC, as explained in Section 3 the results of the study are unconvincing due to:

- The use of inappropriate methodologies
- The invalidity of the survey's many assumptions
- No analysis of Best Practicable Environmental Option considering both environmental impacts and costs to producers.

It is argued below that the EU's current approach to Producer Responsibility for WEEE is questionable in terms of the environmental benefits it will actually achieve, and flawed in relation to the financial incentives it will give for improved product design. These arguments are explored further in Sections 7.2 to 7.5 below, discussing the:

- Effectiveness of Producer Responsibility for WEEE.
- Environmental impacts of WEEE
- Use of continuous improvement for management of EOLM processes for WEEE
- The role of future legislation for the management of WEEE.

Firstly, the validity of the results of the printer trade-in study is reviewed in Section 7.1 below.

7.1 Validity of results

The validity and relevance of the study results depends on a combination of factors including the goal and scope, data quality, assumptions, data allocation procedures, and characterisation methods used.

7.1.1 Goal and scope setting

The goal and scope of the study will determine the relevance of the results and comparability to other studies. The goal of this study was to investigate the likely effectiveness of the WEEE Directive in terms of its environmental impacts and net costs

in relation to landfilling. This was completed using LCA and LCC methods to investigate a case study of a printer trade-in conducted by HP in 1999 (as described in Section 5.1).

The printer trade-in case study is representative of EOLM processes that would be required under the future WEEE Directive, which would obligate producers to collect products returned through retail outlets. In addition, as printers contain a mixture of plastics, printed circuit boards, metal mechanical components, and cables and wires, results also bring into question the likely effectiveness of the WEEE Directive for products types containing similar materials and components such as:

- Small work and personal care appliances
- Toys
- Mobile phones and pagers
- Telephones, faxes, and answerphones
- Radio and personal radio, stereo and CD
- Home and garden tools
- Video
- Vacuum cleaners and carpet cleaners
- Hi-fi and stereo

7.1.2 Data quality

The quality of data used will limit the validity of the results attained. The quality of data used on the environmental burdens and costs of the printer trade-in was checked against minimum criteria, including coverage, representativeness, type of data, completeness, precision, consistency, reproducibility, and transparency (as described in Section 5.2.4), and also key reporting requirements.

Data were not found on the environmental burdens of gold production, nickel and palladium mining, and emissions from printed circuit board shredding (0.184 kg Gold, 0.115 kg Palladium, and 10.4 kg Nickel recycled). These data omissions are likely to have lowered human and ecotoxicity during processing and within the expanded boundary systems. Exclusion of data on the production of these metals in the expanded systems boundaries must be balanced by exclusion of emissions of the same metals from printed circuit board shredding in the foreground systems boundary. These data omissions could change the overall number of toxicity impact category results favouring either landfilling or recycling and recovery. This would not change the conclusions of the study discussed further below and in Section 8:

7.1.3 Accuracy of assumptions and sensitivity analysis

The validity of environmental impact results is limited by the validity of the underlying assumptions of the LCA conducted. Where data did not fulfil minimum quality criteria, it was included as an estimate and listed under the assumptions of the study (included in Appendix 1). The validity of these assumptions has been tested through sensitivity analysis (as described in Section 6.1.3).

7.1.4 Allocation in LCA and LCC

A major source of inconsistency and inaccuracy in LCA and LCC results from

imprecision in the allocation of environmental impacts and costs to different stages of a product's life cycle (as discussed in Section 5.3.3). Use of process averages is not always sufficiently accurate in allocation where there are common or co-product processes, and yet is particularly common in LCA studies on waste management. Within this study, environmental burdens for common or co-product processes were allocated in proportion to inputs of specific products or materials. Avoidable costs were allocated using a non-routing accounting method known as Mission Costing, elements of which are commonly applied in waste management and logistics.

7.1.5 Validity of characterisation methods

The suitability of the environmental impact categories and characterisation methods used in the LCA will affect the precision of the results, and their comparability to other studies. Most LCA studies on WEEE completed to date use different impact categories and characterisation methods, without proper justification of the methods used. the Where available in the EcoBilan LCA TEAM software tool (EcoBilan, 1998), characterisation methods were selected based on evaluations and recommendations within the literature (as explained in Section 5.4.1).

Despite limitations of LCA and LCC methodology, various measures were taken to ensure that the study findings were valid and relevant to the study goals, and that the methods used were consistent with state-of-the-art LCA and LCC studies in waste management.

7.2 Producer Responsibility: an effective framework of incentives?

Compliance with requirements in the proposed WEEE Directive is likely to result only in small price increases for electronic products (around 4% to 7% of new product prices based on the results for printers presented here). This level of cost is not insignificant. In the highly competitive electronics sector, these increases are likely to be in the same order of magnitude as industry profit margins.

Producer Responsibility is intended to create price incentives of the right order of magnitude to encourage producers to develop products with reduced environmental impact at end-of-life. Contrary to the assumptions of the EC and previous researchers (described in Section 1.1), the results of this investigation demonstrate how such incentives can become disrupted:

- Due to the use of price discounting in financial accounting, a producer's future EOLM costs could be reduced by 20%-50% for small products with 4 year life spans, to 50%-80% for products with a longer life span such as Hi-fis and stereos at 9 years (depending on the discount rate used). This will reduce incentives for producers to adapt the design of their products, particularly for products with longer life spans.

- Evidence from this research (see Sections 6.2.1 and 6.2.2) indicates that the drivers of cost and of environmental impact in the collection, treatment, and recycling of WEEE are not related. For almost all categories of environmental impact

investigated (10 out of 11)[8], there was no overall relationship between the level of environmental impacts and cost. In addition, the distribution of environmental impacts of collection, treatment, and recycling processes for WEEE did not follow the distribution of costs. For example, materials production accounted for a large proportion of the potential environmental impacts of the printer trade-in, but only 10% of the printer trade-in costs. Without a relationship between the environmental impacts and costs of EOLM processes for WEEE, financial incentives will not exist for producers to adapt the design of their products.

– Under the proposed WEEE Directive, producers will not have the exclusive right to any environmental benefits "designed-in" to their products. Unless the EU agree on a text making producers responsible for financing the treatment and recycling of their own products (placed on the market following implementation), companies will be free to "cherry-pick" products with lower end-of-life costs.

To ensure a political success of the WEEE Directive, these fundamental points were deliberately ignored by the EC in drafting its original proposal:

> "*Although there is general awareness about the problems associated with waste electrical and electronic equipment, very little research exists that could give a monetary evaluation of the externalities linked to the current management practices of this waste. The absence of such an analysis, for what is a politically pressing issue, cannot however be construed as a reason for inaction.*"

Some practitioners have previously acknowledged the fact that environmental impacts and waste management costs are unrelated. This is the first study undertaken providing evidence of this:

> "*Unfortunately, the economic framework in which we operate often fails to give signals that accord with the desire to conserve resources and protect the environment.*" – Ramsden, 1994: 65.

If a producer's costs were altered to reflect the actual environmental impacts of WEEE, the proposed Directive would become an instrument of environmental taxation. This is not the Producer Responsibility measure proposed by the EC and critiqued within the scope of this study. The fundamental issue here is that it appears the polluter pays principle has not been properly applied. Producer Responsibility could only work if market mechanisms already fully accounted for the external costs of environmental degradation. At present the EU are only taking first steps in this direction, with proposals for taxing energy products and for carbon dioxide emissions trading (as outlined in the EC's Sustainable Development Strategy in preparation for the Johannesburg Earth Summit in 2002[9]).

[8] Corresponding to 12 out of the 16 environmental impact assessments conducted. Some categories of environmental impact involved more than one assessment. For example, the environmental impact category "*global warming potential*" involved 3 assessments (over 20, 100, and 500 year time frames).
[9] Communication from the Commission, *A Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development*, draft of the Commission's proposal to the Gothenburg European Council, June 2001.

Following the results presented here, the effectiveness of Producer Responsibility for other categories of waste such as packaging, batteries, and automobiles, could similarly be investigated.

7.3 The environmental impacts of WEEE

Based on the results of the printer trade-in, it cannot be assumed that the recovery and recycling of waste electronic products will always have lower environmental impacts than landfilling or that increasing the rate of recycling by mass will necessarily reduce the environmental impacts of WEEE. For the "*plastics and PCBs recovered*" scenario (with the highest recovery and recycling rate at 99% by mass), results indicate that non-renewable resource depletion is reduced by almost 100% relative to landfilling, and air acidification by around 65%. In contrast, the increased transport requirements of recycling and recovery increase the potential for eutrophication by around 15% relative to landfilling. For other environmental impacts, such as for photochemical oxidant formation, ecological toxicity, and global warming, the "*plastics and PCBs recovered*" scenario did not have the lowest level of impact compared to other scenarios.

The results of the LCA are discussed further below in terms of their relationship to energy production processes, the environmental impacts of electronics recovery and recycling, and a comparison of the overall results for each scenario.

7.3.1 The relationship of results linked to energy production

Environmental impact results linked with energy production, including photochemical oxidant formation potential, global warming potential, acidification, and eutrophication, do not follow a consistent pattern. For example, for photochemical oxidant formation potential the "*plastics and PCBs landfilled*" scenario is worst, while (for two of the three time-scales used) the "*plastics and PCBs recovered*" scenario is worst for global warming potential. Such differences are caused by non-energy related emissions. For example:

- The landfilling of printers results in the release of 178 kg of methane from plastics (SP, 1998: 40), accounting for between 4% and 23% of the global warming potential of the "*100% landfilling*" scenario.

- The refurbishment of printer products involves a cleaning step in which around 6 kg of hydrocarbons are released to the atmosphere, accounting for between 35% and 60% of the photochemical oxidant formation potential of the "*plastics and PCBs recovered*" scenario.

In addition, different energy production processes result in different emissions, which are weighted differently within each impact category. For example, 93% of the results for eutrophication in the "*plastics and PCBs recovered*" scenario are caused by precipitation of nitrogen oxides arising mainly from transportation. In comparison, emissions of nitrogen oxides account for around 30% of results for acidification, but do not contribute to the results for photochemical oxidant formation potential.

7.3.2 The environmental impacts of WEEE recovery and recycling

The conventional "received wisdom" is that recycling of materials has lower impacts on the environment than production from raw materials e.g. as acknowledged in the UK in the 1995 waste management strategy (DOE, 1995). It is also an underlying assumption of the proposed WEEE Directive, as introduced in Section 1.2.1:

> "*Primary production of metals constitutes 10% of the world CO_2 emissions. Depending on the metal, between 70% and 95% of the energy used for the primary extraction of metals could be saved through enhanced recycling. In view of the fact that more than 3.5 million tonnes of metals are contained in the WEEE generated annually, the present Proposal contributes significantly to the CO_2 reduction required to reach the Kyoto targets.*" – WEEE (May 2000: 20)

In the study presented here, in 11 of the 16 the environmental impact assessments conducted landfilling did not have the highest level of impact compared ro other scenarios (as shown in Section 6.1.2). This includes all eutrophication results, 4 out of 6 results for photochemical oxidant formation potential, 3 out of 9 for global warming potential, 4 out of 6 for human toxicity, and 2 out of 6 results for aquatic toxicity.

In comparison to the recycling of conventional materials, such as paper, drinks cans, and glass, electronic products are composed of a complex mix of different components and materials (as described in Section 2.1). The separation and refining of this combination of materials requires inputs of energy and materials, and results in process emissions (as detailed for the processing stage in Section 6.1.1). For example, in the "*plastics and PCBs recovered*" scenario, initial collection and processing accounted for around 70% of carbon dioxide emissions. As a result, for some impact categories the balance of environment burdens for electronics recycling favour "*100% landfilling*".

7.3.3 Overall comparison of scenarios

For many types of waste electronic products similar in composition to the printer products studied, recovery and recycling may not result in improvements for all categories of environmental impact. Results indicate that the environmental impacts of WEEE are dependent on the specific components recovered or recycled, and not the recovery and recycling rate by mass. Overall, no best environmental option was identified between the scenarios:

- Rates of recycling proposed by the EC (with the "*plastics and PCBs recovered*") lowered the potential for resource depletion and air acidification when compared to other scenarios investigated, by almost 100% and around 65% relative to landfilling respectively. However, the overall potential impact of eutrophication, eco-toxicity, global warming, photochemical oxidant formation were lower in other scenarios.

- The EC have given examples of resource conservation, control of hazardous substances, and global warming as impacts they expect to be improved by the proposed WEEE Directive. The results of this study indicate that global warming and eco-toxicity is lowest when plastics are landfilled and not sent for energy recovery (as in the "*plastics landfilled*" scenario). However, this could result in a failure to meet recovery and recycling targets proposed, and in an increase in the potential for resource conservation relative to the "*plastics and PCBs recovered*" scenario. In

addition, this scenario does not have the lowest level of impact for eutrophication and air acidification compared to other scenarios.

- At present in the UK, around only 10%-11% of IT products are recycled at end-of-life (ICER, 2000: 29). Using the available recycling infrastructure, most of these appliances will only have a basic level of recovery, where steel and aluminium components and copper cabling are recycled (as examined in the "*plastics and PCBs landfilled*" scenario). This scenario is not the best environmental option for any category of impact. Overall, recycling of metal components has the highest level of impact for air acidification and photochemical oxidant formation potential. However, it cannot be concluded that the "*plastics and PCBs landfilled*" scenario was overall the worst environmental option. The impact on human and ecological toxicity and greenhouse gas emissions, two environment issues highlighted by the EC to be addressed through the proposed directive, is not highest compared to other scenarios.

- The proposed WEEE Directive aims to achieve reductions in environmental impacts over disposal of WEEE without recovery or recycling. The results based on the example presented here indicate that landfilling has the highest level of impact for resource consumption and terrestrial ecotoxicity. However, landfilling has the lowest level of impact for eutrophication. In addition, landfilling has a relatively low level of impact for human toxicity, which has the lowest and second lowest impact compared to other scenarios using CST and USES 1.0 methods respectively.

The Commission's original WEEE Directive proposal set various targets for the recycling and recovery of WEEE, ranging between 50% and 75% for recovery, and 60% and 85% for recycling, depending on product category (COM[2000] 347: Article 6). These specific targets were not, however, based on any assessment of the environmental impacts of different waste management and recycling options. Moreover, these targets are based on an assumed "hierarchy" of waste management options, dictating that recycling and recovery will always have lower environmental impacts than landfilling. Rather than addressing the basis for these targets, subsequent amendments to this proposal from the European Parliament and Commission have only increased targets by 5% o 10% (Amendment 39; A5-0148/2001 - 2000/0158 [COD]; 9767/01 - 2000/0158 [COD]). The approach adopted by the European Union in the proposed WEEE Directive is questionable in terms of the reduction in environmental impacts increased rates of recovery and recycling will actually achieve. Arguably, the use of recovery and recycling rates by mass could have considerable disadvantages.

Although valuation was not undertaken in the LCA, to determine which level of recovery and recycling is "best", an implicit trade-off must be made between conflicting environmental criteria. The role of valuation in decision making within environmental management is discussed briefly below (in Section 7.4).

7.4 The use of continuous improvement in EOLM for WEEE

The use of continuous improvement in managing the environmental impacts of WEEE has limitations. While it would be possible to reduce some of the environmental impacts of printer trade-in through more selective product treatment and recycling, this could

also increase environmental impacts or costs in other areas. For example, where plastics from printers are landfilled and not incinerated with energy recovery, global warming potential is reduced from between ±15%, to 18%-26% lower than 100% landfilling. However, this also results in an increase in resource depletion potential from around 99% to 75% less than landfilling.

Objectives set during the planning stage of continuous improvement may not be compatible, and there is likely to be conflict arising between different environmental and financial criteria. This can be demonstrated using examples from the printer trade-in case study:

- Conflict between cost and environmental objectives: *if plastic recycling were possible for mixed plastics (as opposed to only energy recovery), although it may reduce the environmental impacts of the trade-in compared to landfill, it would also increase its cost due to difficulties in identifying and segregating plastics of different polymer types.*

- Conflict between cost objectives: *Minimising the time required for sorting activities may reduce the costs of the processing stage, but may also reduce the number of suitable products identified for resale.*

- Conflict between environmental objectives: *Although the recovery and recycling of printers reduced the potential for air acidification and resource consumption relative to landfill, it also resulted in increases in eutrophication, global warming, and ecological toxicity.*

Although beyond the scope of this research, a variety of methods may be employed to weight, value, and optimise conflicting criteria in decision-making in relation to environmental cost-benefit analysis. Using environmental economics, environmental impacts can be valued in terms of the cost of the damage caused, the cost of damage prevention, or the contingency value placed on the environment by society (Pearce *et al*, 1992; Jacobs, 1991; Maas and Tantjem, 1999). Various authors have developed environmental impact weighting methods, which can be used to derive environmental impact indicator scores in LCA. One example of such a method is the Eco-Indicator score developed in the Netherlands (Goedkoop and Spriensma, 2000). In addition, researchers in operational logistics are currently developing algorithms to for use in optimising electronics recycling processes where there is conflict between multiple environmental and financial criteria (Bullinger *et al*, 1999).

There are limits to scientific and economic analysis in decision-making. For example, the decision to use the deep-sea for the disposal of the Brent Spar oil platform was based on a detailed scientific Environmental Impact Assessment and economic cost-benefit analysis. However, it still resulted in widespread public outrage and action by consumers in Europe against Shell (Löfstedt and Renn, 1997). There is growing consensus in all areas of the academic community that the perceived legitimacy and public acceptance of decision-making, in particular with regards to the environment, can be improved when it includes public and stakeholder dialogue and accountability. This applies equally in LCA (ISO, 1998), risk communication and management (Chess *et al*, 1995; Renn *et al*, 1996), and industrial environmental management (Brink *et al*, 1996; Earl, 1996).

Where scientific and economic assessment and analysis cannot determine the Best Practicable Environmental Option from conflicting environmental and financial criteria for the treatment and recycling of WEEE, increased confidence in a decision can be

gained through dialogue with stakeholders concerned. This can help in two respects, it can gain support and buy-in from key stakeholders who are most likely to be affected by a decision, and can inform decision-makers on the likely response of stakeholders to a decision.

7.5 The effectiveness of legislation for WEEE

In adopting new legislation, it is important that governments take into account the broader environmental, economic, social and developmental implications of their policies. For example, within the "Agenda 21"report of the Earth Summit in 1992, an objective of international legal instruments is described as:

> "*To identify and prevent actual or potential conflicts, particularly between environmental and social / economic agreements or instruments, with a view to ensuring that such agreements or instruments are consistent. Where conflicts arise, they should be appropriately resolved…* " – UNCED, 1992: 237.

Based on the example of printer recycling presented here, it can be questioned whether the WEEE Directive will achieve this objective:

- It is likely to result in increased costs to consumers and producers, which are unlikely to provide incentives for producers to develop products with reduced environmental impacts at end-of-life as intended. Producer Responsibility for WEEE could only work if market mechanisms already fully accounted for external environmental costs.

- To reduce the overall environmental impact of products through the life-cycle, it is essential that the EU develop a coherent framework of product-based environmental policies, as proposed within the EC's draft Integrated Product Policy (COM [2001] 68 final). Arguably, the implicit prioritisation of resource conservation and air acidification over other environmental impacts (given the example of printer recycling within the LCA results) by the proposed WEEE Directive is neither coherent nor legitimate in this respect. For example, the landfilling of plastics without energy recovery could support commitments within the Kyoto convention on climate change (UNFCC - 1992) for reductions in greenhouse gas emissions, and help lower the release of potentially toxic metals to ecosystems compared to other scenarios. However, it would also result in a failure to meet the recycling targets proposed in the WEEE Directive to reduce the consumption of resources and conserve landfill space, and could require closer comparison of the relative effects on ambient air quality between scenarios.

- It is not likely to address the needs of lower-income sectors of society, who are most likely to dispose of their end-of-life products to landfill or illegally due to lower accessibility to existing disposal arrangements and a higher dependency on older second-hand appliances (Mayers and Cooper, 2000).

Arguably therefore, the results presented here bring into question the ability of the WEEE Directive to achieve the EC's original objective to reduce the environmental impacts of all categories of WEEE from a life-cycle perspective.

In most western countries only finite landfill space is available and alternative waste management options must be identified (as addressed in the UK's waste management strategy; DETR, 2000). The EC should investigate alternative policy instruments to Producer Responsibility in reducing the environmental impacts of WEEE (which was beyond the scope of this research). These could include:

- Controls on the use of hazardous substances in products (such as proposed by the EU RoHS Directive, COM[2000]347 - 2000/0159[COD]) acting in combination with controls on process emissions for recycling and disposal (such as required in the EU Integrated Pollution Prevention and Control Directive, 1996 [96/91]). The use of strategies banning substances from use compared to those controlling substance emissions at end-of-life have been discussed more extensively by Cowell *et al.* (1999), in relation to qualifying and defining options for sustainable development.

- Aim at reducing energy use and emissions arising from collection, treatment, and recycling processes for WEEE. For example and in no particular order, targeting energy use in disassembly facilities, the use of hydrocarbons in cleaning refurbished products (contributing substantially to the potential for photochemical oxidant formation), and efficient transport and collection routing. Such approaches have been advocated within the different literature on "reverse logistics" (for examples see Stock, 1992; Kopicki *et al.*, 1993; Krikke, 1998; Jahre, 1998).

If the environmental impacts of WEEE came under adequate control through these approaches, the political will to improve treatment and recycling rates for WEEE, conserve resources, and reduce landfilling could be addressed through policies targeting local waste management authorities, responsible for providing waste management services to householders. These arrangements are not normally financed through charges to Producers, but through disposal fees and / or local waste taxes.

The EU institutions are still in the process of amending the proposed WEEE Directive, with questions still remaining on the suitability and likely effectiveness of the Producer Responsibility approach. Future research could usefully advance the findings outlined in this study by investigating:

- Recycling and disposal processes in other countries where recycling and treatment costs and the environmental impacts of transportation and electricity generation will be different.
- Results including peer review and incorporating any new ongoing developments in LCA methodology and impact characterisation.
- Other product categories subject to Producer Responsibility, such as white goods, televisions, packaging, batteries and automobiles.

8. Conclusions

This research has examined in detail the likely environmental impacts and costs of the EU's proposed WEEE Directive. The background to the research, methodology, and findings are summarised below.

8.1 Research background

Following the adoption of a proposed EU Directive for Waste Electrical and Electronic Equipment, producers of electronic products will be required to finance and organise the treatment and recycling of their waste products at "end-of-life" (as explained in Section 1). This Directive has been developed based on the assumption that Producer Responsibility will provide financial incentives to producers to design products with reduced environmental impact at end-of-life. It has also been developed based on the assumption that increased levels of recycling will reduce the environmental impacts of WEEE from a life cycle perspective.

The results of LCA and LCC studies conducted to date provide only limited insight into the relationships between environmental impacts and costs in the management of WEEE (as explained in Section 3). The aims of this study were to:

- Determine the likely environmental impacts and cost implications for producers of the proposed Producer Responsibility legislation for Waste Electrical and Electronic Equipment (WEEE).
- Investigate the potential for reducing the environmental impact of End-of-Life Management (EOLM) processes for WEEE cost effectively.

8.2 Research method

A printer "trade-in" conducted in the UK is used as a case study in the research evaluation (described in detail in Section 5.1). This trade-in was conducted between a major international producer of IT products and printers (the sponsor company, Hewlett-Packard Limited) and a major group of high-street retailers in the UK (Dixons Stores Group). Consumers were offered various discounts on the price of selected new printer products on exchange for their older printers. During the month of April 1999 (the period of the trade-in) some 3,250 printers, weighing over 20 tonnes in total, were returned through retail outlets to a subcontracted recycling company in the UK (Intex Computers). This case study included a wide range of model types and brands and fulfilled requirements for collection, treatment, and recycling of WEEE under the future proposed Directive.

LCA and LCC methods were used to conduct an analysis of the environmental impacts and costs of the printer trade-in. A non-routine management accounting method, known as Mission Costing (MC), was used to underpin the methodology used in the LCC. These methods were selected due to their unique ability to ensure adequate environmental impact and cost allocation, applicability, scope, and compatibility with management

systems based on continuous improvement (as explained in Section 4).

LCA and LCC methodology involves four steps: goal and scope setting (explained in Section 5.2), LCA and LCC inventory calculation (explained in Section 5.3), impact characterisation and normalisation (explained in Section 5.4), and improvement assessment (explained in Section 5.5).

8.3 Research findings

Research findings are presented and analysed in the results section (Section 6) and then evaluated in the discussion section (Section 7).

Based on the example of printer products studied, the results indicate that it is unlikely that the inclusion of costs for the collection, treatment, and recycling of WEEE into product prices will incentivise producers to develop products with reduced environmental impact. This is due to:

- The use of price discounting to calculate the present value of a producer's future EOLM costs.
- The absence of a relationship between the environmental impacts and cost of WEEE.
- A failure to ensure producers will be financially responsible for products they have individually placed on the market following implementation of the WEEE Directive.

Contrary to the original assumptions of the EC and previous researchers, Producer Responsibility for WEEE could only work if market mechanisms already accounted for external environmental costs. Indeed, if market mechanisms did account properly for externalities, such as environmental impacts, there would be very little need for environmental legislation!

The WEEE Directive, as it is currently proposed by the EC, could result in social and environmental benefits. For example, free-of-charge product disposal services will be provided to consumers through retail outlets and to householders with their own means of transport to municipal sites. The recovery and recycling rates proposed could also have some environmental benefits compared to landfilling, such as reduced depletion of non-renewable resources and air acidification. However, results indicated they could also result in substantial increases in environmental impacts compared to landfilling and than with lower rates of recovery and recycling, such as for human and ecotoxicity, eutrophication, global warming, and photochemical oxidant formation.

The results indicated that the changes in environmental impact achieved by the proposed WEEE Directive are unlikely to be coherent with the original aims of the EC, the aims of the proposed EU Sustainable Development strategy, and the need for an Integrated Product Policy in within Europe across all categories of WEEE. Arguably, contrary to the original assumptions of the EC and previous researchers, the proposed WEEE Directive may not result in an overall reduction in the environmental impacts of WEEE from a lifecycle perspective, and the use of recovery and recycling targets by mass could have considerable disadvantages.

The EC could do better to focus on alternative policy instruments to Producer Responsibility to reduce the environmental impacts of WEEE. These could include requirements for increased WEEE treatment and recycling targeting local waste management authorities, improved control of chemicals used in products and of emissions from recycling and disposal processes, and improved environmental practices and efficient logistics in recycling chains. Subsequent scientific, sociological, and economic research could very usefully advance and test further the findings presented here.

The following chapter in the research portfolio presents a study of the use and disposal of IT products by commercial organisations in the UK in detail (Chapter 2, Vol. 1).

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Appendix 1: EOLM assumptions and sensitivity analysis

Collection

Consolidation

– One pallet occupies 1.5 m^2 of floor space (based on average pallet size of 1.2 * 1.2 metres).
Sensitivity analysis: examine effects of 50% error (assume one pallet occupies 2.25 m^2 of floor space)

– Energy use for heating and lighting at high-street retail outlets (e.g. in city centre locations) is 375 kWh / m^2 / yr, based on best practice energy consumption figure of 250 kWh / m^2 / yr (DOE, 1994: 23).
Sensitivity analysis: assume consolidation centre is operating at best practice.

– Energy use for heating and lighting at out-of-town outlets (e.g. in large retail parks) is 660 kWh / m^2 / yr, based on best practice energy consumption figure of 440 kWh / m^2 / yr (DOE, 1994: 23).
Sensitivity analysis: assume consolidation centre is operating at best practice.

- Energy use for heating and lighting at warehouse 225 kWh / m^2 / yr, based on best practice energy consumption figure of 150 kWh / m^2 / yr (DOE, 1994).
  Sensitivity analysis: assume consolidation centre is operating at best practice.

- Energy used for heating and lighting assumed to be 90% from natural gas and 10% electricity, based on energy use in processor's warehouse.
  Sensitivity analysis: warehouse uses oil fuelled heating system (using heavy fuel oil as worst case scenario)

Processing

Printer sorting and dissassembly

- The density of Kerosine has been assumed to be 0.8 mg / ml based on values provided in Brane and King (1967: 321). Kerosine was contained in the cleaner used to clean printer casings during refurbishment.

Shredding and pre-processing of printed circuit boards

- 80% of non-metallic materials removed as "shredder-fluff" during refining, consisting of 50% ceramic materials and 50% polymer-based materials.
  Sensitivity analysis: examine effects of 50% error (40% of non-metallic materials removed)

- Shredder fluff disposed of as inert non-special waste to landfill.

- Shredding process includes dust screens and capture of dusts under low pressure, which are then disposed of as waste to landfill with shredder fluff.

Materials production

Copper and precious metals smelting from PCB scrap

- Carbon content of circuit boards (9.6% by mass) converted to Carbon Dioxide during smelting and post-combustion processes. No Carbon Monoxide emissions reported: based on data from 1994 provided by Boliden.

- Silicon content of PCB emitted as particulate matter in the flue, and as slag which used as aggregate replacement in roads during smelting (on the basis of process mass balance: based on data from 1994 provided by Boliden.

Copper smelting from copper cabling and adapters

- 90% by mass of cabling assumed to be copper (no data available).
  Sensitivity analysis: examine effects of 50% error (45% by mass of cable assumed to be copper)

- 10% by mass of cabling is assumed to be polypropylene (5%) and PVC (5%).

- The combustion of plastic polymers during smelting is assumed to have the same environmental burdens as plastics incineration with energy recovery, as the energy contained in plastics can be used within the smelting process (Provided by Boliden, 1995).

Resale

- One third of printers sent to maintenance companies for resale reused, two thirds disposed of as non-hazardous waste in UK landfill.
  Sensitivity analysis: assume ½ of printers are resold and enter reuse.

Waste processing

Landfill

- With 88% (by mass) of municipal solid waste being disposed of in landfill in the UK (White *et al.*, 1995: 274) and the unsuitability of electronics wastes (consisting largely of metals) for incineration, it is assumed that all waste fractions were disposed of in landfill.
  Sensitivity analysis: Incineration was not investigated as an alternative due to a lack of sufficient data.

- The solubility of metals in printed circuit boards varies directly relation to mass, i.e. a doubling in mass results in a doubling in the leachable quantity of metals within a circuit board.

- Given increased standards required under future landfill directive, it is assumed that all landfill sites used were contained:

  40% collection of methane gas from landfilled plastics and 90% destruction of collected gases (given efficiencies of 84% to 100% in practice; White *et al.*, 1995: 287).

  70% collection and treatment of leachate, resulting in 15.5 kg of active waste sludge per m^3 of municipal solid waste, the remaining leachate leaking to surrounding substrate or watercourses (White *et al.* 1995: 291-292).

  The density of municipal solid waste is assumed to be 0.9 m3 / tonne (White *et al.*, 1995. 293)

- The methane generated by one tonne of mixed plastics in landfill is assumed to be the average of that for PVC, Polystyrene, and Polyethyene (for which methane generation data was available).

– For purposes of calculating quantities of metals leached from steel plates in landfill, the composition of steel was assumed to be 60% iron and 20% chromium (by mass) based on values provided by CRC (1981: F159-F160).

Plastics incineration

– The environmental burdens of incinerating by one tonne 1 tonne of unspecified mixed plastics is assumed to be the average of that for PVC, Polystyrene, Polyethyene, and Polypropylene (for which incineration data was available).

Transportation

NB: All distances are based on locations from the trade-in example. The market for raw materials is global which necessitates international shipments of recyclate. The effect transportation distances has on the results is discussed in the results section.

Collection and reverse distribution

– All transport distances are one-way, as vehicles were either used on "round-robin" routes with multiple drop-off or pick-up points, or the return stage of a delivery trip was used.

– Due to delivery of old printer on sale of new during shopping trip, transfer from home considered outside of the scope of waste management, and not included in LCA.

– Average distance between high-street retail outlets and returns warehouse in Stephenage assumed to be 450 km, using a special collection visiting each store on a "round-robin" basis.
Sensitivity analysis: examine the effect of 50% error.

– Average distance between out-of-town stores and returns warehouse in Basingstoke assumed to be 300 km, utilising the return visit for product deliveries.
Sensitivity analysis: examine the effect of 50% error.

Shipment to materials producers and resellers

– Distances estimated by sea using measurements made in WinGIS:

Copper cabling to Indian copper smelter: 13,840 km
Aluminium scrap to West African aluminium smelter: 10,000 km †
Printed Circuit Board Scrap to Swedish precious metals smelter: 3,390 km
Steel panels to European steel smelter: 800 km †

– Distances estimated by road using measurements made in WinGIS (in 40 tonne containers):

  Copper cabling to Indian copper smelter: 500 km †
  Aluminium scrap to African aluminium smelter: 500 km †
  Printed Circuit Board Scrap to Swedish precious metals smelter: 800 km †
  Steel panels to European steel smelter: 800 km †
  Recovered cardboard to UK cardboard producer: 300 km †
  Printers for resale and reuse in maintenance: 300 km †
  Average distance to landfill: 32 km †

– *Sensitivity analysis: examine effects of 50% error on distances based on approximated facility locations and approximated road distances (indicated by the symbol* †)

Appendix 2: End-of-Life Management processes and environmental impacts

Actor stage		Process description	Allocated by	Key measures	Environmental impacts and benefits
1. End-use		The product end-user has equipment they no longer have a requirement for and decides to discard or dispose of it	N/A	None	None
2. Transport and logistics		Products and materials may have to be transported or shipped using various means of transport throughout the product end-of-life management chain	Transport miles per tonne Vehicle type	Particulates, NO_x, & VOC emissions Particulates Fuel consumption SO_x emissions CO_2 emissions Lead particulate emissions NO_X emissions	Photochemical smogs Human toxicity Resource consumption Acidification Climate change Human toxicity / ecotoxicity Eutrophication / acidification
3. Collection	(a) Indoor warehouse / retailer	End-of-life products are consolidated at a central point and possibly sorted in preparation for further processing using fork-lift trucks e.g. at a retailer.	Number of pallets Capacity (in pallets) Total floor space Full pallets only	Electricity consumption: Fuel consumption CO_2 emissions Particulate emissions SO_x emissions Used batteries disposed: Depends on battery and disposal process used	Various indirect: Resource consumption Climate change Human and ecotoxicity Acid rain Resource consumption Ecotoxicity and human toxicity
	(b) Outdoor storage	End-of-life products are consolidated at a central point and possibly sorted in preparation for further processing e.g. at a municipal site.	Land area used Total volume of products	Used batteries disposed: Depends on battery and disposal process used	Resource consumption Ecotoxicity and human toxicity

4. Electronics waste processing	(a) Goods in / receipt (indoor)	Products are received, sorted, stored, and moved about within a processing facility as part of day-to-day activities using fork-lift trucks.	See 3 (a) above	See 3 (a) above	See 3 (a) above
	(b) Product receipt and storage (outdoor)	Products are received, sorted, stored, and moved about within an outdoor processing area as part of day-to-day activities using fork-lift trucks.	See 3 (b) above	See 3 (b) above	See 3 (b) above
	(c) Testing and refurbishment	Products for resale first undergo a diagnostics test using various instruments (and rejected as scrap upon failure). Products passing this test are then re-engineered (if necessary), cleaned, and repackaged prior to resale.	By unit	Electricity consumption: Fuel consumption CO_2 emissions Particulate emissions SO_x emissions Packaging materials used Cleaning with VOCs	Various indirect: Resource consumption Climate change Ecotoxicity and human toxicity Acid rain Resource consumption Photochemical smogs
	(d) Manual disassembly	Products and parts are broken down to component level or material constituents in preparation for further processing using common work tools e,g screwdriver, hammer, and power-drill. May involve a certain extent of automation e.g conveyor system.	By unit By weight By pallet	Electricity consumption: Fuel consumption CO_2 emissions Particulate emissions SO_x emissions	Various indirect: Resource consumption Climate change Ecotoxicity and human toxicity Acid rain
	(e) Shredding, granulation, and refining (metals)	Whole or partial products are shredded and granulated in large automated machines, and various ferrous, non-ferrous, and precious and rare metals recovered from the resultant particulate material. Separation is typically through the use of a combination magnetic and density separation (water, air, and vibration) techniques. This may be in combination with automobiles, especially in the case of white goods.	By weight	Electricity consumption: Fuel consumption CO_2 emissions Particulate emissions (including metals) SO_x emissions VOC emissions Dioxin generation PCB emissions Water usage Metal rich aqueous waste	Various indirect: Resource consumption Climate change Ecotoxicity and human toxicity Acid rain Photochemical smogs Ecotoxicity and human toxicity Ecotoxicity and human toxicity Water consumption Ecotoxicity and human toxicity

	(f) Small scale printed circuit board refining (metals)	Precious metals are smelted out of printed circuit boards through a process of smelting to produce ingots of refined mixed precious metals and a black ash.	By weight	Natural gas consumption CO_2 emissions Metal particulate emissions Dioxin emissions PCB emissions	Resource consumption Climate change Ecotoxicity and human toxicity Human toxicity Human toxicity
	(g) Plastics granulation	Plastics are granulated to coarse pieces for volume reduction purposes.	By weight	Electricity consumption: Fuel consumption CO_2 emissions Particulate emissions SO_x emissions	Various indirect: Resource consumption Climate change Ecotoxicity and human toxicity Acid rain
	(h) CRT glass separation	Screen and cone glass may be separated through use of a hot wire, circular saw, or kiln to break the seal (a glass paste or frit) between these sections. Such separation may allow the eventual reuse of screen glass in the production of new CRT tubes.	By unit By weight	Electricity consumption: Fuel consumption CO_2 emissions Particulate emissions SO_x emissions	Various indirect: Resource consumption Climate change Ecotoxicity and human toxicity Acid rain
	(i) Metals recycling	Scrap metals are first shredded and then granulated to reduce particle size. Steel is removed by magnetic separation, before being sent to a steelworks for smelting. Aluminium is removed by a series of density separation processes, such as vibrating tables, before being sent to an Aluminium smelter. If ready-sorted metals are received by the recycling company, they may forgo these processes.	By weight	Electricity consumption: Fuel consumption CO_2 emissions Particulate emissions SO_x emissions	Various indirect: Resource consumption Climate change Ecotoxicity and human toxicity Acid rain
	(j) Cable recycling	Cables chopped and shredded using and automated process to recover copper from plastic cables.	See 4 (e) above	See 4 (e) above	See 4 (e) above

	(l) Printed circuit board refining (leaching process)	Printed circuit boards are washed with a cyanide solution to leach our precious metals such as Gold, which then may be recovered (HOW?). This process leaves circuit board residue, and a spent cyanide solution, which must somehow be disposed.	By weight	Emissions of Cyanide solution to ground and water (point source or rogue): Consumption of Cyanide solution: Disposal of waste / hazardous waste:	Eco-toxicity and human toxicity Resource consumption Ecotoxiity and human toxicity
5. Materials production	(a) Plastics granulation, extrusion, and recycling	Plastics are granulated and then extruded to a fine and homogenous particulate form, in which they can be reused as plastic.	By weight	Electricity consumption: Fuel consumption CO_2 emissions Particulate emissions SO_x emissions Reuse of recovered plastics	Various indirect: Resource consumption Climate change Ecotoxicity and human toxicity Acid rain Various: Reduction in material consumption Reduction in net energy consumption Reduction in waste disposed Other [indirect]
	(b) CRT granulation and recycling	In the recovery of glass from CRTs, CRTs may be granulated whole or in parts to produce a glass cullet for further processing. This cullet may either be used directly as a raw material, or further processed for use in material production.	By weight By unit	Electricity consumption: Fuel consumption CO_2 emissions Particulate emissions Fuel consumption VOC emissions SO_x emissions Air and water emissions of metals Metal rich aqueous waste	Various indirect: Resource consumption Climate change Ecotoxicity and human toxicity Resource consumption Photochemical smogs Acid rain Human and ecological toxicity Ecotoxicity and human toxicity

	(c) Metal recycling	Production of metals from recovered materials through smelting.	By weight	Fuel consumption: SO_x and NO_x air emissions NO_x air emissions CO_2 air emissions Metal water and air emissions: Reuse of recovered metals:	Resource consumption Acidification Eutrophication Climate change Human toxicity / ecotoxicity Reduction in material consumption Reduction in net energy consumption Reduction in waste disposed
6. Waste processing	(a) Landfill	The disposal of any residues from processing or sorting in landfill sites	By weight	Metals in leachate PCB in leachate / landfill Landfill usage Electricity / fuel consumption	Eco-toxicity / human toxicity Eco-toxicity / human toxicity Materials wasted Various indirect (if significant)
	(b) Incineration	The disposal of any residues from processing or sorting through incineration	By weight	Metal air and water emissions Dioxin air emissions Polybrominated dibenzo-dioxins and furans emissions PCB air emissions CO_2 air emissions NO_x air emissions Partriculates	Eco-toxicity / human toxicity Eco-toxicity / human toxicity Eco-toxicity / human toxicity Eco-toxicity / human toxicity Climate change Eutrophication and acidification Human toxicity
	(c) Incineration with energy recovery	The disposal of materials through incineration with energy recovery	By weight	Metal water and air emissions Dioxin air emissions Polybrominated dibenzo-dioxins and furans emissions PCB particulate air emissions CO_2 air emissions NO_x emissions Particulates Electricity saved - Fuel consumption - CO_2 emissions - Particulate emissions - SO_x emissions	Eco-toxicity / human toxicity Eco-toxicity / human toxicity Eco-toxicity / human toxicity Eco-toxicity / human toxicity Climate change Eutrophication and acidification Respiratory problems Various indirect: - Resource consumption - Climate change - Human toxicity - Acid rain

	(d) High temperature incineration	The destruction of hazardous organic wastes through high temperature incineration	By drum By weight	Metal particulate air emissions Dioxin air emissions Polybrominated dibenzo-dioxins and furans emissions PCB particulate air emissions CO_2 air emissions NO_x air emissions and particulates Partriculates	Eco-toxicity / human toxicity Eco-toxicity / human toxicity Eco-toxicity / human toxicity Eco-toxicity / human toxicity Climate change Photochemical smogs Respiratory problems
	(e) Chemical treatment	The neutralisation and treatment of aqueous hazardous wastes through chemical treatment.	By volume / concen-tration	Metal rich aqueous releases Electricity consumption: Fuel consumption CO_2 emissions Particulate emissions SO_x emissions	Eco-toxicity / human toxicity Various indirect: Resource consumption Climate change Metal contamination / ecotoxicity and human toxicity Acid rain
	(f) Hazardous waste landfill	The disposal of any hazardous wastes in a landfill dedicated to hazardous wastes	By weight	Metals in leachate PCB in leachate / landfill Landfill usage Electricity / fuel consumption	Eco-toxicity / human toxicity Eco-toxicity / human toxicity Materials wasted Various indirect (if significant)
7. Resale	(a) Through retail / distribution outlets	The resale of tested and reconditioned second-hand products through trade-fairs or specialised retail outfits.	Number of products Capacity (in products)	Electricity consumption: Fuel consumption CO_2 emissions Particulate emissions SO_x emissions	Various indirect: Resource consumption Climate change Metal contamination / ecotoxicity and human toxicity Acid rain
	(b) Telephone / web-based resale	The resale of tested and reconditioned second-hand products by telephone or through the internet.	By product	Electricity consumption: Fuel consumption CO_2 emissions Particulate emissions SO_x emissions	Various indirect: Resource consumption Climate change Human toxicity Acid rain

Appendix 3: Life cycle inventory results

Plastics and PCBs recovered scenario

LIFE CYCLE INVENTORY

	Flow	Units	Environmental burden
Inputs:	(r) 1-methoxy propan-2-ol	kg	1.2E-01
	(r) Barium Sulphate (BaSO4, in ground)	kg	8.8E+00
	(r) Bauxite (Al2O3, ore)	kg	6.7E-01
	(r) Bentonite (Al2O3.4SiO2.H2O, in ground)	kg	1.1E+00
	(r) Calcium Sulphate (CaSO4, ore)	kg	2.0E-02
	(r) Chromium (Cr, ore)	kg	1.4E-03
	(r) Clay (in ground)	kg	3.4E+00
	(r) Coal (in ground)	kg	2.3E+03
	(r) Commercial butane	g	1.7E+02
	(r) Copper (Cu, ore)	kg	7.2E-03
	(r) Gravel (unspecified)	kg	2.8E+00
	(r) Iron (Fe, ore)	kg	3.1E+01
	(r) Iron Sulphate (FeSO4, ore)	kg	2.3E-02
	(r) Kerosine	kg	1.0E-01
	(r) Lead (Pb, ore)	kg	2.2E-03
	(r) Lignite (in ground)	kg	2.2E+03
	(r) Limestone (CaCO3, in ground)	kg	1.3E+03
	(r) Manganese (Mn, ore)	kg	8.2E-04
	(r) Natural Gas (in ground)	kg	5.6E+03
	(r) Nickel (Ni, ore)	kg	4.8E-04
	(r) Oil (in ground)	kg	5.3E+02
	(r) Propan-2-ol	kg	9.8E-02
	(r) Pyrite (FeS2, ore)	kg	2.2E+02
	(r) Sand (in ground)	kg	6.9E+00
	(r) Silver (Ag, ore)	kg	3.6E-05
	(r) Sodium Chloride (NaCl, in ground or in sea)	kg	3.2E+01
	(r) Sulphur (S, in ground)	kg	5.0E-02
	(r) Uranium (U, ore)	kg	1.4E-01
	(r) Water	kg	2.1E+00
	(r) Zinc (Zn, ore)	kg	5.2E-05
	Argon (Ar)	kg	3.3E-01
	Borax (B4Na2O7)	kg	1.6E-01
	Chlorine (Cl2)	kg	1.9E-01
	Diesel Oil	kg	6.5E+02
	Explosive (unspecified)	kg	2.7E-01
	Gasoline (leaded)	kg	2.2E+00
	Gasoline (unleaded)	kg	2.0E+00
	Heavy Fuel Oil	kg	4.1E+01
	Iron Scrap	kg	1.8E-01
	Land Use (II -> III)	m2a	3.0E+00
	Land Use (II -> IV)	m2a	4.1E-01
	Land Use (III -> IV)	m2a	1.4E-01
	Maize	kg	3.4E+01
	Potatoes	kg	9.2E+00
	Raw Materials (unspecified)	kg	2.9E+02
	Traded-in printers (high-street)	kg	1.0E+03
	Traded-in printers (out-of-town)	kg	2.1E+04
	Water Used (total)	litre	1.4E+05
	Water: Unspecified Origin	litre	1.4E+05
	Wood	kg	1.7E+01
	Wood (standing)	m3	4.5E-03
Outputs:	(a) 1-methoxy propan-2-ol	kg	1.2E-01
	(a) Acetaldehyde (CH3CHO)	g	2.8E-01
	(a) Acetic Acid (CH3COOH)	g	2.8E+01
	(a) Acetone (CH3COCH3)	g	1.2E-01
	(a) Acetylene (C2H2)	g	6.4E+00
	(a) Aldehyde (unspecified)	g	2.6E-01
	(a) Alkane (unspecified)	g	6.5E+02
	(a) Alkene (unspecified)	g	7.5E+00
	(a) Alkyne (unspecified)	g	1.2E-02
	(a) Aluminium (Al)	g	1.2E+02
	(a) Ammonia (NH3)	g	1.6E+02
	(a) Antimony (Sb)	g	2.4E-02
	(a) AOX (Adsorbable Organic Halogens)	g	1.0E-10
	(a) Aromatic Hydrocarbons (unspecified)	g	7.8E+01
	(a) Arsenic (As)	g	3.5E-01
	(a) Barium (Ba)	g	1.5E+00
	(a) Benzaldehyde (C6H5CHO)	g	2.2E-06
	(a) Benzene (C6H6)	g	1.0E+02
	(a) Benzo(a)pyrene (C20H12)	g	2.6E-02
	(a) Berylium (Be)	g	2.4E-02
	(a) Boron (B)	g	1.2E+01
	(a) Bromium (Br)	g	2.4E+00
	(a) Butane (n-C4H10)	g	3.2E+02
	(a) Butene (1-CH3CH2CHCH2)	g	8.1E-02
	(a) Cadmium (Cd)	g	8.7E-01
	(a) Calcium (Ca)	g	1.6E+01
	(a) Carbon Dioxide (CO2, biomass)	g	1.3E+02
	(a) Carbon Dioxide (CO2, fossil)	g	3.8E+07
	(a) Carbon Monoxide (CO)	g	4.5E+04
	(a) Carbon Tetrafluoride (CF4)	g	1.7E-03
	(a) Chlorine (Cl2)	g	6.5E-06
	(a) Chromium (Cr III, Cr VI)	g	1.6E+00
	(a) Cobalt (Co)	g	8.2E-02
	(a) Copper (Cu)	g	1.4E+01
	(a) Cyanide (CN-)	g	3.8E-02
	(a) Dioxins (unspecified)	g	5.4E-05
	(a) Ethane (C2H6)	g	5.8E+02
	(a) Ethanol (C2H5OH)	g	2.1E-01
	(a) Ethylbenzene (C8H10)	g	8.1E-02
	(a) Ethylene (C2H4)	g	2.3E+03
	(a) Fluorides (F-)	g	6.9E-04
	(a) Fluorine (F2)	g	4.3E-04
	(a) Formaldehyde (CH2O)	g	1.9E+01
	(a) Halogenated Matter (unspecified)	g	1.2E-02
	(a) Halon 1301 (CF3Br)	g	1.6E-01
	(a) Heptane (C7H16)	g	5.5E-01
	(a) Hexane (C6H14)	g	1.1E+00
	(a) Hydrocarbons (except methane)	g	1.2E+04
	(a) Hydrocarbons (unspecified)	g	1.5E+02
	(a) Hydrogen (H2)	g	2.8E-05
	(a) Hydrogen Chloride (HCl)	g	8.7E+03
	(a) Hydrogen Fluoride (HF)	g	1.6E+02
	(a) Hydrogen Sulphide (H2S)	g	9.2E+01
	(a) Iodine (I)	g	5.9E-01
	(a) Iron (Fe)	g	6.2E+01
	(a) Kerosine	kg	1.1E-01
	(a) lanthanum (La)	g	3.9E-02
	(a) Lead (Pb)	g	8.0E+01
	(a) Magnesium (Mg)	g	4.3E+01
	(a) Manganese (Mn)	g	2.5E+01
	(a) Mercury (Hg)	g	5.7E+00
	(a) Metals (unspecified)	g	2.6E+02
	(a) Methane (CH4)	g	5.3E+04
	(a) Methanol (CH3OH)	g	3.4E-01
	(a) Molybdenum (Mo)	g	8.0E-02
	(a) Nickel (Ni)	g	4.4E+00
	(a) Nitrogen Oxides (NOx as NO2)	g	6.7E+04
	(a) Nitrous Oxide (N2O)	g	4.6E+02
	(a) Organic Matter (unspecified)	g	3.3E-01
	(a) Particulates (unspecified)	g	2.1E+04
	(a) Pentane (C5H12)	g	2.2E+02
	(a) Phenol (C6H5OH)	g	1.7E-05
	(a) Phosphorus (P)	g	2.3E+00
	(a) Phosphorus Pentoxide (P2O5)	g	7.4E-04
	(a) Platinum (Pt)	g	4.0E-05
	(a) Polycyclic Aromatic Hydrocarbons (PAH, except naphthalene)	g	2.3E-03
	(a) Polycyclic Aromatic Hydrocarbons (PAH, unspecified)	g	2.0E+00
	(a) Potassium (K)	g	1.8E+01
	(a) Propan-2-ol	kg	9.8E-02
	(a) Propane (C3H8)	g	1.8E+02
	(a) Propionaldehyde (CH3CH2CHO)	g	6.0E-06
	(a) Propionic Acid (CH3CH2COOH)	g	7.9E-03
	(a) Propylene (CH2CHCH3)	g	7.1E+00
	(a) Scandium (Sc)	g	1.3E-02
	(a) Selenium (Se)	g	3.1E-01

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	Classification	Units	Charact-erisation	Environmental impact
Methods:	CML-Eutrophication	g eq. PO4	*	9.4E+03
	(a) Nitrogen Oxides (NOx as NO2)	g eq. PO4	0.13	8.7E+03
	(a) Nitrous Oxide (N2O)	g eq. PO4	0.27	1.3E+02
	(w) Ammonia (NH4+, NH3, as N)	g eq. PO4	0.42	3.2E+01
	(w) COD (Chemical Oxygen Demand)	g eq. PO4	0.022	8.6E+01
	(w) Nitrogenous Matter (Kjeldahl, as N)	g eq. PO4	0.42	1.4E-01
	(w) Nitrogenous Matter (unspecified, as N)	g eq. PO4	0.42	1.0E+01
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g eq. PO4	3.06	4.2E+02
	(w) Phosphorous Matter (unspecified, as P)	g eq. PO4	3.06	4.0E+00
	(w) Phosphorus (P)	g eq. PO4	3.06	1.0E-01
	(w) Phosphorus Pentoxide (P2O5)	g eq. PO4	1.336	2.9E-02
	CST-Aquatic Eco-toxicity	eq. Zn water	*	3.1E+04
	(a) Arsenic (As)	eq. Zn water	0.078	2.7E-02
	(a) Cadmium (Cd)	eq. Zn water	79	6.8E+01
	(a) Chromium (Cr III, Cr VI)	eq. Zn water	0.39	6.3E-01
	(a) Copper (Cu)	eq. Zn water	0.66	9.1E+00
	(a) Lead (Pb)	eq. Zn water	1.28	0.0E+00
	(a) Mercury (Hg)	eq. Zn water	196	1.1E+03
	(a) Nickel (Ni)	eq. Zn water	0.12	5.3E-01
	(a) Zinc (Zn)	eq. Zn water	0.076	0.0E+00
	(s) Arsenic (As)	eq. Zn water	0.24	1.1E-02
	(s) Cadmium (Cd)	eq. Zn water	240	5.4E+01
	(s) Chromium (Cr III, Cr VI)	eq. Zn water	1.2	1.5E+02
	(s) Copper (Cu)	eq. Zn water	2	7.9E+01
	(s) Lead (Pb)	eq. Zn water	3.9	9.0E-01
	(s) Mercury (Hg)	eq. Zn water	600	3.4E-02
	(s) Nickel (Ni)	eq. Zn water	0.36	7.9E+00
	(s) Zinc (Zn)	eq. Zn water	0.23	9.7E-01
	(w) Arsenic (As3+, As5+)	eq. Zn water	0.52	2.7E+00
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Zn water	0.00013	1.6E-01
	(w) Cadmium (Cd++)	eq. Zn water	520	3.1E+03
	(w) Chromium (Cr III, Cr VI)	eq. Zn water	2.6	1.2E+02
	(w) Copper (Cu+, Cu++)	eq. Zn water	5.2	4.6E+02
	(w) Lead (Pb++, Pb4+)	eq. Zn water	5.2	0.0E+00
	(w) Mercury (Hg+, Hg++)	eq. Zn water	1300	1.7E+04
	(w) Nickel (Ni++, Ni3+)	eq. Zn water	0.79	9.8E+00
	(w) Oils (unspecified)	eq. Zn water	0.13	9.8E+01
	(w) Phenol (C6H5OH)	eq. Zn water	15.4	6.9E+01
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Zn water	0.01	1.4E+00
	(w) Zinc (Zn++)	eq. Zn water	1	0.0E+00
	CST-Human Toxicity	eq. Pb air	*	1.0E+07
	(a) Aldehyde (unspecified)	eq. Pb air	0.0087	2.3E-03
	(a) Arsenic (As)	eq. Pb air	9000	3.2E+03
	(a) Benzene (C6H6)	eq. Pb air	0.012	1.2E+00
	(a) Cadmium (Cd)	eq. Pb air	19000	1.6E+04
	(a) Carbon Monoxide (CO)	eq. Pb air	0.00014	6.3E+00
	(a) Chromium (Cr III, Cr VI)	eq. Pb air	3700	6.0E+03
	(a) Cobalt (Co)	eq. Pb air	12900	1.1E+03
	(a) Copper (Cu)	eq. Pb air	145	2.0E+03
	(a) Formaldehyde (CH2O)	eq. Pb air	0.0099	1.9E-01
	(a) Lead (Pb)	eq. Pb air	2300	0.0E+00
	(a) Mercury (Hg)	eq. Pb air	46000	2.6E+05
	(a) Nickel (Ni)	eq. Pb air	370	1.6E+03
	(a) Nitrogen Oxides (NOx as NO2)	eq. Pb air	0.002	1.3E+02
	(a) Particulates (unspecified)	eq. Pb air	0.0075	0.0E+00
	(a) Selenium (Se)	eq. Pb air	64000	2.0E+04
	(a) Sulphur Oxides (SOx as SO2)	eq. Pb air	0.0075	0.0E+00
	(a) Tin (Sn)	eq. Pb air	9	7.0E-02
	(a) Zinc (Zn)	eq. Pb air	27	0.0E+00
	(s) Arsenic (As)	eq. Pb air	0.7	3.2E-02
	(s) Cadmium (Cd)	eq. Pb air	1.46	3.3E-01
	(s) Chromium (Cr III, Cr VI)	eq. Pb air	0.29	3.6E+01
	(s) Cobalt (Co)	eq. Pb air	1	3.6E-04
	(s) Copper (Cu)	eq. Pb air	0.009	3.6E-01
	(s) Lead (Pb)	eq. Pb air	0.6	1.4E-01
	(s) Mercury (Hg)	eq. Pb air	3.6	2.0E-04
	(s) Nickel (Ni)	eq. Pb air	0.029	6.3E-01
	(s) Zinc (Zn)	eq. Pb air	0.0007	2.9E-03
	(w) Arsenic (As3+, As5+)	eq. Pb air	1.5	7.7E+00
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Pb air	0.022	2.8E+01
	(w) Cadmium (Cd++)	eq. Pb air	3.2	1.9E+01
	(w) Chromium (Cr III, Cr VI)	eq. Pb air	0.62	2.9E+01
	(w) Cobalt (Co I, Co II, Co III)	eq. Pb air	2.2	1.3E-01
	(w) Copper (Cu+, Cu++)	eq. Pb air	0.022	2.0E+00
	(w) Fluorides (F-)	eq. Pb air	0.045	7.8E-01
	(w) Lead (Pb++, Pb4+)	eq. Pb air	0.86	0.0E+00
	(w) Mercury (Hg+, Hg++)	eq. Pb air	7.8	1.0E+02
	(w) Nickel (Ni++, Ni3+)	eq. Pb air	0.062	7.7E-01
	(w) Phenol (C6H5OH)	eq. Pb air	0.052	2.3E-01
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Pb air	3.20E-06	4.4E-04
	(w) Selenium (Se II, Se IV, Se VI)	eq. Pb air	10.9	6.2E-01
	(w) Tin (Sn++, Sn4+)	eq. Pb air	0.0015	3.0E-07
	(w) Zinc (Zn++)	eq. Pb air	0.0032	0.0E+00
	CST-Terrestrial Eco-toxicity	eq. Zn air	*	1.4E+03
	(a) Arsenic (As)	eq. Zn air	0.75	2.6E-01
	(a) Cadmium (Cd)	eq. Zn air	3.14	2.7E+00
	(a) Chromium (Cr III, Cr VI)	eq. Zn air	0.08	1.3E-01
	(a) Cobalt (Co)	eq. Zn air	0.08	6.5E-03
	(a) Copper (Cu)	eq. Zn air	0.14	1.9E+00
	(a) Lead (Pb)	eq. Zn air	0.13	0.0E+00
	(a) Mercury (Hg)	eq. Zn air	5.94	3.4E+01
	(a) Nickel (Ni)	eq. Zn air	0.35	1.5E+00
	(a) Zinc (Zn)	eq. Zn air	0.33	0.0E+00
	(s) Arsenic (As)	eq. Zn air	2.3	1.0E-01
	(s) Cadmium (Cd)	eq. Zn air	9.6	2.1E+00
	(s) Chromium (Cr III, Cr VI)	eq. Zn air	0.26	3.3E+01
	(s) Cobalt (Co)	eq. Zn air	0.26	9.3E-05
	(s) Copper (Cu)	eq. Zn air	0.42	1.7E+01
	(s) Lead (Pb)	eq. Zn air	0.41	9.5E-02
	(s) Mercury (Hg)	eq. Zn air	18.3	1.0E-03
	(s) Nickel (Ni)	eq. Zn air	1.1	2.4E+01
	(s) Zinc (Zn)	eq. Zn air	1	4.2E+00
	EB(R*Y)-Depletion of non renewable resources	yr-1	*	9.6E+02
	(r) Barium Sulphate (BaSO4, in ground)	yr-1	26.91	2.4E+02
	(r) Bauxite (Al2O3, ore)	yr-1	0.108	7.2E-02
	(r) Chromium (Cr, ore)	yr-1	0.2133	3.0E-04
	(r) Chromium (Cr, ore)	yr-1	0.319	4.5E-04
	(r) Coal (in ground)	yr-1	0.0005037	1.2E+00
	(r) Copper (Cu, ore)	yr-1	28.16	2.0E-01
	(r) Iron (Fe, ore)	yr-1	0.04	1.2E+00
	(r) Lead (Pb, ore)	yr-1	157	3.5E-01
	(r) Lignite (in ground)	yr-1	0.0005037	1.1E+00
	(r) Manganese (Mn, ore)	yr-1	0.296	2.4E-04
	(r) Natural Gas (in ground)	yr-1	0.117	6.5E+02
	(r) Nickel (Ni, ore)	yr-1	59.7	2.9E-02
	(r) Oil (in ground)	yr-1	0.0557	2.9E+01
	(r) Silver (Ag, ore)	yr-1	92837	3.3E+00
	(r) Sulphur (S, in ground)	yr-1	4.408	2.2E-01
	(r) Uranium (U, ore)	yr-1	181	2.5E+01
	(r) Zinc (Zn, ore)	yr-1	40.29	2.1E-03
	ETH-Air Acidification	g eq. H+	/	4.6E+03
	(a) Ammonia (NH3)	g eq. H+	17	3.9E+00
	(a) Hydrogen Chloride (HCl)	g eq. H+	36.5	2.4E+02
	(a) Hydrogen Fluoride (HF)	g eq. H+	20	8.1E+00
	(a) Hydrogen Sulphide (H2S)	g eq. H+	17	5.4E+00
	(a) Nitrogen Oxides (NOx as NO2)	g eq. H+	46	1.5E+03
	(a) Sulphur Oxides (SOx as SO2)	g eq. H+	32	0.0E+00
	IPCC-Greenhouse effect (direct, 100 years)	g eq. CO2	*	3.9E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	3.8E+07
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	5700	9.9E+00
	(a) Halon 1301 (CF3Br)	g eq. CO2	6900	1.1E+03
	(a) Methane (CH4)	g eq. CO2	24	1.3E+06
	(a) Nitrous Oxide (N2O)	g eq. CO2	360	1.7E+05
	IPCC-Greenhouse effect (direct, 20 years)	g eq. CO2	*	4.1E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	3.8E+07
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	3900	6.8E+00

Plastics and PCBs recovered scenario

LIFE CYCLE INVENTORY

	(a) Silicon (Si)	g	2.4E+02
	(a) Sodium (Na)	g	9.4E+00
	(a) Strontium (Sr)	g	2.4E+00
	(a) Sulphur Oxides (SOx as SO2)	g	9.3E+04
	(a) Tars (unspecified)	g	7.3E-07
	(a) Thallium (Tl)	g	1.2E-02
	(a) Thorium (Th)	g	2.5E-02
	(a) Tin (Sn)	g	7.7E-03
	(a) Titanium (Ti)	g	4.3E+00
	(a) Toluene (C6H5CH3)	g	3.8E+01
	(a) Uranium (U)	g	2.4E-02
	(a) Vanadium (V)	g	6.0E+00
	(a) Water vapour	kg	2.1E+00
	(a) Xylene (C6H4(CH3)2)	g	1.5E+00
	(a) Zinc (Zn)	g	2.1E+02
	(a) Zirconium (Zr)	g	1.8E-02
	(ar) Aerosols and Halogenes (unspecified)	kBq	4.3E-02
	(ar) Carbon (C14)	kBq	1.4E+01
	(ar) Cesium (Cs134)	kBq	5.5E-04
	(ar) Cesium (Cs137)	kBq	5.5E-04
	(ar) Cobalt (Co58)	kBq	5.5E-04
	(ar) Cobalt (Co60)	kBq	5.5E-04
	(ar) Gas (unspecified)	kBq	1.4E+03
	(ar) Iodine (I131)	kBq	3.2E-03
	(ar) Iodine (I133)	kBq	6.3E-03
	(ar) Krypton (Kr85)	kBq	8.4E+01
	(ar) Lead (Pb210)	kBq	5.7E-01
	(ar) Polonium (Po210)	kBq	9.9E-01
	(ar) Potassium (K40)	kBq	1.5E-01
	(ar) Protactinium (Pa234m)	kBq	7.8E-03
	(ar) Radioactive Substance (unspecified)	kBq	7.7E+06
	(ar) Radium (Ra226)	kBq	6.8E-01
	(ar) Radium (Ra228)	kBq	7.6E-02
	(ar) Radon (Rn220)	kBq	2.3E+00
	(ar) Radon (Rn222)	kBq	6.6E+04
	(ar) Thorium (Th228)	kBq	6.4E-02
	(ar) Thorium (Th230)	kBq	1.1E-01
	(ar) Thorium (Th232)	kBq	4.1E-02
	(ar) Thorium (Th234)	kBq	7.8E-03
	(ar) Tritium (H3)	kBq	1.7E+02
	(ar) Uranium (U234)	kBq	2.0E-01
	(ar) Uranium (U235)	kBq	1.5E-03
	(ar) Uranium (U238)	kBq	3.4E-01
	(ar) Xenon (Xe133)	kBq	1.2E+03
	(s) Aluminium (Al)	g	1.1E+02
	(s) Arsenic (As)	g	4.6E-02
	(s) Cadmium (Cd)	g	2.2E-01
	(s) Calcium (Ca)	g	4.6E+02
	(s) Carbon (C)	g	3.5E+02
	(s) Chromium (Cr III, Cr VI)	g	1.3E+02
	(s) Cobalt (Co)	g	3.6E-04
	(s) Copper (Cu)	g	4.0E+01
	(s) Iron (Fe)	g	7.3E+02
	(s) Lead (Pb)	g	2.3E-01
	(s) Manganese (Mn)	g	4.6E+00
	(s) Mercury (Hg)	g	5.6E-05
	(s) Nickel (Ni)	g	2.2E+01
	(s) Nitrogen (N)	g	1.5E-03
	(s) Oils (unspecified)	g	1.2E+01
	(s) Phosphorus (P)	g	4.7E+00
	(s) Sulphur (S)	g	6.8E+01
	(s) Zinc (Zn)	g	4.2E+00
	(sr) Americium (Am241)	kBq	1.5E+02
	(sr) Americium (Am243)	kBq	3.2E+00
	(sr) Cesium (Cs135)	kBq	7.1E+04
	(sr) Cesium (Cs137)	kBq	2.0E-01
	(sr) Curium (Cm244)	kBq	2.9E+02
	(sr) Curium (Cm245)	kBq	3.3E-02
	(sr) Iodine (I129)	kBq	4.6E-03
	(sr) Neptunium (Np237)	kBq	4.5E+01
	(sr) Palladium (Pd107)	kBq	1.6E-02
	(sr) Plutonium (Pu239)	kBq	5.5E+04
	(sr) Plutonium (Pu240)	kBq	7.8E+04
	(sr) Plutonium (Pu241)	kBq	1.8E+07
	(sr) Plutonium (Pu242)	kBq	3.0E+02
	(sr) Radium (Ra226)	kBq	3.8E+02
	(sr) Samarium (Sm151)	kBq	6.5E+01
	(sr) Selenium (Se79)	kBq	5.1E-02
	(sr) Strontium (Sr90)	kBq	1.1E+04
	(sr) Technetium (Tc99)	kBq	2.2E+00
	(sr) Thorium (Th230)	kBq	3.8E+02
	(sr) Tin (Sn126)	kBq	8.9E-02
	(sr) Uranium (U234)	kBq	2.3E+02
	(sr) Uranium (U235)	kBq	4.2E+00
	(sr) Uranium (U238)	kBq	6.5E+01
	(sr) Zirconium (Zr93)	kBq	2.8E-01
	(w) Acids (H+)	g	9.5E-03
	(w) Alcohol (unspecified)	g	5.8E-02
	(w) Aldehyde (unspecified)	g	4.0E-02
	(w) Alkane (unspecified)	g	1.3E+00
	(w) Alkene (unspecified)	g	1.2E-01
	(w) Aluminium (Al3+)	g	2.6E+03
	(w) Aluminium Hydroxide (Al(OH)3)	g	6.7E-04
	(w) Ammonia (NH4+, NH3, as N)	g	7.6E+01
	(w) AOX (Adsorbable Organic Halogens)	g	9.0E-02
	(w) Aromatic Hydrocarbons (unspecified)	g	1.9E+01
	(w) Arsenic (As3+, As5+)	g	5.2E+00
	(w) Barium (Ba++)	g	2.7E+02
	(w) Barytes	g	1.6E+03
	(w) Benzene (C6H6)	g	2.9E+00
	(w) BOD5 (Biochemical Oxygen Demand)	g	1.3E+03
	(w) Boric Acid (H3BO3)	g	8.6E-01
	(w) Boron (B III)	g	1.6E-01
	(w) Cadmium (Cd++)	g	5.9E+00
	(w) Calcium (Ca++)	g	1.4E+03
	(w) Carbonates (CO3--, HCO3-, CO2, as C)	g	1.0E+00
	(w) Cerium (Ce++)	g	3.8E-06
	(w) Cesium (Cs++)	g	1.8E-03
	(w) Chlorides (Cl-)	g	5.9E+05
	(w) Chlorinated Matter (unspecified, as Cl)	g	2.1E+02
	(w) Chloroform (CHCl3)	g	2.3E-04
	(w) Chromium (Cr III)	g	9.8E-01
	(w) Chromium (Cr III, Cr VI)	g	4.7E+01
	(w) Chromium (Cr VI)	g	7.7E-04
	(w) Cobalt (Co I, Co II, Co III)	g	6.1E-02
	(w) COD (Chemical Oxygen Demand)	g	3.9E+03
	(w) Copper (Cu+, Cu++)	g	8.9E+01
	(w) Cyanides (CN-)	g	1.3E+00
	(w) Dissolved Matter (unspecified)	g	7.0E+02
	(w) Dissolved Organic Carbon (DOC)	g	9.4E+01
	(w) Edetic Acid (C10H16N2O8, EDTA)	g	1.5E-03
	(w) Ethylbenzene (C6H5C2H5)	g	5.8E-02
	(w) Fluorides (F-)	g	1.7E+01
	(w) Formaldehyde (CH2O)	g	2.9E-06
	(w) Hexachloroethane (C2Cl6)	g	4.0E-10
	(w) Hydrazine (N2H4)	g	6.7E-04
	(w) Hydrocarbons (unspecified)	g	2.4E+00
	(w) Hypochlorite (ClO-)	g	6.8E-02
	(w) Hypochlorous Acid (HClO)	g	6.8E-02
	(w) Inorganic Dissolved Matter (unspecified)	g	4.0E+02
	(w) Iode (I-)	g	1.8E-01
	(w) Iron (Fe++, Fe3+)	g	4.6E+03
	(w) Lead (Pb++, Pb4+)	g	7.3E-01
	(w) Lithium Salts (Lithine)	g	7.5E-05
	(w) Magnesium (Mg++)	g	4.7E+02
	(w) Manganese (Mn II, Mn IV, Mn VII)	g	3.4E+00
	(w) Mercury (Hg+, Hg++)	g	1.3E+01

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	(a) Halon 1301 (CF3Br)	g eq. CO2	7900	1.3E+03
	(a) Methane (CH4)	g eq. CO2	64	3.4E+06
	(a) Nitrous Oxide (N2O)	g eq. CO2	330	1.5E+05
	IPCC-Greenhouse effect (direct, 500 years)	g eq. CO2	*	3.8E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	3.8E+07
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	8900	1.5E+01
	(a) Halon 1301 (CF3Br)	g eq. CO2	2700	4.3E+02
	(a) Methane (CH4)	g eq. CO2	7.5	4.0E+05
	(a) Nitrous Oxide (N2O)	g eq. CO2	190	8.8E+04
	USES 1.0-Aquatic Ecotoxicity	g eq. 1-4-dichlorobenzene	*	1.4E+05
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	5.6	2.0E+00
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.0013	1.3E-01
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	320	8.3E+00
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130	1.1E+02
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	2.6	2.1E-01
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	2.9	4.0E+01
	(a) Ethylene (C2H4)	g eq. 1-4-dichlorobenzene	0.0022	5.0E+00
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	6.1	1.2E+02
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.2	0.0E+00
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	16000	9.1E+04
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	80	3.5E+02
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	39	6.5E-04
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	9.70E-05	3.7E-03
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	11	6.6E+01
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	2.6	0.0E+00
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	3.00E-08	1.4E-09
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	3.90E-06	8.7E-07
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.40E-09	1.8E-07
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	6.80E-08	2.4E-11
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	1.40E-08	5.5E-07
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.80E-09	4.2E-10
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	16000	8.9E-01
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	5.80E-07	1.3E-05
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	3.90E-08	1.6E-07
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	190	9.8E+02
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	1	2.9E+00
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	4500	2.7E+04
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	0.7	1.6E-04
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	84	8.3E+01
	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	84	3.9E+03
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	84	6.5E-02
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	160	4.6E-04
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	0.021	1.4E-02
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	1.1	1.1E-06
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	0.18	4.0E-07
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.16	9.7E-06
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	380	8.4E+01
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.86	0.0E+00
	USES 1.0-Human Toxicity	g eq. 1-4-dichlorobenzene	*	2.9E+08
	(a) Ammonia (NH3)	g eq. 1-4-dichlorobenzene	16	2.5E+03
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	42000	1.5E+04
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	29	3.0E+03
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	3700	9.6E+01
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	23000	2.0E+04
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	7600	6.2E+02
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	350	4.8E+03
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	0.42	8.1E+00
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	67000	0.0E+00
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	29000	1.6E+05
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	9800	4.3E+04
	(a) Nitrogen Oxides (NOx as NO2)	g eq. 1-4-dichlorobenzene	0.26	1.7E+04
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	2.2	3.7E-05
	(a) Sulphur Oxides (SOx as SO2)	g eq. 1-4-dichlorobenzene	0.16	0.0E+00
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.036	1.4E+00
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	4900	3.0E+04
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	0.63	0.0E+00
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	670	3.1E+01
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	20000	4.5E+03
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	1500	5.4E-01
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	30	1.2E+03
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	350	8.1E+01
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	29000	1.6E+00
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	800	1.8E+04
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	12	5.1E+01
	(w) Ammonia (NH4+, NH3, as N)	g eq. 1-4-dichlorobenzene	17	1.3E+03
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	51	2.6E+02
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	22	6.5E+01
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	130	7.7E+02
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	32	7.3E-03
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	9.3	9.2E+00
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	67000	5.2E+01
	(w) Cobalt (Co I, Co II, Co III)	g eq. 1-4-dichlorobenzene	31	1.9E+00
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.1	9.8E+01
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	0.35	1.0E-06
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	0.026	0.0E+00
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	18000	2.4E+05
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	12	7.8E+00
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	63	7.8E+02
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	0.89	4.0E+00
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	37	3.6E-05
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.053	1.3E-01
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	1200	2.6E-03
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.11	6.7E-06
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	19	4.2E+00
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.058	0.0E+00
	USES 1.0-Terrestrial Ecotoxicity	g eq. 1-4-dichlorobenzene	*	2.0E+09
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	72000	2.5E+04
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.063	6.5E+00
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	64000000	1.7E+06
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130000000	1.1E+08
	(a) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	220000	3.5E+05
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	17000	1.4E+03
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	910000	1.3E+07
	(a) Ethylene (C2H4)	g eq. 1-4-dichlorobenzene	17	3.8E+04
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	2600	5.0E+04
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	11000	0.0E+00
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	13000000	7.4E+07
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	190000	8.3E+05
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	11000	1.8E-01
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.035	1.3E+00
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	450000	2.7E+06
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	660000	0.0E+00
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	200000	9.1E+03
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	340000000	7.6E+07
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	600000	7.6E+07
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	45000	1.6E+01
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	2400000	9.5E+07
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	29000	6.7E+03
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	17000000	9.5E+02
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	520000	1.1E+07
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	1800000	7.6E+06
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	9.70E-06	5.0E-05
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.039	1.1E-01
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	0.025	1.5E-01
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	5.2	1.2E-03
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	1.10E-05	1.1E-05
	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.10E-05	5.2E-04
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	1.10E-05	8.5E-09
	(w) Cobalt (Co I, Co II, Co III)	g eq. 1-4-dichlorobenzene	2.00E-07	1.2E-08
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.00E-05	8.9E-04
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	2.5	7.2E-06
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	2.00E-07	0.0E+00
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	8200000	1.1E+08
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	0.078	5.1E-02
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	3.10E-05	3.8E-04
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	34	1.5E+02
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	110	1.1E-04

Plastics and PCBs recovered scenario

LIFE CYCLE INVENTORY

	(w) Metals (unspecified)	g	2.8E+02
	(w) Methylene Chloride (CH2Cl2)	g	6.5E-01
	(w) Molybdenum (Mo II, Mo III, Mo IV, Mo V, Mo VI)	g	1.8E-01
	(w) Morpholine (C4H9NO)	g	7.1E-03
	(w) Nickel (Ni++, Ni3+)	g	1.2E+01
	(w) Nitrates (NO3-)	g	1.1E+03
	(w) Nitrites (NO2-)	g	8.1E-01
	(w) Nitrogenous Matter (Kjeldahl, as N)	g	3.4E-01
	(w) Nitrogenous Matter (unspecified, as N)	g	2.4E+01
	(w) Oils (unspecified)	g	7.6E+02
	(w) Organic Dissolved Matter (unspecified)	g	3.0E-01
	(w) Oxalic Acid ((COOH)2)	g	2.9E-03
	(w) Phenol (C6H5OH)	g	4.5E+00
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g	1.4E+02
	(w) Phosphorous Matter (unspecified, as P)	g	1.3E+00
	(w) Phosphorus (P)	g	3.4E-02
	(w) Phosphorus Pentoxide (P2O5)	g	2.2E-02
	(w) Polycyclic Aromatic Hydrocarbons (PAH, unspecified)	g	1.8E-01
	(w) Potassium (K+)	g	2.5E+02
	(w) Rubidium (Rb+)	g	1.8E-02
	(w) Salts (unspecified)	g	3.0E+04
	(w) Saponifiable Oils and Fats	g	7.2E+01
	(w) Selenium (Se II, Se IV, Se VI)	g	5.7E-02
	(w) Silicon Dioxide (SiO2)	g	2.3E-01
	(w) Silver (Ag+)	g	1.1E-03
	(w) Sodium (Na+)	g	6.1E+03
	(w) Strontium (Sr II)	g	9.8E+01
	(w) Sulphates (SO4--)	g	3.2E+04
	(w) Sulphides (S--)	g	7.4E-01
	(w) Sulphites (SO3--)	g	4.4E-01
	(w) Sulphurated Matter (unspecified, as S)	g	2.7E-05
	(w) Suspended Matter (unspecified)	g	7.8E+03
	(w) Tars (unspecified)	g	1.0E-08
	(w) Tetrachloroethylene (C2Cl4)	g	9.8E-07
	(w) Tin (Sn++, Sn4+)	g	2.0E-04
	(w) Titanium (Ti3+, Ti4+)	g	2.5E+00
	(w) TOC (Total Organic Carbon)	g	8.6E+03
	(w) Toluene (C6H5CH3)	g	2.5E+00
	(w) Trichlorethane (1,1,1-CH3CCl3)	g	2.2E-06
	(w) Trichloroethylene (C2HCl3)	g	6.1E-05
	(w) Triethylene Glycol (C6H14O4)	g	7.5E+01
	(w) Vanadium (V3+, V5+)	g	2.2E-01
	(w) VOC (Volatile Organic Compounds)	g	1.6E+01
	(w) Water (unspecified)	litre	6.9E+02
	(w) Water: Chemically Polluted	litre	3.7E+04
	(w) Xylene (C6H4(CH3)2)	g	2.4E+00
	(w) Zinc (Zn++)	g	1.4E+03
	(wr) Antimony (Sb124)	kBq	3.3E-02
	(wr) Cesium (Cs134)	kBq	2.9E-02
	(wr) Cesium (Cs137)	kBq	4.2E-02
	(wr) Cobalt (Co58)	kBq	9.5E-02
	(wr) Cobalt (Co60)	kBq	5.9E-02
	(wr) Iodine (I131)	kBq	3.6E-03
	(wr) Manganese (Mn54)	kBq	4.7E-03
	(wr) Protactinium (Pa234m)	kBq	1.4E-01
	(wr) Radioactive Substance (unspecified)	kBq	7.0E+04
	(wr) Radium (Ra224)	kBq	8.9E-02
	(wr) Radium (Ra226)	kBq	2.8E+02
	(wr) Radium (Ra228)	kBq	1.8E-01
	(wr) Silver (Ag110m)	kBq	1.4E-01
	(wr) Thorium (Th228)	kBq	3.5E-01
	(wr) Thorium (Th230)	kBq	1.4E+01
	(wr) Thorium (Th234)	kBq	1.4E-01
	(wr) Tritium (H3)	kBq	1.7E+03
	(wr) Uranium (U234)	kBq	4.8E+00
	(wr) Uranium (U235)	kBq	2.1E-01
	(wr) Uranium (U238)	kBq	4.5E+00
	Aluminium (Al)	kg	4.2E+02
	Cardboard	kg	4.6E+02
	Copper	kg	1.1E+02
	Copper (Cu)	kg	4.0E+02
	Gold (Au)	kg	2.2E-01
	Lead (Pb)	kg	2.0E+01
	Nickel (Ni)	kg	1.0E+01
	Palladium (Pd)	kg	1.3E-01
	Polypropylene (PP)	kg	7.8E+00
	Printers for resale	kg	4.9E+03
	Printers for reuse in maintenance	kg	7.2E+02
	Recovered Matter (total)	kg	9.8E+02
	Recovered Matter (unspecified)	kg	7.1E+02
	Recovered Matter: Aluminium Scrap	kg	2.5E+01
	Recovered Matter: Cardboard	kg	2.9E+01
	Recovered Matter: Iron Scrap	kg	1.7E-02
	Recovered Matter: Steel Scrap	kg	2.2E+02
	Recovered Matter: Toner Cartridges	kg	7.5E+01
	Silver (Ag)	kg	4.0E-01
	Steel Plate	kg	6.7E+03
	Waste (hazardous)	kg	9.9E-02
	Waste (incineration)	kg	2.2E-01
	Waste (municipal and industrial)	kg	4.5E+01
	Waste (total)	kg	3.8E+02
	Waste (unspecified)	kg	2.2E+02
	Waste: Active	kg	1.6E+01
	Waste: Highly Radioactive (class C)	kg	4.2E-03
	Waste: Low Radioactive (class A)	kg	1.5E-01
	Waste: Mineral (inert)	kg	3.0E+02
	Waste: Mining	kg	2.2E+02
	Waste: Non Mineral (inert)	kg	9.4E-03
	Waste: Non Toxic Chemicals (unspecified)	kg	6.3E-02
	Waste: Radioactive	kg	3.7E-06
	Waste: Radioactive (unspecified)	kg	1.7E-03
	Waste: Slags and Ash (unspecified)	kg	3.4E+01
	Zinc (Zn)	kg	5.6E+00

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.022	5.6E-02
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	2	4.4E-06
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.024	1.5E-06
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	3.40E-05	7.5E-06
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	2.50E-05	0.0E+00
	WMO-Depletion of the ozone layer (high)	g eq. CFC-11	*	2.8E+00
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	17.2	2.8E+00
	WMO-Depletion of the ozone layer (low)	g eq. CFC-11	*	1.6E+00
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	10	1.6E+00
	WMO-Photochemical oxidant formation (high)	g eq. ethylene	*	1.5E+04
	(a) Acetaldehyde (CH3CHO)	g eq. ethylene	1.22	3.5E-01
	(a) Acetone (CH3COCH3)	g eq. ethylene	0.27	3.4E-02
	(a) Acetylene (C2H2)	g eq. ethylene	0.42	2.7E+00
	(a) Aldehyde (unspecified)	g eq. ethylene	1.263	3.3E-01
	(a) Alkane (unspecified)	g eq. ethylene	1.173	7.7E+02
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	1.285	1.0E+02
	(a) Benzaldehyde (C6H5CHO)	g eq. ethylene	-0.12	-2.6E-07
	(a) Benzene (C6H6)	g eq. ethylene	0.45	4.7E+01
	(a) Butane (n-C4H10)	g eq. ethylene	1.15	3.6E+02
	(a) Butene (1-CH3CH2CHCH2)	g eq. ethylene	1.85	1.5E-01
	(a) Ethane (C2H6)	g eq. ethylene	0.3	1.7E+02
	(a) Ethanol (C2H5OH)	g eq. ethylene	0.89	1.8E-01
	(a) Ethylene (C2H4)	g eq. ethylene	1	2.3E+03
	(a) Formaldehyde (CH2O)	g eq. ethylene	0.58	1.1E+01
	(a) Heptane (C7H16)	g eq. ethylene	1.65	9.1E-01
	(a) Hexane (C6H14)	g eq. ethylene	1.51	1.7E+00
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.799	9.8E+03
	(a) Hydrocarbons (unspecified)	g eq. ethylene	0.808	1.2E+02
	(a) Methane (CH4)	g eq. ethylene	0.03	1.6E+03
	(a) Methanol (CH3OH)	g eq. ethylene	0.21	7.1E-02
	(a) Propane (C3H8)	g eq. ethylene	1.24	2.2E+02
	(a) Propionaldehyde (CH3CH2CHO)	g eq. ethylene	1.6	9.5E-06
	(a) Propylene (CH2CHCH3)	g eq. ethylene	1.63	1.2E+01
	(a) Toluene (C6H5CH3)	g eq. ethylene	0.83	3.2E+01
	WMO-Photochemical oxidant formation (low)	g eq. ethylene	*	4.9E+03
	(a) Acetaldehyde (CH3CHO)	g eq. ethylene	0.33	9.4E-02
	(a) Acetone (CH3COCH3)	g eq. ethylene	0.1	1.2E-02
	(a) Acetylene (C2H2)	g eq. ethylene	0.1	6.4E-01
	(a) Aldehyde (unspecified)	g eq. ethylene	0.079	2.1E-02
	(a) Alkane (unspecified)	g eq. ethylene	0.114	7.5E+01
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	0.481	3.7E+01
	(a) Benzaldehyde (C6H5CHO)	g eq. ethylene	-0.82	-1.8E-06
	(a) Benzene (C6H6)	g eq. ethylene	0.11	1.1E+01
	(a) Butane (n-C4H10)	g eq. ethylene	0.15	4.8E+01
	(a) Butene (1-CH3CH2CHCH2)	g eq. ethylene	0.57	4.6E-02
	(a) Ethane (C2H6)	g eq. ethylene	0.02	1.2E+01
	(a) Ethanol (C2H5OH)	g eq. ethylene	0.04	8.2E-03
	(a) Ethylene (C2H4)	g eq. ethylene	1	2.3E+03
	(a) Formaldehyde (CH2O)	g eq. ethylene	0.22	4.3E+00
	(a) Heptane (C7H16)	g eq. ethylene	0.13	7.2E-02
	(a) Hexane (C6H14)	g eq. ethylene	0.1	1.1E-01
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.195	2.4E+03
	(a) Hydrocarbons (unspecified)	g eq. ethylene	0.194	2.9E+01
	(a) Methane (CH4)	g eq. ethylene	0	0.0E+00
	(a) Methanol (CH3OH)	g eq. ethylene	0.09	3.0E-02
	(a) Propane (C3H8)	g eq. ethylene	0.16	2.9E+01
	(a) Propionaldehyde (CH3CH2CHO)	g eq. ethylene	0.28	1.7E-06
	(a) Propylene (CH2CHCH3)	g eq. ethylene	0.75	5.3E+00
	(a) Toluene (C6H5CH3)	g eq. ethylene	0.41	1.6E+01

Plastics landfilled scenario

LIFE CYCLE INVENTORY

	Flow	Units	Environmental burden
Inputs:	(r) 1-methoxy propan-2-ol	kg	1.2E-01
	(r) Barium Sulphate (BaSO4, in ground)	kg	8.8E+00
	(r) Bauxite (Al2O3, ore)	kg	6.7E-01
	(r) Bentonite (Al2O3.4SiO2.H2O, in ground)	kg	1.1E+00
	(r) Calcium Sulphate (CaSO4, ore)	kg	1.8E-02
	(r) Chromium (Cr, ore)	kg	1.4E-03
	(r) Clay (in ground)	kg	3.3E+00
	(r) Coal (in ground)	kg	2.2E+03
	(r) Commercial butane	g	1.7E+02
	(r) Copper (Cu, ore)	kg	7.1E-03
	(r) Gravel (unspecified)	kg	2.5E+00
	(r) Iron (Fe, ore)	kg	3.0E+01
	(r) Iron Sulphate (FeSO4, ore)	kg	2.1E-02
	(r) Kerosine	kg	1.0E-01
	(r) Lead (Pb, ore)	kg	2.2E-03
	(r) Lignite (in ground)	kg	2.2E+03
	(r) Limestone (CaCO3, in ground)	kg	4.6E+01
	(r) Manganese (Mn, ore)	kg	8.2E-04
	(r) Natural Gas (in ground)	kg	5.5E+03
	(r) Nickel (Ni, ore)	kg	4.7E-04
	(r) Oil (in ground)	kg	5.2E+02
	(r) Propan-2-ol	kg	9.8E-02
	(r) Pyrite (FeS2, ore)	kg	2.2E+02
	(r) Sand (in ground)	kg	6.9E+00
	(r) Silver (Ag, ore)	kg	3.5E-05
	(r) Sodium Chloride (NaCl, in ground or in sea)	kg	2.0E+00
	(r) Sulphur (S, in ground)	kg	9.3E-04
	(r) Uranium (U, ore)	kg	1.4E-01
	(r) Water	kg	2.1E+00
	(r) Zinc (Zn, ore)	kg	5.2E-05
	Argon (Ar)	kg	3.3E-01
	Borax (B4Na2O7)	kg	1.6E-01
	Chlorine (Cl2)	kg	1.9E-01
	Diesel Oil	kg	6.3E+02
	Explosive (unspecified)	kg	2.5E-01
	Gasoline (leaded)	kg	2.2E+00
	Gasoline (unleaded)	kg	2.0E+00
	Heavy Fuel Oil	kg	4.1E+01
	Iron Scrap	kg	1.6E-01
	Land Use (II -> III)	m2a	2.7E+00
	Land Use (II -> IV)	m2a	3.6E-01
	Land Use (III -> IV)	m2a	1.3E-01
	Maize	kg	3.4E+01
	Potatoes	kg	9.2E+00
	Raw Materials (unspecified)	kg	2.9E+02
	Traded-in printers (high-street)	kg	1.0E+03
	Traded-in printers (out-of-town)	kg	2.1E+04
	Water Used (total)	litre	1.4E+05
	Water: Unspecified Origin	litre	1.4E+05
	Wood	kg	1.6E+01
	Wood (standing)	m3	4.0E-03
Outputs:	(a) 1-methoxy propan-2-ol	kg	1.2E-01
	(a) Acetaldehyde (CH3CHO)	g	2.7E-01
	(a) Acetic Acid (CH3COOH)	g	2.7E+01
	(a) Acetone (CH3COCH3)	g	1.1E-01
	(a) Acetylene (C2H2)	g	5.8E+00
	(a) Aldehyde (unspecified)	g	2.5E-01
	(a) Alkane (unspecified)	g	6.5E+02
	(a) Alkene (unspecified)	g	6.9E+00
	(a) Alkyne (unspecified)	g	1.2E-02
	(a) Aluminium (Al)	g	1.1E+02
	(a) Ammonia (NH3)	g	1.2E+02
	(a) Antimony (Sb)	g	2.1E-02
	(a) AOX (Adsorbable Organic Halogens)	g	9.2E-11
	(a) Aromatic Hydrocarbons (unspecified)	g	7.3E+01
	(a) Arsenic (As)	g	3.3E-01
	(a) Barium (Ba)	g	1.3E+00
	(a) Benzaldehyde (C6H5CHO)	g	2.2E-06
	(a) Benzene (C6H6)	g	9.9E+01
	(a) Benzo(a)pyrene (C20H12)	g	2.4E-02
	(a) Beryllium (Be)	g	2.2E-02
	(a) Boron (B)	g	1.1E+01
	(a) Bromium (Br)	g	2.1E+00
	(a) Butane (n-C4H10)	g	3.2E+02
	(a) Butene (1-CH3CH2CHCH2)	g	7.8E-02
	(a) Cadmium (Cd)	g	1.3E-01
	(a) Calcium (Ca)	g	1.5E+01
	(a) Carbon Dioxide (CO2, biomass)	g	1.3E+02
	(a) Carbon Dioxide (CO2, fossil)	g	2.5E+07
	(a) Carbon Monoxide (CO)	g	4.3E+04
	(a) Carbon Tetrafluoride (CF4)	g	1.7E-03
	(a) Chlorine (Cl2)	g	5.8E-06
	(a) Chromium (Cr III, Cr VI)	g	1.6E+00
	(a) Cobalt (Co)	g	7.6E-02
	(a) Copper (Cu)	g	1.4E+01
	(a) Cyanide (CN-)	g	3.5E-02
	(a) Dioxins (unspecified)	g	8.1E-07
	(a) Ethane (C2H6)	g	5.7E+02
	(a) Ethanol (C2H5OH)	g	1.9E-01
	(a) Ethylbenzene (C8H10)	g	7.8E-02
	(a) Ethylene (C2H4)	g	2.2E+03
	(a) Fluorides (F-)	g	6.2E-04
	(a) Fluorine (F2)	g	3.9E-04
	(a) Formaldehyde (CH2O)	g	1.9E+01
	(a) Halogenated Matter (unspecified)	g	2.3E-03
	(a) Halon 1301 (CF3Br)	g	1.6E-01
	(a) Heptane (C7H16)	g	5.2E-01
	(a) Hexane (C6H14)	g	1.1E+00
	(a) Hydrocarbons (except methane)	g	1.1E+04
	(a) Hydrocarbons (unspecified)	g	1.5E+02
	(a) Hydrogen (H2)	g	2.5E-05
	(a) Hydrogen Chloride (HCl)	g	1.7E+03
	(a) Hydrogen Fluoride (HF)	g	1.5E+02
	(a) Hydrogen Sulphide (H2S)	g	8.9E+01
	(a) Iodine (I)	g	5.4E-01
	(a) Iron (Fe)	g	5.7E+01
	(a) Kerosine	kg	1.1E-01
	(a) Ianthanum (La)	g	3.5E-02
	(a) Lead (Pb)	g	7.6E+01
	(a) Magnesium (Mg)	g	3.9E+01
	(a) Manganese (Mn)	g	2.5E+01
	(a) Mercury (Hg)	g	3.1E-01
	(a) Metals (unspecified)	g	2.4E+02
	(a) Methane (CH4)	g	1.6E+05
	(a) Methanol (CH3OH)	g	3.0E-01
	(a) Molybdenum (Mo)	g	7.4E-02
	(a) Nickel (Ni)	g	4.2E+00
	(a) Nitrogen Oxides (NOx as NO2)	g	6.2E+04
	(a) Nitrous Oxide (N2O)	g	4.3E+02
	(a) Organic Matter (unspecified)	g	2.9E-01
	(a) Particulates (unspecified)	g	1.2E+04
	(a) Pentane (C5H12)	g	2.2E+02
	(a) Phenol (C6H5OH)	g	1.7E-05
	(a) Phosphorus (P)	g	2.2E+00
	(a) Phosphorus Pentoxide (P2O5)	g	6.6E-04
	(a) Platinum (Pt)	g	4.0E-05
	(a) Polycyclic Aromatic Hydrocarbons (PAH, except naphthalene)	g	2.3E-03
	(a) Polycyclic Aromatic Hydrocarbons (PAH, unspecified)	g	2.0E+00
	(a) Potassium (K)	g	1.7E+01
	(a) Propan-2-ol	kg	9.8E-02
	(a) Propane (C3H8)	g	1.8E+02
	(a) Propionaldehyde (CH3CH2CHO)	g	5.9E-06
	(a) Propionic Acid (CH3CH2COOH)	g	7.8E-03
	(a) Propylene (CH2CHCH3)	g	6.4E+00
	(a) Scandium (Sc)	g	1.2E-02
	(a) Selenium (Se)	g	2.9E-01
	(a) Silicon (Si)	g	2.2E+02
	(a) Sodium (Na)	g	8.6E+00
	(a) Strontium (Sr)	g	2.2E+00
	(a) Sulphur Oxides (SOx as SO2)	g	9.0E+04
	(a) Tars (unspecified)	g	6.6E-07
	(a) Thallium (Tl)	g	1.1E-02

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	Classification	Units	Charact-erisation	Environmental impact
Methods:	CML-Eutrophication	g eq. PO4	*	8.7E+03
	(a) Nitrogen Oxides (NOx as NO2)	g eq. PO4	0.13	8.0E+03
	(a) Nitrous Oxide (N2O)	g eq. PO4	0.27	1.2E+02
	(w) Ammonia (NH4+, NH3, as N)	g eq. PO4	0.42	2.3E+01
	(w) COD (Chemical Oxygen Demand)	g eq. PO4	0.022	8.6E+01
	(w) Nitrogenous Matter (Kjeldahl, as N)	g eq. PO4	0.42	1.3E-01
	(w) Nitrogenous Matter (unspecified, as N)	g eq. PO4	0.42	9.1E+00
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g eq. PO4	3.06	4.2E+02
	(w) Phosphorous Matter (unspecified, as P)	g eq. PO4	3.06	4.0E+00
	(w) Phosphorus (P)	g eq. PO4	3.06	1.0E-01
	(w) Phosphorus Pentoxide (P2O5)	g eq. PO4	1.336	2.6E-02
	CST-Aquatic Eco-toxicity	eq. Zn water	*	8.4E+03
	(a) Arsenic (As)	eq. Zn water	0.078	2.5E-02
	(a) Cadmium (Cd)	eq. Zn water	79	1.0E+01
	(a) Chromium (Cr III, Cr VI)	eq. Zn water	0.39	6.2E-01
	(a) Copper (Cu)	eq. Zn water	0.66	9.1E+00
	(a) Lead (Pb)	eq. Zn water	1.28	0.0E+00
	(a) Mercury (Hg)	eq. Zn water	196	6.1E+01
	(a) Nickel (Ni)	eq. Zn water	0.12	5.1E-01
	(a) Zinc (Zn)	eq. Zn water	0.076	0.0E+00
	(s) Arsenic (As)	eq. Zn water	0.24	1.1E-02
	(s) Cadmium (Cd)	eq. Zn water	240	5.4E+01
	(s) Chromium (Cr III, Cr VI)	eq. Zn water	1.2	1.5E+02
	(s) Copper (Cu)	eq. Zn water	2	7.9E+01
	(s) Lead (Pb)	eq. Zn water	3.9	9.0E-01
	(s) Mercury (Hg)	eq. Zn water	600	3.4E-02
	(s) Nickel (Ni)	eq. Zn water	0.36	7.9E+00
	(s) Zinc (Zn)	eq. Zn water	0.23	9.7E-01
	(w) Arsenic (As3+, As5+)	eq. Zn water	0.52	2.7E+00
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Zn water	0.00013	1.6E-01
	(w) Cadmium (Cd++)	eq. Zn water	520	8.6E+01
	(w) Chromium (Cr III, Cr VI)	eq. Zn water	2.6	1.2E+02
	(w) Copper (Cu+, Cu++)	eq. Zn water	5.2	8.2E+01
	(w) Lead (Pb++, Pb4+)	eq. Zn water	5.2	0.0E+00
	(w) Mercury (Hg+, Hg++)	eq. Zn water	1300	3.0E+02
	(w) Nickel (Ni++, Ni3+)	eq. Zn water	0.79	9.7E+00
	(w) Oils (unspecified)	eq. Zn water	0.13	9.4E+01
	(w) Phenol (C6H5OH)	eq. Zn water	15.4	6.6E+01
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Zn water	0.01	1.4E+00
	(w) Zinc (Zn++)	eq. Zn water	1	0.0E+00
	CST-Human Toxicity	eq. Pb air	*	9.9E+06
	(a) Aldehyde (unspecified)	eq. Pb air	0.0087	2.2E-03
	(a) Arsenic (As)	eq. Pb air	9000	2.9E+03
	(a) Benzene (C6H6)	eq. Pb air	0.012	1.2E+00
	(a) Cadmium (Cd)	eq. Pb air	19000	2.4E+03
	(a) Carbon Monoxide (CO)	eq. Pb air	0.00014	6.0E+00
	(a) Chromium (Cr III, Cr VI)	eq. Pb air	3700	5.8E+03
	(a) Cobalt (Co)	eq. Pb air	12900	9.8E+03
	(a) Copper (Cu)	eq. Pb air	145	2.0E+03
	(a) Formaldehyde (CH2O)	eq. Pb air	0.0099	1.9E-01
	(a) Lead (Pb)	eq. Pb air	2300	0.0E+00
	(a) Mercury (Hg)	eq. Pb air	46000	1.4E+04
	(a) Nickel (Ni)	eq. Pb air	370	1.6E+03
	(a) Nitrogen Oxides (NOx as NO2)	eq. Pb air	0.002	1.2E+02
	(a) Particulates (unspecified)	eq. Pb air	0.0075	8.8E+01
	(a) Selenium (Se)	eq. Pb air	64000	1.8E+04
	(a) Sulphur Oxides (SOx as SO2)	eq. Pb air	0.0075	6.8E+02
	(a) Tin (Sn)	eq. Pb air	9	6.3E-02
	(a) Zinc (Zn)	eq. Pb air	27	0.0E+00
	(s) Arsenic (As)	eq. Pb air	0.7	3.2E-02
	(s) Cadmium (Cd)	eq. Pb air	1.46	3.3E-01
	(s) Chromium (Cr III, Cr VI)	eq. Pb air	0.29	3.6E+01
	(s) Cobalt (Co)	eq. Pb air	1	3.6E-04
	(s) Copper (Cu)	eq. Pb air	0.009	3.6E-01
	(s) Lead (Pb)	eq. Pb air	0.6	1.4E-01
	(s) Mercury (Hg)	eq. Pb air	3.6	2.0E-04
	(s) Nickel (Ni)	eq. Pb air	0.029	6.3E-01
	(s) Zinc (Zn)	eq. Pb air	0.0007	2.9E-03
	(w) Arsenic (As3+, As5+)	eq. Pb air	1.5	7.7E+00
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Pb air	0.022	2.8E+01
	(w) Cadmium (Cd++)	eq. Pb air	3.2	5.3E-01
	(w) Chromium (Cr III, Cr VI)	eq. Pb air	0.62	2.9E+01
	(w) Cobalt (Co I, Co II, Co III)	eq. Pb air	2.2	1.3E-01
	(w) Copper (Cu+, Cu++)	eq. Pb air	0.022	3.5E-01
	(w) Fluorides (F-)	eq. Pb air	0.045	7.7E-01
	(w) Lead (Pb++, Pb4+)	eq. Pb air	0.86	0.0E+00
	(w) Mercury (Hg+, Hg++)	eq. Pb air	7.8	1.8E+00
	(w) Nickel (Ni++, Ni3+)	eq. Pb air	0.062	7.6E-01
	(w) Phenol (C6H5OH)	eq. Pb air	0.052	2.2E-01
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Pb air	3.20E-06	4.4E-04
	(w) Selenium (Se II, Se IV, Se VI)	eq. Pb air	10.9	5.6E-01
	(w) Tin (Sn++, Sn4+)	eq. Pb air	0.0015	2.7E-07
	(w) Zinc (Zn++)	eq. Pb air	0.0032	0.0E+00
	CST-Terrestrial Eco-toxicity	eq. Zn air	*	1.3E+03
	(a) Arsenic (As)	eq. Zn air	0.75	2.4E-01
	(a) Cadmium (Cd)	eq. Zn air	3.14	4.0E-01
	(a) Chromium (Cr III, Cr VI)	eq. Zn air	0.08	1.3E-01
	(a) Cobalt (Co)	eq. Zn air	0.08	6.1E-03
	(a) Copper (Cu)	eq. Zn air	0.14	1.9E+00
	(a) Lead (Pb)	eq. Zn air	0.13	0.0E+00
	(a) Mercury (Hg)	eq. Zn air	5.94	1.9E+00
	(a) Nickel (Ni)	eq. Zn air	0.35	1.5E+00
	(a) Zinc (Zn)	eq. Zn air	0.33	0.0E+00
	(s) Arsenic (As)	eq. Zn air	2.3	1.0E-01
	(s) Cadmium (Cd)	eq. Zn air	9.6	2.1E+00
	(s) Chromium (Cr III, Cr VI)	eq. Zn air	0.26	3.3E+01
	(s) Cobalt (Co)	eq. Zn air	0.26	9.3E-05
	(s) Copper (Cu)	eq. Zn air	0.42	1.7E+01
	(s) Lead (Pb)	eq. Zn air	0.41	9.5E-02
	(s) Mercury (Hg)	eq. Zn air	18.3	1.0E-03
	(s) Nickel (Ni)	eq. Zn air	1.1	2.4E+01
	(s) Zinc (Zn)	eq. Zn air	1	4.2E+00
	EB(R*Y)-Depletion of non renewable resources	yr-1	*	9.4E+02
	(r) Barium Sulphate (BaSO4, in ground)	yr-1	26.91	2.4E+03
	(r) Bauxite (Al2O3, ore)	yr-1	0.108	7.2E-02
	(r) Chromium (Cr, ore)	yr-1	0.2133	3.0E-04
	(r) Chromium (Cr, ore)	yr-1	0.319	4.5E-04
	(r) Coal (in ground)	yr-1	0.0005037	1.1E+00
	(r) Copper (Cu, ore)	yr-1	28.16	2.0E-01
	(r) Iron (Fe, ore)	yr-1	0.04	1.2E+00
	(r) Lead (Pb, ore)	yr-1	157	3.5E-01
	(r) Lignite (in ground)	yr-1	0.0005037	1.1E+00
	(r) Manganese (Mn, ore)	yr-1	0.296	2.4E-04
	(r) Natural Gas (in ground)	yr-1	0.117	6.4E+02
	(r) Nickel (Ni, ore)	yr-1	59.7	2.8E-02
	(r) Oil (in ground)	yr-1	0.0557	2.9E+01
	(r) Silver (Ag, ore)	yr-1	92837	3.3E+00
	(r) Sulphur (S, in ground)	yr-1	4.408	4.1E-03
	(r) Uranium (U, ore)	yr-1	181	2.5E+01
	(r) Zinc (Zn, ore)	yr-1	40.29	2.1E-03
	ETH-Air Acidification	g eq. H+	/	4.2E+03
	(a) Ammonia (NH3)	g eq. H+	17	7.3E+00
	(a) Hydrogen Chloride (HCl)	g eq. H+	36.5	4.7E+01
	(a) Hydrogen Fluoride (HF)	g eq. H+	20	7.5E+00
	(a) Hydrogen Sulphide (H2S)	g eq. H+	17	5.3E+00
	(a) Nitrogen Oxides (NOx as NO2)	g eq. H+	46	1.3E+03
	(a) Sulphur Oxides (SOx as SO2)	g eq. H+	32	2.8E+03
	IPCC-Greenhouse effect (direct, 100 years)	g eq. CO2	*	2.9E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	2.5E+07
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	5700	9.8E+00
	(a) Halon 1301 (CF3Br)	g eq. CO2	6900	1.1E+03
	(a) Methane (CH4)	g eq. CO2	24	3.9E+06
	(a) Nitrous Oxide (N2O)	g eq. CO2	360	1.5E+05
	IPCC-Greenhouse effect (direct, 20 years)	g eq. CO2	*	3.5E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	2.5E+07
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	3900	6.7E+00
	(a) Halon 1301 (CF3Br)	g eq. CO2	7900	1.2E+03
	(a) Methane (CH4)	g eq. CO2	64	1.0E+07
	(a) Nitrous Oxide (N2O)	g eq. CO2	330	1.4E+05
	IPCC-Greenhouse effect (direct, 500 years)	g eq. CO2	*	2.6E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	2.5E+07
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	8900	1.5E+01

Plastics landfilled scenario

LIFE CYCLE INVENTORY

	(a) Thorium (Th)	g	2.2E-02
	(a) Tin (Sn)	g	7.0E-03
	(a) Titanium (Ti)	g	3.9E+00
	(a) Toluene (C6H5CH3)	g	3.8E+01
	(a) Uranium (U)	g	2.2E-02
	(a) Vanadium (V)	g	5.8E+00
	(a) Water vapour	kg	2.1E+00
	(a) Xylene (C6H4(CH3)2)	g	1.4E+00
	(a) Zinc (Zn)	g	1.3E+02
	(a) Zirconium (Zr)	g	1.7E-02
	(ar) Aerosols and Halogenes (unspecified)	kBq	3.9E-02
	(ar) Carbon (C14)	kBq	1.3E+01
	(ar) Cesium (Cs134)	kBq	4.9E-04
	(ar) Cesium (Cs137)	kBq	4.9E-04
	(ar) Cobalt (Co58)	kBq	4.9E-04
	(ar) Cobalt (Co60)	kBq	4.9E-04
	(ar) Gas (unspecified)	kBq	1.2E+03
	(ar) Iodine (I131)	kBq	2.9E-03
	(ar) Iodine (I133)	kBq	5.7E-03
	(ar) Krypton (Kr85)	kBq	7.5E+01
	(ar) Lead (Pb210)	kBq	5.1E-01
	(ar) Polonium (Po210)	kBq	8.9E-01
	(ar) Potassium (K40)	kBq	1.4E-01
	(ar) Protactinium (Pa234m)	kBq	7.0E-03
	(ar) Radioactive Substance (unspecified)	kBq	7.6E+06
	(ar) Radium (Ra226)	kBq	6.1E-01
	(ar) Radium (Ra228)	kBq	6.8E-02
	(ar) Radon (Rn220)	kBq	2.1E+00
	(ar) Radon (Rn222)	kBq	5.9E+04
	(ar) Thorium (Th228)	kBq	5.8E-02
	(ar) Thorium (Th230)	kBq	1.0E-01
	(ar) Thorium (Th232)	kBq	3.7E-02
	(ar) Thorium (Th234)	kBq	7.0E-03
	(ar) Tritium (H3)	kBq	1.5E+02
	(ar) Uranium (U234)	kBq	1.8E-01
	(ar) Uranium (U235)	kBq	1.3E-03
	(ar) Uranium (U238)	kBq	3.1E-01
	(ar) Xenon (Xe133)	kBq	1.1E+03
	(s) Aluminium (Al)	g	1.1E+02
	(s) Arsenic (As)	g	4.5E-02
	(s) Cadmium (Cd)	g	2.2E-01
	(s) Calcium (Ca)	g	4.5E+02
	(s) Carbon (C)	g	3.5E+02
	(s) Chromium (Cr III, Cr VI)	g	1.3E+02
	(s) Cobalt (Co)	g	3.6E-04
	(s) Copper (Cu)	g	4.0E+01
	(s) Iron (Fe)	g	7.3E+02
	(s) Lead (Pb)	g	2.3E-01
	(s) Manganese (Mn)	g	4.5E+00
	(s) Mercury (Hg)	g	5.6E-05
	(s) Nickel (Ni)	g	2.2E+01
	(s) Nitrogen (N)	g	1.5E-03
	(s) Oils (unspecified)	g	1.2E+01
	(s) Phosphorus (P)	g	4.7E+00
	(s) Sulphur (S)	g	6.8E+01
	(s) Zinc (Zn)	g	4.2E+00
	(sr) Americium (Am241)	kBq	1.3E+02
	(sr) Americium (Am243)	kBq	2.8E+00
	(sr) Cesium (Cs135)	kBq	6.3E+04
	(sr) Cesium (Cs137)	kBq	1.8E-01
	(sr) Curium (Cm244)	kBq	2.6E+02
	(sr) Curium (Cm245)	kBq	2.9E-02
	(sr) Iodine (I129)	kBq	4.2E-03
	(sr) Neptunium (Np237)	kBq	4.1E+01
	(sr) Palladium (Pd107)	kBq	1.4E-02
	(sr) Plutonium (Pu239)	kBq	4.9E+04
	(sr) Plutonium (Pu240)	kBq	7.0E+04
	(sr) Plutonium (Pu241)	kBq	1.6E+07
	(sr) Plutonium (Pu242)	kBq	2.6E+02
	(sr) Radium (Ra226)	kBq	3.4E+02
	(sr) Samarium (Sm151)	kBq	5.9E+01
	(sr) Selenium (Se79)	kBq	4.6E-02
	(sr) Strontium (Sr90)	kBq	9.5E+03
	(sr) Technetium (Tc99)	kBq	1.9E+00
	(sr) Thorium (Th230)	kBq	3.4E+02
	(sr) Tin (Sn126)	kBq	8.0E-02
	(sr) Uranium (U234)	kBq	2.1E+02
	(sr) Uranium (U235)	kBq	3.8E+00
	(sr) Uranium (U238)	kBq	5.8E+01
	(sr) Zirconium (Zr93)	kBq	2.5E-01
	(w) Acids (H+)	g	9.3E-01
	(w) Alcohol (unspecified)	g	5.2E-02
	(w) Aldehyde (unspecified)	g	4.0E-02
	(w) Alkane (unspecified)	g	1.2E+00
	(w) Alkene (unspecified)	g	1.1E-01
	(w) Aluminium (Al3+)	g	2.6E+03
	(w) Aluminium Hydroxide (Al(OH)3)	g	6.0E-04
	(w) Ammonia (NH4+, NH3, as N)	g	5.6E+01
	(w) AOX (Adsorbable Organic Halogens)	g	8.6E-02
	(w) Aromatic Hydrocarbons (unspecified)	g	1.8E+01
	(w) Arsenic (As3+, As5+)	g	5.1E+00
	(w) Barium (Ba++)	g	2.6E+02
	(w) Barytes	g	1.6E+03
	(w) Benzene (C6H6)	g	2.9E+00
	(w) BOD5 (Biochemical Oxygen Demand)	g	1.3E+03
	(w) Boric Acid (H3BO3)	g	7.7E-01
	(w) Boron (B III)	g	1.6E-01
	(w) Cadmium (Cd++)	g	1.6E-01
	(w) Calcium (Ca++)	g	1.4E+03
	(w) Carbonates (CO3--, HCO3-, CO2, as C)	g	9.3E-01
	(w) Cerium (Ce++)	g	3.8E-06
	(w) Cesium (Cs++)	g	1.6E-03
	(w) Chlorides (Cl-)	g	6.3E+04
	(w) Chlorinated Matter (unspecified, as Cl)	g	2.1E+02
	(w) Chloroform (CHCl3)	g	2.2E-04
	(w) Chromium (Cr III)	g	9.8E-01
	(w) Chromium (Cr III, Cr VI)	g	4.7E+01
	(w) Chromium (Cr VI)	g	7.7E-04
	(w) Cobalt (Co I, Co II, Co III)	g	6.0E-02
	(w) COD (Chemical Oxygen Demand)	g	3.9E+03
	(w) Copper (Cu+, Cu++)	g	1.6E+01
	(w) Cyanides (CN-)	g	1.2E+00
	(w) Dissolved Matter (unspecified)	g	6.5E+02
	(w) Dissolved Organic Carbon (DOC)	g	9.2E+01
	(w) Edetic Acid (C10H16N2O8, EDTA)	g	1.3E-03
	(w) Ethylbenzene (C6H5C2H5)	g	5.3E-02
	(w) Fluorides (F-)	g	1.7E+01
	(w) Formaldehyde (CH2O)	g	2.9E-06
	(w) Hexachloroethane (C2Cl6)	g	4.0E-10
	(w) Hydrazine (N2H4)	g	6.0E-04
	(w) Hydrocarbons (unspecified)	g	2.4E+00
	(w) Hypochlorite (ClO-)	g	6.8E-02
	(w) Hypochlorous Acid (HClO)	g	6.8E-02
	(w) Inorganic Dissolved Matter (unspecified)	g	4.0E+02
	(w) Iode (I-)	g	1.7E-01
	(w) Iron (Fe++, Fe3+)	g	4.6E+03
	(w) Lead (Pb++, Pb4+)	g	1.7E+01
	(w) Lithium Salts (Lithine)	g	6.7E-05
	(w) Magnesium (Mg++)	g	4.7E+02
	(w) Manganese (Mn II, Mn IV, Mn VII)	g	3.1E+00
	(w) Mercury (Hg+, Hg++)	g	2.3E-01
	(w) Metals (unspecified)	g	2.7E+02
	(w) Methylene Chloride (CH2Cl2)	g	6.4E-01
	(w) Molybdenum (Mo II, Mo III, Mo IV, Mo V, Mo VI)	g	1.7E-01
	(w) Morpholine (C4H9NO)	g	6.4E-03
	(w) Nickel (Ni++, Ni3+)	g	1.2E+01
	(w) Nitrates (NO3-)	g	1.1E+03
	(w) Nitrites (NO2-)	g	8.1E-01
	(w) Nitrogenous Matter (Kjeldahl, as N)	g	3.0E-01
	(w) Nitrogenous Matter (unspecified, as N)	g	2.2E+01
	(w) Oils (unspecified)	g	7.2E+02
	(w) Organic Dissolved Matter (unspecified)	g	2.9E-01
	(w) Oxalic Acid ((COOH)2)	g	2.6E-03
	(w) Phenol (C6H5OH)	g	4.3E+00

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	(a) Halon 1301 (CF3Br)	g eq. CO2	2700	4.2E+02
	(a) Methane (CH4)	g eq. CO2	7.5	1.2E+06
	(a) Nitrous Oxide (N2O)	g eq. CO2	190	8.1E+04
	USES 1.0-Aquatic Ecotoxicity	g eq. 1-4-dichlorobenzene	*	2.2E+04
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	5.6	1.8E+00
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.0013	1.3E-01
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	320	7.6E+00
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130	1.7E+01
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	2.6	2.0E-01
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	2.9	4.0E+01
	(a) Ethylene (C2H4)	g eq. 1-4-dichlorobenzene	0.0022	4.9E+00
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	6.1	1.2E+02
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.2	0.0E+00
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	16000	5.0E+03
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	80	3.4E+02
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	39	6.4E-04
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	9.70E-05	3.7E-03
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	11	6.4E+01
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	2.6	0.0E+00
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	3.00E-08	1.4E-09
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	3.90E-06	8.7E-07
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.40E-09	1.8E-07
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	6.80E-08	2.4E-11
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	1.40E-08	5.5E-07
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.80E-09	4.2E-10
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	16000	8.9E-01
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	5.80E-07	1.3E-05
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	3.90E-08	1.6E-07
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	190	9.7E+02
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	1	2.9E+00
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	4500	7.4E+02
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	0.7	1.6E-04
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	84	8.2E+01
	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	84	3.9E+03
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	84	6.5E-02
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	160	4.6E-04
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	0.021	1.4E-02
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	1.1	1.1E-06
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	0.18	3.9E-07
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.16	9.6E-06
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	380	7.5E+01
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.86	0.0E+00
	USES 1.0-Human Toxicity	g eq. 1-4-dichlorobenzene	*	2.8E+08
	(a) Ammonia (NH3)	g eq. 1-4-dichlorobenzene	16	2.0E+03
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	42000	1.4E+04
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	29	2.9E+03
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	3700	8.8E+01
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	23000	3.0E+03
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	7600	5.8E+02
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	350	4.8E+03
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	0.42	8.0E+00
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	67000	0.0E+00
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	29000	9.1E+03
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	9800	4.2E+04
	(a) Nitrogen Oxides (NOx as NO2)	g eq. 1-4-dichlorobenzene	0.26	1.6E+04
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	2.2	3.6E-05
	(a) Sulphur Oxides (SOx as SO2)	g eq. 1-4-dichlorobenzene	0.16	1.4E+04
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.036	1.4E+00
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	4900	2.8E+04
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	0.63	0.0E+00
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	670	3.0E+01
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	20000	4.5E+03
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	1500	5.4E-01
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	30	1.2E+03
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	350	8.1E+01
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	29000	1.6E+00
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	800	1.8E+04
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	12	5.0E+01
	(w) Ammonia (NH4+, NH3, as N)	g eq. 1-4-dichlorobenzene	17	9.5E+02
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	51	2.6E+02
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	22	6.4E+01
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	130	2.1E+01
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	32	7.2E-03
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	9.3	9.1E+00
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	67000	5.2E+01
	(w) Cobalt (Co I, Co II, Co III)	g eq. 1-4-dichlorobenzene	31	1.9E+00
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.1	1.7E+01
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	0.35	1.0E-06
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	0.026	0.0E+00
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	18000	4.2E+03
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	12	7.7E+00
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	63	7.8E+02
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	0.89	3.8E+06
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	37	3.6E-05
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.053	1.3E-01
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	1200	2.6E-03
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.11	6.6E-06
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	19	3.8E+00
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.058	0.0E+00
	USES 1.0-Terrestrial Ecotoxicity	g eq. 1-4-dichlorobenzene	*	1.7E+09
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	72000	2.3E+04
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.063	6.2E+00
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	64000000	1.5E+06
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130000000	1.7E+07
	(a) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	220000	3.5E+05
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	17000	1.3E+03
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	910000	1.3E+07
	(a) Ethylene (C2H4)	g eq. 1-4-dichlorobenzene	17	3.8E+04
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	2600	5.0E+04
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	11000	0.0E+00
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	13000000	4.1E+06
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	190000	8.1E+05
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	11000	1.8E-01
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.035	1.3E+00
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	450000	2.6E+06
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	660000	0.0E+00
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	200000	9.1E+03
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	340000000	7.6E+07
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	600000	7.5E+07
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	45000	1.6E+01
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	2400000	9.5E+07
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	29000	6.7E+03
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	17000000	9.5E+02
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	520000	1.1E+07
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	1800000	7.6E+06
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	9.70E-06	5.0E-05
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.039	1.1E-01
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	0.025	4.1E-03
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	5.2	1.2E-03
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	1.10E-05	1.1E-05
	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.10E-05	5.1E-04
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	1.10E-05	8.5E-09
	(w) Cobalt (Co I, Co II, Co III)	g eq. 1-4-dichlorobenzene	2.00E-07	1.2E-08
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.00E-05	1.6E-04
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	2.5	7.1E-06
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	2.00E-07	0.0E+00
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	8200000	1.9E+06
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	0.078	5.0E-02
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	3.10E-05	3.8E-04
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	34	1.5E+02
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	110	1.1E-04
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.022	5.2E-02
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	2	4.4E-06
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.024	1.4E-06
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	3.40E-05	6.8E-06
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	2.50E-05	0.0E+00
	WMO-Depletion of the ozone layer (high)	g eq. CFC-11	*	2.7E+00
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	17.2	2.7E+00
	WMO-Depletion of the ozone layer (low)	g eq. CFC-11	*	1.6E+00
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	10	1.6E+00
	WMO-Photochemical oxidant formation (high)	g eq. ethylene	*	1.8E+04
	(a) Acetaldehyde (CH3CHO)	g eq. ethylene	1.22	3.3E-01
	(a) Acetone (CH3COCH3)	g eq. ethylene	0.27	3.1E-02
	(a) Acetylene (C2H2)	g eq. ethylene	0.42	2.4E+00

Plastics landfilled scenario

LIFE CYCLE INVENTORY

	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g	1.4E+02
	(w) Phosphorous Matter (unspecified, as P)	g	1.3E+00
	(w) Phosphorus (P)	g	3.3E-02
	(w) Phosphorus Pentoxide (P2O5)	g	2.0E-02
	(w) Polycyclic Aromatic Hydrocarbons (PAH, unspecified)	g	1.6E-01
	(w) Potassium (K+)	g	2.4E+02
	(w) Rubidium (Rb+)	g	1.6E-02
	(w) Salts (unspecified)	g	1.8E+04
	(w) Saponifiable Oils and Fats	g	7.1E+01
	(w) Selenium (Se II, Se IV, Se VI)	g	5.1E-02
	(w) Silicon Dioxide (SiO2)	g	2.3E-01
	(w) Silver (Ag+)	g	9.5E-04
	(w) Sodium (Na+)	g	6.0E+03
	(w) Strontium (Sr II)	g	9.7E+01
	(w) Sulphates (SO4--)	g	2.9E+04
	(w) Sulphides (S--)	g	7.0E-01
	(w) Sulphites (SO3--)	g	4.4E-01
	(w) Sulphurated Matter (unspecified, as S)	g	2.4E-05
	(w) Suspended Matter (unspecified)	g	7.5E+03
	(w) Tars (unspecified)	g	9.4E-09
	(w) Tetrachloroethylene (C2Cl4)	g	9.7E-07
	(w) Tin (Sn++, Sn4+)	g	1.8E-04
	(w) Titanium (Ti3+, Ti4+)	g	2.5E+00
	(w) TOC (Total Organic Carbon)	g	2.5E+03
	(w) Toluene (C6H5CH3)	g	2.4E+00
	(w) Trichlorethane (1,1,1-CH3CCl3)	g	2.2E-06
	(w) Trichloroethylene (C2HCl3)	g	6.0E-05
	(w) Triethylene Glycol (C6H14O4)	g	7.4E+01
	(w) Vanadium (V3+, V5+)	g	2.0E-01
	(w) VOC (Volatile Organic Compounds)	g	1.6E+01
	(w) Water (unspecified)	litre	6.2E+02
	(w) Water: Chemically Polluted	litre	3.7E+04
	(w) Xylene (C6H4(CH3)2)	g	2.2E+00
	(w) Zinc (Zn++)	g	3.6E+01
	(wr) Antimony (Sb124)	kBq	2.9E-02
	(wr) Cesium (Cs134)	kBq	2.6E-02
	(wr) Cesium (Cs137)	kBq	3.8E-02
	(wr) Cobalt (Co58)	kBq	8.5E-02
	(wr) Cobalt (Co60)	kBq	5.3E-02
	(wr) Iodine (I131)	kBq	3.2E-03
	(wr) Manganese (Mn54)	kBq	4.2E-03
	(wr) Protactinium (Pa234m)	kBq	1.3E-01
	(wr) Radioactive Substance (unspecified)	kBq	7.0E+04
	(wr) Radium (Ra224)	kBq	7.9E-02
	(wr) Radium (Ra226)	kBq	2.5E+02
	(wr) Radium (Ra228)	kBq	1.6E-01
	(wr) Silver (Ag110m)	kBq	1.3E-01
	(wr) Thorium (Th228)	kBq	3.2E-01
	(wr) Thorium (Th230)	kBq	1.2E+01
	(wr) Thorium (Th234)	kBq	1.3E-01
	(wr) Tritium (H3)	kBq	1.5E+03
	(wr) Uranium (U234)	kBq	4.3E+00
	(wr) Uranium (U235)	kBq	1.9E-01
	(wr) Uranium (U238)	kBq	4.0E+00
	Aluminium (Al)	kg	4.2E+02
	Cardboard	kg	4.6E+02
	Copper	kg	1.1E+02
	Copper (Cu)	kg	4.0E+02
	Gold (Au)	kg	2.2E-01
	Lead (Pb)	kg	2.0E+01
	Nickel (Ni)	kg	1.0E+01
	Palladium (Pd)	kg	1.3E-01
	Polypropylene (PP)	kg	7.8E+00
	Printers for resale	kg	4.9E+03
	Printers for reuse in maintenance	kg	7.2E+02
	Recovered Matter (total)	kg	9.8E+02
	Recovered Matter (unspecified)	kg	7.1E+02
	Recovered Matter: Aluminium Scrap	kg	2.5E+01
	Recovered Matter: Cardboard	kg	2.9E+01
	Recovered Matter: Iron Scrap	kg	1.5E-02
	Recovered Matter: Steel Scrap	kg	2.2E+02
	Recovered Matter: Toner Cartridges	kg	7.5E+01
	Silver (Ag)	kg	4.0E-01
	Steel Plate	kg	6.7E+03
	Waste (hazardous)	kg	8.9E-02
	Waste (incineration)	kg	2.2E-01
	Waste (municipal and industrial)	kg	4.5E+01
	Waste (total)	kg	3.5E+02
	Waste (unspecified)	kg	2.2E+02
	Waste: Active	kg	1.6E+01
	Waste: Highly Radioactive (class C)	kg	3.8E-03
	Waste: Low Radioactive (class A)	kg	1.4E-01
	Waste: Mineral (inert)	kg	2.8E+02
	Waste: Mining	kg	2.0E+02
	Waste: Non Mineral (inert)	kg	8.4E-03
	Waste: Non Toxic Chemicals (unspecified)	kg	6.3E-02
	Waste: Radioactive	kg	3.7E-06
	Waste: Radioactive (unspecified)	kg	1.5E-03
	Waste: Slags and Ash (unspecified)	kg	3.1E+01
	Zinc (Zn)	kg	5.6E+00

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	(a) Aldehyde (unspecified)	g eq. ethylene	1.263	3.1E-01
	(a) Alkane (unspecified)	g eq. ethylene	1.173	7.6E+02
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	1.285	9.4E+01
	(a) Benzaldehyde (C6H5CHO)	g eq. ethylene	-0.12	-2.6E-07
	(a) Benzene (C6H6)	g eq. ethylene	0.45	4.4E+01
	(a) Butane (n-C4H10)	g eq. ethylene	1.15	3.6E+02
	(a) Butene (1-CH3CH2CHCH2)	g eq. ethylene	1.85	1.4E-01
	(a) Ethane (C2H6)	g eq. ethylene	0.3	1.7E+02
	(a) Ethanol (C2H5OH)	g eq. ethylene	0.89	1.7E-01
	(a) Ethylene (C2H4)	g eq. ethylene	1	2.2E+03
	(a) Formaldehyde (CH2O)	g eq. ethylene	0.58	1.1E+01
	(a) Heptane (C7H16)	g eq. ethylene	1.65	8.5E-01
	(a) Hexane (C6H14)	g eq. ethylene	1.51	1.6E+00
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.799	8.9E+03
	(a) Hydrocarbons (unspecified)	g eq. ethylene	0.808	1.2E+02
	(a) Methane (CH4)	g eq. ethylene	0.03	4.9E+03
	(a) Methanol (CH3OH)	g eq. ethylene	0.21	6.4E-02
	(a) Propane (C3H8)	g eq. ethylene	1.24	2.2E+02
	(a) Propionaldehyde (CH3CH2CHO)	g eq. ethylene	1.6	9.5E-06
	(a) Propylene (CH2CHCH3)	g eq. ethylene	1.63	1.0E+01
	(a) Toluene (C6H5CH3)	g eq. ethylene	0.83	3.1E+01
	WMO-Photochemical oxidant formation (low)	g eq. ethylene	*	4.7E+03
	(a) Acetaldehyde (CH3CHO)	g eq. ethylene	0.33	9.0E-02
	(a) Acetone (CH3COCH3)	g eq. ethylene	0.1	1.1E-02
	(a) Acetylene (C2H2)	g eq. ethylene	0.1	5.8E-01
	(a) Aldehyde (unspecified)	g eq. ethylene	0.079	2.0E-02
	(a) Alkane (unspecified)	g eq. ethylene	0.114	7.4E+01
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	0.481	3.5E+01
	(a) Benzaldehyde (C6H5CHO)	g eq. ethylene	-0.82	-1.8E-06
	(a) Benzene (C6H6)	g eq. ethylene	0.11	1.1E+01
	(a) Butane (n-C4H10)	g eq. ethylene	0.15	4.7E+01
	(a) Butene (1-CH3CH2CHCH2)	g eq. ethylene	0.57	4.4E-02
	(a) Ethane (C2H6)	g eq. ethylene	0.02	1.1E+01
	(a) Ethanol (C2H5OH)	g eq. ethylene	0.04	7.5E-03
	(a) Ethylene (C2H4)	g eq. ethylene	1	2.2E+03
	(a) Formaldehyde (CH2O)	g eq. ethylene	0.22	4.2E+00
	(a) Heptane (C7H16)	g eq. ethylene	0.13	6.7E-02
	(a) Hexane (C6H14)	g eq. ethylene	0.1	1.1E-01
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.195	2.2E+03
	(a) Hydrocarbons (unspecified)	g eq. ethylene	0.194	2.8E+01
	(a) Methane (CH4)	g eq. ethylene	0	0.0E+00
	(a) Methanol (CH3OH)	g eq. ethylene	0.09	2.7E-02
	(a) Propane (C3H8)	g eq. ethylene	0.16	2.8E+01
	(a) Propionaldehyde (CH3CH2CHO)	g eq. ethylene	0.28	1.7E-06
	(a) Propylene (CH2CHCH3)	g eq. ethylene	0.75	4.8E+00
	(a) Toluene (C6H5CH3)	g eq. ethylene	0.41	1.6E+01

Plastics landfilled scenario (expanded boundary)

LIFE CYCLE INVENTORY

	Flow	Units	Environmental burden
Inputs:	(r) Barium Sulphate (BaSO4, in ground)	kg	6.5E-01
	(r) Bauxite (Al2O3, ore)	kg	3.6E-01
	(r) Bentonite (Al2O3.4SiO2.H2O, in ground)	kg	2.2E-01
	(r) Chromium (Cr, ore)	kg	2.2E-02
	(r) Clay (in ground)	kg	6.4E-01
	(r) Coal (in ground)	kg	2.4E+02
	(r) Copper (Cu, ore)	kg	1.6E+04
	(r) Iron (Fe, ore)	kg	8.1E+00
	(r) Lead (Pb, ore)	kg	1.0E+01
	(r) Lignite (in ground)	kg	1.4E+02
	(r) Limestone (CaCO3, in ground)	kg	8.1E+00
	(r) Manganese (Mn, ore)	kg	2.5E-02
	(r) Natural Gas (in ground)	kg	1.6E+02
	(r) Nickel (Ni, ore)	kg	1.0E+01
	(r) Oil (in ground)	kg	1.1E+02
	(r) Palladium (Pd, ore)	kg	9.0E-02
	(r) Pyrite (FeS2, ore)	kg	6.8E+01
	(r) Sand (in ground)	kg	5.0E+00
	(r) Silver (Ag, ore)	kg	8.5E-01
	(r) Sodium Chloride (NaCl, in ground or in sea)	kg	2.8E-01
	(r) Uranium (U, ore)	kg	9.6E-03
	(r) Zinc (Zn, ore)	kg	5.6E+00
	Gold (Au)	kg	1.8E-01
	Lead Scrap	kg	1.0E+01
	Water Used (total)	litre	2.4E+04
	Water: Unspecified Origin	litre	2.4E+04
	Wood	kg	2.5E+00
Outputs:	(a) Acetaldehyde (CH3CHO)	g	1.6E-01
	(a) Acetic Acid (CH3COOH)	g	9.9E-01
	(a) Acetone (CH3COCH3)	g	1.6E-01
	(a) Acrolein (CH2CHCHO)	g	2.4E-06
	(a) Alcohol (unspecified)	g	3.6E-02
	(a) Aldehyde (unspecified)	g	5.9E-02
	(a) Alkane (unspecified)	g	3.8E+01
	(a) Alkene (unspecified)	g	1.3E+00
	(a) Alkyne (unspecified)	g	3.8E-01
	(a) Aluminium (Al)	g	1.3E+01
	(a) Ammonia (NH3)	g	2.4E+00
	(a) Antimony (Sb)	g	2.9E-03
	(a) Aromatic Hydrocarbons (unspecified)	g	8.6E-02
	(a) Arsenic (As)	g	3.6E+00
	(a) Barium (Ba)	g	1.7E-01
	(a) Benzaldehyde (C6H5CHO)	g	2.5E-07
	(a) Benzene (C6H6)	g	3.5E+00
	(a) Benzo(a)pyrene (C20H12)	g	5.7E-04
	(a) Boron (B)	g	3.2E+00
	(a) Bromium (Br)	g	5.3E-01
	(a) Cadmium (Cd)	g	3.8E-01
	(a) Calcium (Ca)	g	5.3E+00
	(a) Carbon Dioxide (CO2, fossil)	g	1.2E+06
	(a) Carbon Hexafluoride (C2F6)	g	5.7E-04
	(a) Carbon Monoxide (CO)	g	5.7E+02
	(a) Carbon Tetrafluoride (CF4)	g	1.3E-02
	(a) CFC 11 (CFCl3)	g	1.2E-03
	(a) CFC 114 (CF2ClCF2Cl)	g	3.1E-02
	(a) CFC 12 (CCl2F2)	g	2.5E-04
	(a) CFC 13 (CF3Cl)	g	1.6E-04
	(a) Chromium (Cr III, Cr VI)	g	5.8E-02
	(a) Cobalt (Co)	g	4.7E-02
	(a) Copper (Cu)	g	7.3E+01
	(a) Cyanide (CN-)	g	3.2E-03
	(a) Dioxins (unspecified)	g	2.7E-08
	(a) Ethane (C2H6)	g	6.4E-01
	(a) Ethanol (C2H5OH)	g	3.1E-01
	(a) Ethylbenzene (C8H10)	g	4.9E-01
	(a) Ethylene (C2H4)	g	6.0E-01
	(a) Halon 1301 (CF3Br)	g	4.0E-02
	(a) HCFC 22 (CHF2Cl)	g	2.0E-11
	(a) Hydrocarbons (except methane)	g	8.8E+02
	(a) Hydrogen Chloride (HCl)	g	1.4E+02
	(a) Hydrogen Fluoride (HF)	g	1.5E+01
	(a) Hydrogen Sulphide (H2S)	g	3.1E+00
	(a) Iron (Fe)	g	9.7E+00
	(a) Lead (Pb)	g	4.4E+01
	(a) Magnesium (Mg)	g	4.4E+00
	(a) Manganese (Mn)	g	2.6E-01
	(a) Mercury (Hg)	g	9.8E-02
	(a) Methane (CH4)	g	2.4E+03
	(a) Methanol (CH3OH)	g	4.2E-01
	(a) Molybdenum (Mo)	g	1.2E-02
	(a) Nickel (Ni)	g	3.7E+01
	(a) Nitrogen Oxides (NOx as NO2)	g	2.1E+03
	(a) Nitrous Oxide (N2O)	g	2.6E+01
	(a) Particulates (unspecified)	g	7.7E+02
	(a) Pentachlorobenzene (C6HCl5)	g	2.1E-07
	(a) Pentachlorophenol (PCP, C6Cl5OH)	g	3.3E-08
	(a) Phenol (C6H5OH)	g	4.1E-04
	(a) Phosphorus (P)	g	3.0E-01
	(a) Polycyclic Aromatic Hydrocarbons (PAH, unspecified)	g	3.0E-02
	(a) Potassium (K)	g	2.5E+00
	(a) Scandium (Sc)	g	1.0E-03
	(a) Selenium (Se)	g	4.3E-02
	(a) Silicon (Si)	g	4.2E+01
	(a) Sodium (Na)	g	7.9E-01
	(a) Strontium (Sr)	g	1.9E-01
	(a) Sulphur Oxides (SOx as SO2)	g	2.8E+05
	(a) Thallium (Tl)	g	8.4E-04
	(a) Tin (Sn)	g	1.6E-03
	(a) Titanium (Ti)	g	4.6E-01
	(a) Toluene (C6H5CH3)	g	1.1E+00
	(a) Vanadium (V)	g	2.1E+00
	(a) Xylene (C6H4(CH3)2)	g	2.2E+00
	(a) Zinc (Zn)	g	7.6E+01
	(s) Aluminium (Al)	g	8.9E+00
	(s) Arsenic (As)	g	3.5E-03
	(s) Cadmium (Cd)	g	1.2E-04
	(s) Calcium (Ca)	g	3.5E+01
	(s) Carbon (C)	g	2.7E+01
	(s) Chromium (Cr III, Cr VI)	g	4.4E-02
	(s) Cobalt (Co)	g	1.4E-04

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	Classification	Units	Charact-erisation	Environmental impact
Methods:	CML-Eutrophication	g eq. PO4	*	3.5E+02
	(a) Nitrogen Oxides (NOx as NO2)	g eq. PO4	0.13	2.7E+02
	(a) Nitrous Oxide (N2O)	g eq. PO4	0.27	6.9E+00
	(w) Ammonia (NH4+, NH3, as N)	g eq. PO4	0.42	3.3E+00
	(w) COD (Chemical Oxygen Demand)	g eq. PO4	0.022	3.1E-01
	(w) Nitrogenous Matter (unspecified, as N)	g eq. PO4	0.42	8.8E-01
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g eq. PO4	3.06	6.8E+01
	CST-Aquatic Eco-toxicity	eq. Zn water	*	2.3E+02
	(a) Arsenic (As)	eq. Zn water	0.078	2.8E-01
	(a) Cadmium (Cd)	eq. Zn water	79	3.0E+01
	(a) Chromium (Cr III, Cr VI)	eq. Zn water	0.39	2.2E-02
	(a) Copper (Cu)	eq. Zn water	0.66	4.8E+01
	(a) Lead (Pb)	eq. Zn water	1.28	5.7E+01
	(a) Mercury (Hg)	eq. Zn water	196	1.9E+01
	(a) Nickel (Ni)	eq. Zn water	0.12	4.5E+00
	(a) Zinc (Zn)	eq. Zn water	0.076	5.7E+00
	(s) Arsenic (As)	eq. Zn water	0.24	8.5E-04
	(s) Cadmium (Cd)	eq. Zn water	240	2.8E-02
	(s) Chromium (Cr III, Cr VI)	eq. Zn water	1.2	5.3E-02
	(s) Copper (Cu)	eq. Zn water	2	1.4E-03
	(s) Lead (Pb)	eq. Zn water	3.9	1.2E-02
	(s) Mercury (Hg)	eq. Zn water	600	1.2E-02
	(s) Nickel (Ni)	eq. Zn water	0.36	3.7E-04
	(s) Zinc (Zn)	eq. Zn water	0.23	3.2E-02
	(w) Arsenic (As3+, As5+)	eq. Zn water	0.52	3.9E-01
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Zn water	0.00013	1.8E-04
	(w) Cadmium (Cd++)	eq. Zn water	520	7.6E+00
	(w) Copper (Cu+, Cu++)	eq. Zn water	5.2	1.1E+01
	(w) Lead (Pb++, Pb4+)	eq. Zn water	5.2	1.1E+01
	(w) Mercury (Hg+, Hg++)	eq. Zn water	1300	1.3E+00
	(w) Nickel (Ni++, Ni3+)	eq. Zn water	0.79	1.6E+00
	(w) Oils (unspecified)	eq. Zn water	0.13	1.3E+01
	(w) Phenol (C6H5OH)	eq. Zn water	15.4	1.0E+01
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Zn water	0.01	2.2E-01
	(w) Zinc (Zn++)	eq. Zn water	1	4.0E+00
	CST-Human Toxicity	eq. Pb air	*	1.8E+05
	(a) Aldehyde (unspecified)	eq. Pb air	0.0087	5.1E-04
	(a) Arsenic (As)	eq. Pb air	9000	3.3E+04
	(a) Benzene (C6H6)	eq. Pb air	0.012	4.2E-02
	(a) Cadmium (Cd)	eq. Pb air	19000	7.3E+03
	(a) Carbon Monoxide (CO)	eq. Pb air	0.00014	8.0E-02
	(a) Chromium (Cr III, Cr VI)	eq. Pb air	3700	2.1E+02
	(a) Cobalt (Co)	eq. Pb air	12900	6.1E+02
	(a) Copper (Cu)	eq. Pb air	145	1.1E+04
	(a) Lead (Pb)	eq. Pb air	2300	1.0E+05
	(a) Mercury (Hg)	eq. Pb air	46000	4.5E+03
	(a) Nickel (Ni)	eq. Pb air	370	1.4E+04
	(a) Nitrogen Oxides (NOx as NO2)	eq. Pb air	0.002	4.1E+00
	(a) Particulates (unspecified)	eq. Pb air	0.0075	5.8E+00
	(a) Selenium (Se)	eq. Pb air	64000	2.8E+03
	(a) Sulphur Oxides (SOx as SO2)	eq. Pb air	0.0075	2.1E+03
	(a) Tin (Sn)	eq. Pb air	9	1.5E-02
	(a) Zinc (Zn)	eq. Pb air	27	2.0E+03
	(s) Arsenic (As)	eq. Pb air	0.7	2.5E-03
	(s) Cadmium (Cd)	eq. Pb air	1.46	1.7E-04
	(s) Chromium (Cr III, Cr VI)	eq. Pb air	0.29	1.3E-02
	(s) Cobalt (Co)	eq. Pb air	1	1.4E-04
	(s) Copper (Cu)	eq. Pb air	0.009	6.1E-06
	(s) Lead (Pb)	eq. Pb air	0.6	1.9E-03
	(s) Mercury (Hg)	eq. Pb air	3.6	7.5E-05
	(s) Nickel (Ni)	eq. Pb air	0.029	3.0E-05
	(s) Zinc (Zn)	eq. Pb air	0.0007	9.8E-05
	(w) Arsenic (As3+, As5+)	eq. Pb air	1.5	1.1E+00
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Pb air	0.022	3.1E-02
	(w) Cadmium (Cd++)	eq. Pb air	3.2	4.7E-02
	(w) Cobalt (Co I, Co II, Co III)	eq. Pb air	2.2	1.1E+00
	(w) Copper (Cu+, Cu++)	eq. Pb air	0.022	4.8E-02
	(w) Fluorides (F-)	eq. Pb air	0.045	1.2E-01
	(w) Lead (Pb++, Pb4+)	eq. Pb air	0.86	1.9E+00
	(w) Mercury (Hg+, Hg++)	eq. Pb air	7.8	8.0E-03
	(w) Nickel (Ni++, Ni3+)	eq. Pb air	0.062	1.2E-01
	(w) Phenol (C6H5OH)	eq. Pb air	0.052	3.5E-02
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Pb air	3.20E-06	7.1E-05
	(w) Selenium (Se II, Se IV, Se VI)	eq. Pb air	10.9	1.3E+01
	(w) Tin (Sn++, Sn4+)	eq. Pb air	0.0015	2.0E-06
	(w) Zinc (Zn++)	eq. Pb air	0.0032	1.3E-02
	CST-Terrestrial Eco-toxicity	eq. Zn air	*	5.9E+01
	(a) Arsenic (As)	eq. Zn air	0.75	2.7E+00
	(a) Cadmium (Cd)	eq. Zn air	3.14	1.2E+00
	(a) Chromium (Cr III, Cr VI)	eq. Zn air	0.08	4.6E-03
	(a) Cobalt (Co)	eq. Zn air	0.08	3.8E-03
	(a) Copper (Cu)	eq. Zn air	0.14	1.0E+01
	(a) Lead (Pb)	eq. Zn air	0.13	5.8E+00
	(a) Mercury (Hg)	eq. Zn air	5.94	5.8E-01
	(a) Nickel (Ni)	eq. Zn air	0.35	1.3E+01
	(a) Zinc (Zn)	eq. Zn air	0.33	2.5E+01
	(s) Arsenic (As)	eq. Zn air	2.3	8.2E-03
	(s) Cadmium (Cd)	eq. Zn air	9.6	1.1E-03
	(s) Chromium (Cr III, Cr VI)	eq. Zn air	0.26	1.2E-02
	(s) Cobalt (Co)	eq. Zn air	0.26	3.5E-05
	(s) Copper (Cu)	eq. Zn air	0.42	2.9E-04
	(s) Lead (Pb)	eq. Zn air	0.41	1.3E-03
	(s) Mercury (Hg)	eq. Zn air	18.3	3.8E-04
	(s) Nickel (Ni)	eq. Zn air	1.1	1.1E-03
	(s) Zinc (Zn)	eq. Zn air	1	1.4E-01
	EB(R*Y)-Depletion of non renewable resources	yr-1	*	5.2E+05
	(r) Barium Sulphate (BaSO4, in ground)	yr-1	26.91	1.8E+01
	(r) Bauxite (Al2O3, ore)	yr-1	0.108	3.9E-02
	(r) Chromium (Cr, ore)	yr-1	0.2133	4.7E-03
	(r) Chromium (Cr, ore)	yr-1	0.319	7.1E-03
	(r) Coal (in ground)	yr-1	0.000504	1.2E-01
	(r) Copper (Cu, ore)	yr-1	28.16	4.4E+05
	(r) Iron (Fe, ore)	yr-1	0.04	3.2E-01
	(r) Lead (Pb, ore)	yr-1	157	1.6E+03
	(r) Lignite (in ground)	yr-1	0.000504	7.0E-02
	(r) Manganese (Mn, ore)	yr-1	0.296	7.4E-03
	(r) Natural Gas (in ground)	yr-1	0.117	1.8E+01
	(r) Nickel (Ni, ore)	yr-1	59.7	6.2E+02
	(r) Oil (in ground)	yr-1	0.0557	6.3E+00
	(r) Palladium (Pd, ore)	yr-1	20545.69	1.9E+03

Plastics landfilled scenario (expanded boundary)

LIFE CYCLE INVENTORY

	(s) Copper (Cu)	g	6.8E-04
	(s) Iron (Fe)	g	1.4E+01
	(s) Lead (Pb)	g	3.1E-03
	(s) Manganese (Mn)	g	3.5E-01
	(s) Mercury (Hg)	g	2.1E-05
	(s) Nickel (Ni)	g	1.0E-03
	(s) Nitrogen (N)	g	1.9E-03
	(s) Oils (unspecified)	g	4.5E+00
	(s) Phosphorus (P)	g	1.6E-01
	(s) Sulphur (S)	g	5.3E+00
	(s) Zinc (Zn)	g	1.4E-01
	(w) Alkane (unspecified)	g	1.9E-01
	(w) Alkene (unspecified)	g	1.8E-02
	(w) Aluminium (Al3+)	g	3.8E+02
	(w) Ammonia (NH4+, NH3, as N)	g	7.9E+00
	(w) AOX (Adsorbable Organic Halogens)	g	3.8E-01
	(w) Aromatic Hydrocarbons (unspecified)	g	5.6E-01
	(w) Arsenic (As3+, As5+)	g	7.5E-01
	(w) Barium (Ba++)	g	4.2E+01
	(w) Barytes	g	1.3E+02
	(w) Benzene (C6H6)	g	6.7E-01
	(w) BOD5 (Biochemical Oxygen Demand)	g	1.4E+00
	(w) Boron (B III)	g	3.3E-01
	(w) Cadmium (Cd++)	g	1.5E-02
	(w) Calcium (Ca++)	g	5.3E+02
	(w) Chlorides (Cl-)	g	5.1E+03
	(w) Chlorinated Matter (unspecified, as Cl)	g	1.4E+01
	(w) Chromium (Cr III)	g	2.4E+00
	(w) Chromium (Cr VI)	g	8.2E-04
	(w) Cobalt (Co I, Co II, Co III)	g	5.1E-01
	(w) COD (Chemical Oxygen Demand)	g	1.4E+01
	(w) Copper (Cu+, Cu++)	g	2.2E+00
	(w) Cyanides (CN-)	g	7.8E-02
	(w) Dissolved Matter (unspecified)	g	1.6E+02
	(w) Dissolved Organic Carbon (DOC)	g	2.0E+00
	(w) Ethylbenzene (C6H5C2H5)	g	3.2E-02
	(w) Fluorides (F-)	g	2.7E+00
	(w) Formaldehyde (CH2O)	g	1.4E-05
	(w) Hydrocarbons (unspecified)	g	1.5E-01
	(w) Iode (I-)	g	1.4E-01
	(w) Iron (Fe++, Fe3+)	g	3.4E+02
	(w) Lead (Pb++, Pb4+)	g	2.2E+00
	(w) Magnesium (Mg++)	g	3.1E+02
	(w) Manganese (Mn II, Mn IV, Mn VII)	g	5.1E+00
	(w) Mercury (Hg+, Hg++)	g	1.0E-03
	(w) Methylene Chloride (CH2Cl2)	g	1.2E-02
	(w) Molybdenum (Mo II, Mo III, Mo IV, Mo V, Mo VI)	g	6.9E-01
	(w) Nickel (Ni++, Ni3+)	g	2.0E+00
	(w) Nitrates (NO3-)	g	8.8E+00
	(w) Nitrites (NO2-)	g	3.8E-01
	(w) Nitrogenous Matter (unspecified, as N)	g	2.1E+00
	(w) Oils (unspecified)	g	9.9E+01
	(w) Phenol (C6H5OH)	g	6.8E-01
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g	2.2E+01
	(w) Polycyclic Aromatic Hydrocarbons (PAH, unspecified)	g	1.8E-02
	(w) Potassium (K+)	g	1.4E+02
	(w) Salts (unspecified)	g	5.0E+02
	(w) Saponifiable Oils and Fats	g	2.6E+01
	(w) Selenium (Se II, Se IV, Se VI)	g	1.2E+00
	(w) Silver (Ag+)	g	5.1E-04
	(w) Sodium (Na+)	g	2.0E+03
	(w) Strontium (Sr II)	g	3.5E+01
	(w) Sulphates (SO4--)	g	2.8E+03
	(w) Sulphides (S--)	g	1.4E-01
	(w) Sulphites (SO3--)	g	2.3E-01
	(w) Suspended Matter (unspecified)	g	4.3E+02
	(w) Tin (Sn++, Sn4+)	g	1.3E-03
	(w) Titanium (Ti3+, Ti4+)	g	1.4E+01
	(w) TOC (Total Organic Carbon)	g	1.4E+02
	(w) Toluene (C6H5CH3)	g	1.7E-01
	(w) Triethylene Glycol (C6H14O4)	g	1.1E+00
	(w) Vanadium (V3+, V5+)	g	1.2E+00
	(w) Water: Chemically Polluted	litre	0.0E+00
	(w) Xylene (C6H4(CH3)2)	g	1.4E-01
	(w) Zinc (Zn++)	g	4.0E+00
	Mass of printers recycled in alternate scenario	kg	1.5E+04

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	(r) Silver (Ag, ore)	yr-1	92837	7.9E+04
	(r) Uranium (U, ore)	yr-1	181	1.7E+00
	(r) Zinc (Zn, ore)	yr-1	40.29	2.3E+02
	ETH-Air Acidification	g eq. H+	/	8.7E+03
	(a) Ammonia (NH3)	g eq. H+	17	1.4E-01
	(a) CFC 11 (CFCl3)	g eq. H+	34.375	3.4E-05
	(a) Hydrogen Chloride (HCl)	g eq. H+	36.5	3.7E+00
	(a) Hydrogen Fluoride (HF)	g eq. H+	20	7.6E-01
	(a) Hydrogen Sulphide (H2S)	g eq. H+	17	1.8E-01
	(a) Nitrogen Oxides (NOx as NO2)	g eq. H+	46	4.5E+01
	(a) Pentachlorophenol (PCP, C6Cl5OH)	g eq. H+	53.3	6.2E-10
	(a) Sulphur Oxides (SOx as SO2)	g eq. H+	32	8.6E+03
	IPCC-Greenhouse effect (direct, 100 years)	g eq. CO2	*	1.3E+06
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	1.2E+06
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	5700	7.3E+01
	(a) CFC 11 (CFCl3)	g eq. CO2	4600	5.3E+00
	(a) CFC 114 (CF2ClCF2Cl)	g eq. CO2	9800	3.0E+02
	(a) CFC 12 (CCl2F2)	g eq. CO2	10600	2.6E+00
	(a) CFC 13 (CF3Cl)	g eq. CO2	14000	2.2E+00
	(a) Halon 1301 (CF3Br)	g eq. CO2	6900	2.8E+02
	(a) HCFC 22 (CHF2Cl)	g eq. CO2	1900	3.8E-08
	(a) Methane (CH4)	g eq. CO2	24	5.8E+04
	(a) Nitrous Oxide (N2O)	g eq. CO2	360	9.2E+03
	IPCC-Greenhouse effect (direct, 20 years)	g eq. CO2	*	1.4E+06
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	1.2E+06
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	3900	5.0E+01
	(a) CFC 11 (CFCl3)	g eq. CO2	6300	7.3E+00
	(a) CFC 114 (CF2ClCF2Cl)	g eq. CO2	7500	2.3E+02
	(a) CFC 12 (CCl2F2)	g eq. CO2	10200	2.5E+00
	(a) CFC 13 (CF3Cl)	g eq. CO2	10000	1.6E+00
	(a) Halon 1301 (CF3Br)	g eq. CO2	7900	3.2E+02
	(a) HCFC 22 (CHF2Cl)	g eq. CO2	5200	1.0E-07
	(a) Methane (CH4)	g eq. CO2	64	1.6E+05
	(a) Nitrous Oxide (N2O)	g eq. CO2	330	8.5E+03
	IPCC-Greenhouse effect (direct, 500 years)	g eq. CO2	*	1.2E+06
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	1.2E+06
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	8900	1.1E+02
	(a) CFC 11 (CFCl3)	g eq. CO2	1600	1.9E+00
	(a) CFC 114 (CF2ClCF2Cl)	g eq. CO2	8700	2.7E+02
	(a) CFC 12 (CCl2F2)	g eq. CO2	5200	1.3E+00
	(a) CFC 13 (CF3Cl)	g eq. CO2	16300	2.5E+00
	(a) Halon 1301 (CF3Br)	g eq. CO2	2700	1.1E+02
	(a) HCFC 22 (CHF2Cl)	g eq. CO2	590	1.2E-08
	(a) Methane (CH4)	g eq. CO2	7.5	1.8E+04
	(a) Nitrous Oxide (N2O)	g eq. CO2	190	4.9E+03
	USES 1.0-Aquatic Ecotoxicity	g eq. 1-4-dichlorobenzene	*	6.0E+03
	(a) Acrolein (CH2CHCHO)	g eq. 1-4-dichlorobenzene	160	3.8E-04
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	5.6	2.0E+01
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.0013	4.6E-03
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	320	1.8E-01
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130	5.0E+01
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	2.6	1.2E-01
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	2.9	2.1E+02
	(a) Ethylene (C2H4)	g eq. 1-4-dichlorobenzene	0.0022	1.3E-03
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.2	5.3E+01
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	16000	1.6E+03
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	80	3.0E+03
	(a) Pentachlorobenzene (C6HCl5)	g eq. 1-4-dichlorobenzene	0.95	1.9E-07
	(a) Pentachlorophenol (PCP, C6Cl5OH)	g eq. 1-4-dichlorobenzene	100	3.3E-06
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	39	1.6E-02
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	9.70E-05	1.1E-04
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	11	2.3E+01
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	2.6	2.0E+02
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	3.00E-08	1.1E-10
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	3.90E-06	4.6E-10
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.40E-09	6.2E-11
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	6.80E-08	9.3E-12
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	1.40E-08	9.5E-12
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.80E-09	5.6E-12
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	16000	3.3E-01
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	5.80E-07	5.9E-10
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	3.90E-08	5.5E-09
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	190	1.4E+02
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	1	6.7E-01
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	4500	6.6E+01
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	84	2.0E+02
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	84	6.9E-02
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	160	2.2E-03
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	0.021	2.5E-04
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	380	4.6E+02
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.86	3.4E+00
	USES 1.0-Human Toxicity	g eq. 1-4-dichlorobenzene	*	3.6E+06
	(a) Acrolein (CH2CHCHO)	g eq. 1-4-dichlorobenzene	2300	5.5E-03
	(a) Ammonia (NH3)	g eq. 1-4-dichlorobenzene	16	3.8E+01
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	42000	1.5E+05
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	29	1.0E+02
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	3700	2.1E+00
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	23000	8.8E+03
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	7600	3.6E+02
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	350	2.5E+04
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	67000	3.0E+06
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	29000	2.9E+03
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	9800	3.7E+05
	(a) Nitrogen Oxides (NOx as NO2)	g eq. 1-4-dichlorobenzene	0.26	5.3E+02
	(a) Pentachlorobenzene (C6HCl5)	g eq. 1-4-dichlorobenzene	250	5.1E-05
	(a) Pentachlorophenol (PCP, C6Cl5OH)	g eq. 1-4-dichlorobenzene	200	6.6E-06
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	2.2	8.9E-04
	(a) Sulphur Oxides (SOx as SO2)	g eq. 1-4-dichlorobenzene	0.16	4.4E+04
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.036	4.1E-02
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	4900	1.0E+04
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	0.63	4.8E+01
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	670	2.4E+00
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	20000	2.4E+00
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	1500	2.0E-01
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	30	2.0E-02
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	350	1.1E+00
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	29000	6.0E-01
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	800	8.2E-01
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	12	1.7E+00
	(w) Ammonia (NH4+, NH3, as N)	g eq. 1-4-dichlorobenzene	17	1.4E+02
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	51	3.8E+01

Plastics landfilled scenario (expanded boundary)

LIFE CYCLE INVENTORY

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	22	1.5E+01
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	130	1.9E+00
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	9.3	2.2E+01
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	67000	5.5E+01
	(w) Cobalt (Co I, Co II, Co III)	g eq. 1-4-dichlorobenzene	31	1.6E+01
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.1	2.4E+00
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	0.35	4.9E-06
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	0.026	5.7E-02
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	18000	1.9E+01
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	12	1.4E-01
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	63	1.3E+02
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	0.89	6.0E-01
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.053	8.8E-03
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	19	2.3E+01
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.058	2.3E-01
	USES 1.0-Terrestrial Ecotoxicity	g eq. 1-4-dichlorobenzene	*	1.8E+08
	(a) Acrolein (CH2CHCHO)	g eq. 1-4-dichlorobenzene	680	1.6E-03
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	72000	2.6E+05
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.063	2.2E-01
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	64000000	3.6E+04
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	1.3E+08	5.0E+07
	(a) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	220000	1.3E+04
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	17000	8.0E+02
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	910000	6.6E+07
	(a) Ethylene (C2H4)	g eq. 1-4-dichlorobenzene	17	1.0E+01
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	11000	4.9E+05
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	13000000	1.3E+06
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	190000	7.1E+06
	(a) Pentachlorobenzene (C6HCl5)	g eq. 1-4-dichlorobenzene	11000	2.3E-03
	(a) Pentachlorophenol (PCP, C6Cl5OH)	g eq. 1-4-dichlorobenzene	2400000	8.0E-02
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	11000	4.5E+00
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.035	4.0E-02
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	450000	9.6E+05
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	660000	5.0E+07
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	200000	7.1E+02
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	3.4E+08	4.0E+04
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	600000	2.7E+04
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	45000	6.1E+00
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	2400000	1.6E+03
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	29000	9.0E+01
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	17000000	3.5E+02
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	520000	5.3E+02
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	1800000	2.5E+05
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	9.70E-06	7.3E-06
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.039	2.6E-02
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	0.025	3.6E-04
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	1.10E-05	2.6E-05
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	1.10E-05	9.1E-09
	(w) Cobalt (Co I, Co II, Co III)	g eq. 1-4-dichlorobenzene	2.00E-07	1.0E-07
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.00E-05	2.2E-05
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	2.5	3.5E-05
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	2.00E-07	4.4E-07
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	8200000	8.4E+03
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	0.078	9.2E-04
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	3.10E-05	6.2E-05
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	34	2.3E+01
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.022	3.7E-03
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	3.40E-05	4.1E-05
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	2.50E-05	1.0E-04
	WMO-Depletion of the ozone layer (high)	g eq. CFC-11	*	7.2E-01
	(a) CFC 11 (CFCl3)	g eq. CFC-11	1	1.2E-03
	(a) CFC 114 (CF2ClCF2Cl)	g eq. CFC-11	0.85	2.6E-02
	(a) CFC 12 (CCl2F2)	g eq. CFC-11	1.06	2.6E-04
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	17.2	6.9E-01
	(a) HCFC 22 (CHF2Cl)	g eq. CFC-11	0.08	1.6E-12
	WMO-Depletion of the ozone layer (low)	g eq. CFC-11	*	4.2E-01
	(a) CFC 11 (CFCl3)	g eq. CFC-11	1	1.2E-03
	(a) CFC 114 (CF2ClCF2Cl)	g eq. CFC-11	0.57	1.7E-02
	(a) CFC 12 (CCl2F2)	g eq. CFC-11	0.82	2.0E-04
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	10	4.0E-01
	(a) HCFC 22 (CHF2Cl)	g eq. CFC-11	0.032	6.3E-13
	WMO-Photochemical oxidant formation (high)	g eq. ethylene	*	8.3E+02
	(a) Acetaldehyde (CH3CHO)	g eq. ethylene	1.22	1.9E-01
	(a) Acetone (CH3COCH3)	g eq. ethylene	0.27	4.2E-02
	(a) Alcohol (unspecified)	g eq. ethylene	0.55	2.0E-02
	(a) Aldehyde (unspecified)	g eq. ethylene	1.263	7.4E-02
	(a) Alkane (unspecified)	g eq. ethylene	1.173	4.5E+01
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	1.285	1.1E-01
	(a) Benzaldehyde (C6H5CHO)	g eq. ethylene	-0.12	-3.0E-08
	(a) Benzene (C6H6)	g eq. ethylene	0.45	1.6E+00
	(a) Ethane (C2H6)	g eq. ethylene	0.3	1.9E-01
	(a) Ethanol (C2H5OH)	g eq. ethylene	0.89	2.8E-01
	(a) Ethylene (C2H4)	g eq. ethylene	1	6.0E-01
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.799	7.0E+02
	(a) Methane (CH4)	g eq. ethylene	0.03	7.3E+01
	(a) Methanol (CH3OH)	g eq. ethylene	0.21	8.8E-02
	(a) Toluene (C6H5CH3)	g eq. ethylene	0.83	9.5E-01
	WMO-Photochemical oxidant formation (low)	g eq. ethylene	*	1.8E+02
	(a) Acetaldehyde (CH3CHO)	g eq. ethylene	0.33	5.2E-02
	(a) Acetone (CH3COCH3)	g eq. ethylene	0.1	1.6E-02
	(a) Alcohol (unspecified)	g eq. ethylene	0.065	2.3E-03
	(a) Aldehyde (unspecified)	g eq. ethylene	0.079	4.7E-03
	(a) Alkane (unspecified)	g eq. ethylene	0.114	4.4E+00
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	0.481	4.2E-02
	(a) Benzaldehyde (C6H5CHO)	g eq. ethylene	-0.82	-2.1E-07
	(a) Benzene (C6H6)	g eq. ethylene	0.11	3.9E-01
	(a) Ethane (C2H6)	g eq. ethylene	0.02	1.3E-02
	(a) Ethanol (C2H5OH)	g eq. ethylene	0.04	1.3E-02
	(a) Ethylene (C2H4)	g eq. ethylene	1	6.0E-01
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.195	1.7E+02
	(a) Methane (CH4)	g eq. ethylene	0	0.0E+00
	(a) Methanol (CH3OH)	g eq. ethylene	0.09	3.8E-02
	(a) Toluene (C6H5CH3)	g eq. ethylene	0.41	4.7E-01

Plastics and PCBs landfilled scenario

LIFE CYCLE INVENTORY

	Flows	Units	Environmental burden
Inputs:	(r) 1-methoxy propan-2-ol	kg	1.2E-01
	(r) Barium Sulphate (BaSO4, in ground)	kg	8.8E+00
	(r) Bauxite (Al2O3, ore)	kg	6.7E-01
	(r) Bentonite (Al2O3.4SiO2.H2O, in ground)	kg	1.1E+00
	(r) Calcium Sulphate (CaSO4, ore)	kg	1.7E-02
	(r) Chromium (Cr, ore)	kg	1.4E-03
	(r) Clay (in ground)	kg	3.3E+00
	(r) Coal (in ground)	kg	2.2E+03
	(r) Commercial butane	g	1.7E+02
	(r) Copper (Cu, ore)	kg	7.1E-03
	(r) Gravel (unspecified)	kg	2.4E+00
	(r) Iron (Fe, ore)	kg	3.0E+01
	(r) Iron Sulphate (FeSO4, ore)	kg	2.0E-02
	(r) Kerosine	kg	1.0E-01
	(r) Lead (Pb, ore)	kg	2.2E-03
	(r) Lignite (in ground)	kg	2.2E+03
	(r) Limestone (CaCO3, in ground)	kg	4.6E+01
	(r) Manganese (Mn, ore)	kg	8.2E-04
	(r) Natural Gas (in ground)	kg	5.5E+03
	(r) Nickel (Ni, ore)	kg	4.7E-04
	(r) Oil (in ground)	kg	5.2E+02
	(r) Propan-2-ol	kg	9.8E-02
	(r) Pyrite (FeS2, ore)	kg	2.2E+02
	(r) Sand (in ground)	kg	6.9E+00
	(r) Silver (Ag, ore)	kg	3.5E-05
	(r) Sodium Chloride (NaCl, in ground or in sea)	kg	2.0E+00
	(r) Sulphur (S, in ground)	kg	9.3E-04
	(r) Uranium (U, ore)	kg	1.4E-01
	(r) Water	kg	2.1E+00
	(r) Zinc (Zn, ore)	kg	5.2E-05
	Argon (Ar)	kg	3.3E-01
	Borax (B4Na2O7)	kg	1.6E-01
	Chlorine (Cl2)	kg	1.9E-01
	Diesel Oil	kg	5.8E+02
	Explosive (unspecified)	kg	2.4E-01
	Gasoline (leaded)	kg	2.2E+00
	Gasoline (unleaded)	kg	2.0E+00
	Heavy Fuel Oil	kg	3.7E+01
	Iron Scrap	kg	1.6E-01
	Land Use (II -> III)	m2a	2.6E+00
	Land Use (II -> IV)	m2a	3.5E-01
	Land Use (III -> IV)	m2a	1.2E-01
	Maize	kg	3.4E+01
	Potatoes	kg	9.2E+00
	Raw Materials (unspecified)	kg	2.9E+02
	Traded-in printers (high-street)	kg	1.0E+03
	Traded-in printers (out-of-town)	kg	2.1E+04
	Water Used (total)	litre	1.4E+05
	Water: Unspecified Origin	litre	1.4E+05
	Wood	kg	1.6E+01
	Wood (standing)	m3	4.0E-03
Outputs:	(a) 1-methoxy propan-2-ol	kg	1.2E-01
	(a) Acetaldehyde (CH3CHO)	g	2.7E-01
	(a) Acetic Acid (CH3COOH)	g	2.7E+01
	(a) Acetone (CH3COCH3)	g	1.1E-01
	(a) Acetylene (C2H2)	g	5.5E+00
	(a) Aldehyde (unspecified)	g	2.5E-01
	(a) Alkane (unspecified)	g	6.5E+02
	(a) Alkene (unspecified)	g	6.6E+00
	(a) Alkyne (unspecified)	g	1.2E-02
	(a) Aluminium (Al)	g	1.1E+02
	(a) Ammonia (NH3)	g	1.2E+02
	(a) Antimony (Sb)	g	2.0E-02
	(a) AOX (Adsorbable Organic Halogens)	g	8.8E-11
	(a) Aromatic Hydrocarbons (unspecified)	g	7.3E+01
	(a) Arsenic (As)	g	3.1E-01
	(a) Barium (Ba)	g	1.3E+00
	(a) Benzaldehyde (C6H5CHO)	g	2.2E-06
	(a) Benzene (C6H6)	g	9.8E+01
	(a) Benzo(a)pyrene (C20H12)	g	2.3E-02
	(a) Berylium (Be)	g	2.1E-02
	(a) Boron (B)	g	1.0E+01
	(a) Bromium (Br)	g	2.0E+00
	(a) Butane (n-C4H10)	g	3.2E+02
	(a) Butene (1-CH3CH2CHCH2)	g	7.7E-02
	(a) Cadmium (Cd)	g	1.3E-01
	(a) Calcium (Ca)	g	1.4E+01
	(a) Carbon Dioxide (CO2, biomass)	g	1.3E+02
	(a) Carbon Dioxide (CO2, fossil)	g	2.5E+07
	(a) Carbon Monoxide (CO)	g	4.3E+04
	(a) Carbon Tetrafluoride (CF4)	g	1.7E-03
	(a) Chlorine (Cl2)	g	5.7E-06
	(a) Chromium (Cr III, Cr VI)	g	1.6E+00
	(a) Cobalt (Co)	g	7.3E-02
	(a) Copper (Cu)	g	9.5E+00
	(a) Cyanide (CN-)	g	3.3E-02
	(a) Dioxins (unspecified)	g	8.0E-07
	(a) Ethane (C2H6)	g	5.7E+02
	(a) Ethanol (C2H5OH)	g	1.8E-01
	(a) Ethylbenzene (C8H10)	g	7.7E-02
	(a) Ethylene (C2H4)	g	2.2E+03
	(a) Fluorides (F-)	g	6.1E-04
	(a) Fluorine (F2)	g	3.8E-04
	(a) Formaldehyde (CH2O)	g	1.9E+01
	(a) Halogenated Matter (unspecified)	g	2.3E-03
	(a) Halon 1301 (CF3Br)	g	1.6E-01
	(a) Heptane (C7H16)	g	5.1E-01
	(a) Hexane (C6H14)	g	1.0E+00
	(a) Hydrocarbons (except methane)	g	1.1E+04
	(a) Hydrocarbons (unspecified)	g	1.5E+02
	(a) Hydrogen (H2)	g	2.4E-05
	(a) Hydrogen Chloride (HCl)	g	1.7E+03
	(a) Hydrogen Fluoride (HF)	g	1.5E+02
	(a) Hydrogen Sulphide (H2S)	g	8.9E+01
	(a) Iodine (I)	g	5.1E-01
	(a) Iron (Fe)	g	5.5E+01
	(a) Kerosine	kg	1.1E-01
	(a) lanthanum (La)	g	3.3E-02
	(a) Lead (Pb)	g	7.1E+01
	(a) Magnesium (Mg)	g	3.7E+01
	(a) Manganese (Mn)	g	2.5E+01
	(a) Mercury (Hg)	g	3.1E-01
	(a) Metals (unspecified)	g	2.4E+02
	(a) Methane (CH4)	g	1.6E+05
	(a) Methanol (CH3OH)	g	3.0E-01
	(a) Molybdenum (Mo)	g	7.0E-02
	(a) Nickel (Ni)	g	4.1E+00
	(a) Nitrogen Oxides (NOx as NO2)	g	6.0E+04
	(a) Nitrous Oxide (N2O)	g	4.1E+02
	(a) Organic Matter (unspecified)	g	2.9E-01
	(a) Particulates (unspecified)	g	1.2E+04

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	Classification	Units	Charact-erisation	Environmental impact
Methods:	CML-Eutrophication	g eq. PO4	*	8.4E+03
	(a) Nitrogen Oxides (NOx as NO2)	g eq. PO4	0.13	7.8E+03
	(a) Nitrous Oxide (N2O)	g eq. PO4	0.27	1.1E+02
	(w) Ammonia (NH4+, NH3, as N)	g eq. PO4	0.42	2.3E+01
	(w) COD (Chemical Oxygen Demand)	g eq. PO4	0.022	8.6E+01
	(w) Nitrogenous Matter (Kjeldahl, as N)	g eq. PO4	0.42	1.3E-01
	(w) Nitrogenous Matter (unspecified, as N)	g eq. PO4	0.42	9.0E+00
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g eq. PO4	3.06	4.2E+02
	(w) Phosphorous Matter (unspecified, as P)	g eq. PO4	3.06	4.0E+00
	(w) Phosphorus (P)	g eq. PO4	3.06	9.9E-02
	(w) Phosphorus Pentoxide (P2O5)	g eq. PO4	1.336	2.5E-02
	CST-Aquatic Eco-toxicity	eq. Zn water	*	2.0E+03
	(a) Arsenic (As)	eq. Zn water	0.078	2.4E-02
	(a) Cadmium (Cd)	eq. Zn water	79	1.0E+01
	(a) Chromium (Cr III, Cr VI)	eq. Zn water	0.39	6.1E-01
	(a) Copper (Cu)	eq. Zn water	0.66	6.3E+00
	(a) Lead (Pb)	eq. Zn water	1.28	9.1E+01
	(a) Mercury (Hg)	eq. Zn water	196	6.1E+01
	(a) Nickel (Ni)	eq. Zn water	0.12	4.9E-01
	(a) Zinc (Zn)	eq. Zn water	0.076	9.7E+00
	(s) Arsenic (As)	eq. Zn water	0.24	1.1E-02
	(s) Cadmium (Cd)	eq. Zn water	240	5.9E+02
	(s) Chromium (Cr III, Cr VI)	eq. Zn water	1.2	2.1E+02
	(s) Copper (Cu)	eq. Zn water	2	7.9E+01
	(s) Lead (Pb)	eq. Zn water	3.9	9.7E+00
	(s) Mercury (Hg)	eq. Zn water	600	3.4E-02
	(s) Nickel (Ni)	eq. Zn water	0.36	8.7E+01
	(s) Zinc (Zn)	eq. Zn water	0.23	6.7E+00
	(w) Arsenic (As3+, As5+)	eq. Zn water	0.52	2.7E+00
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Zn water	0.00013	1.6E-01
	(w) Cadmium (Cd++)	eq. Zn water	520	8.6E+01
	(w) Chromium (Cr III, Cr VI)	eq. Zn water	2.6	1.2E+02
	(w) Copper (Cu+, Cu++)	eq. Zn water	5.2	8.0E+01
	(w) Lead (Pb++, Pb4+)	eq. Zn water	5.2	8.5E+01
	(w) Mercury (Hg+, Hg++)	eq. Zn water	1300	3.0E+02
	(w) Nickel (Ni++, Ni3+)	eq. Zn water	0.79	9.7E+00
	(w) Oils (unspecified)	eq. Zn water	0.13	9.4E+01
	(w) Phenol (C6H5OH)	eq. Zn water	15.4	6.6E+01
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Zn water	0.01	1.4E+00
	(w) Zinc (Zn++)	eq. Zn water	1	3.6E+01
	CST-Human Toxicity	eq. Pb air	*	2.2E+05
	(a) Aldehyde (unspecified)	eq. Pb air	0.0087	2.1E-03
	(a) Arsenic (As)	eq. Pb air	9000	2.8E+03
	(a) Benzene (C6H6)	eq. Pb air	0.012	1.2E+00
	(a) Cadmium (Cd)	eq. Pb air	19000	2.4E+03
	(a) Carbon Monoxide (CO)	eq. Pb air	0.00014	6.0E+00
	(a) Chromium (Cr III, Cr VI)	eq. Pb air	3700	5.8E+03
	(a) Cobalt (Co)	eq. Pb air	12900	9.4E+02
	(a) Copper (Cu)	eq. Pb air	145	1.4E+03
	(a) Formaldehyde (CH2O)	eq. Pb air	0.0099	1.9E-01
	(a) Lead (Pb)	eq. Pb air	2300	1.6E+05
	(a) Mercury (Hg)	eq. Pb air	46000	1.4E+04
	(a) Nickel (Ni)	eq. Pb air	370	1.5E+03
	(a) Nitrogen Oxides (NOx as NO2)	eq. Pb air	0.002	1.2E+02
	(a) Particulates (unspecified)	eq. Pb air	0.0075	8.7E+01
	(a) Selenium (Se)	eq. Pb air	64000	1.8E+04
	(a) Sulphur Oxides (SOx as SO2)	eq. Pb air	0.0075	6.6E+02
	(a) Tin (Sn)	eq. Pb air	9	6.0E-02
	(a) Zinc (Zn)	eq. Pb air	27	3.4E+03
	(s) Arsenic (As)	eq. Pb air	0.7	3.2E-02
	(s) Cadmium (Cd)	eq. Pb air	1.46	3.6E+00
	(s) Chromium (Cr III, Cr VI)	eq. Pb air	0.29	5.0E+01
	(s) Cobalt (Co)	eq. Pb air	1	3.6E-04
	(s) Copper (Cu)	eq. Pb air	0.009	3.6E-01
	(s) Lead (Pb)	eq. Pb air	0.6	1.5E+00
	(s) Mercury (Hg)	eq. Pb air	3.6	2.0E-04
	(s) Nickel (Ni)	eq. Pb air	0.029	7.0E+00
	(s) Zinc (Zn)	eq. Pb air	0.0007	2.0E-02
	(w) Arsenic (As3+, As5+)	eq. Pb air	1.5	7.7E+00
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Pb air	0.022	2.8E+01
	(w) Cadmium (Cd++)	eq. Pb air	3.2	5.3E-01
	(w) Chromium (Cr III, Cr VI)	eq. Pb air	0.62	2.9E+01
	(w) Cobalt (Co I, Co II, Co III)	eq. Pb air	2.2	1.3E-01
	(w) Copper (Cu+, Cu++)	eq. Pb air	0.022	3.4E-01
	(w) Fluorides (F-)	eq. Pb air	0.045	7.7E-01
	(w) Lead (Pb++, Pb4+)	eq. Pb air	0.86	1.4E+01
	(w) Mercury (Hg+, Hg++)	eq. Pb air	7.8	1.8E+00
	(w) Nickel (Ni++, Ni3+)	eq. Pb air	0.062	7.6E-01
	(w) Phenol (C6H5OH)	eq. Pb air	0.052	2.2E-01
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Pb air	3.20E-06	4.4E-04
	(w) Selenium (Se II, Se IV, Se VI)	eq. Pb air	10.9	5.5E-01
	(w) Tin (Sn++, Sn4+)	eq. Pb air	0.0015	2.6E-07
	(w) Zinc (Zn++)	eq. Pb air	0.0032	1.1E-01
	CST-Terrestrial Eco-toxicity	eq. Zn air	*	4.4E+02
	(a) Arsenic (As)	eq. Zn air	0.75	2.4E-01
	(a) Cadmium (Cd)	eq. Zn air	3.14	4.0E-01
	(a) Chromium (Cr III, Cr VI)	eq. Zn air	0.08	1.3E-01
	(a) Cobalt (Co)	eq. Zn air	0.08	5.8E-03
	(a) Copper (Cu)	eq. Zn air	0.14	1.3E+00
	(a) Lead (Pb)	eq. Zn air	0.13	9.3E+00
	(a) Mercury (Hg)	eq. Zn air	5.94	1.9E+00
	(a) Nickel (Ni)	eq. Zn air	0.35	1.4E+00
	(a) Zinc (Zn)	eq. Zn air	0.33	4.2E+01
	(s) Arsenic (As)	eq. Zn air	2.3	1.0E-01
	(s) Cadmium (Cd)	eq. Zn air	9.6	2.4E+01
	(s) Chromium (Cr III, Cr VI)	eq. Zn air	0.26	4.5E+01
	(s) Cobalt (Co)	eq. Zn air	0.26	9.3E-05
	(s) Copper (Cu)	eq. Zn air	0.42	1.7E+01
	(s) Lead (Pb)	eq. Zn air	0.41	1.0E+00
	(s) Mercury (Hg)	eq. Zn air	18.3	1.0E-03
	(s) Nickel (Ni)	eq. Zn air	1.1	2.7E+02
	(s) Zinc (Zn)	eq. Zn air	1	2.9E+01
	EB(R*Y)-Depletion of non renewable resources	yr-1	*	9.4E+02
	(r) Barium Sulphate (BaSO4, in ground)	yr-1	26.91	2.4E+02
	(r) Bauxite (Al2O3, ore)	yr-1	0.108	7.2E-02
	(r) Chromium (Cr, ore)	yr-1	0.2133	3.0E-04
	(r) Chromium (Cr, ore)	yr-1	0.319	4.5E-04
	(r) Coal (in ground)	yr-1	0.0005037	1.1E+00
	(r) Copper (Cu, ore)	yr-1	28.16	2.0E-01
	(r) Iron (Fe, ore)	yr-1	0.04	1.2E+00
	(r) Lead (Pb, ore)	yr-1	157	3.5E-01
	(r) Lignite (in ground)	yr-1	0.0005037	1.1E+00
	(r) Manganese (Mn, ore)	yr-1	0.296	2.4E-04
	(r) Natural Gas (in ground)	yr-1	0.117	6.4E+02
	(r) Nickel (Ni, ore)	yr-1	59.7	2.8E-02
	(r) Oil (in ground)	yr-1	0.0557	2.9E+01
	(r) Silver (Ag, ore)	yr-1	92837	3.3E+00
	(r) Sulphur (S, in ground)	yr-1	4.408	4.1E-03
	(r) Uranium (U, ore)	yr-1	181	2.5E+01
	(r) Zinc (Zn, ore)	yr-1	40.29	2.1E-03
	ETH-Air Acidification	g eq. H+	/	4.1E+03

Plastics and PCBs landfilled scenario

LIFE CYCLE INVENTORY

	(a) Pentane (C5H12)	g	2.2E+02
	(a) Phenol (C6H5OH)	g	1.7E-05
	(a) Phosphorus (P)	g	2.2E+00
	(a) Phosphorus Pentoxide (P2O5)	g	6.3E-04
	(a) Platinum (Pt)	g	4.0E-05
	(a) Polycyclic Aromatic Hydrocarbons (PAH, except naphth	g	2.3E-03
	(a) Polycyclic Aromatic Hydrocarbons (PAH, unspecified)	g	2.0E+00
	(a) Potassium (K)	g	1.6E+01
	(a) Propan-2-ol	kg	9.8E-02
	(a) Propane (C3H8)	g	1.8E+02
	(a) Propionaldehyde (CH3CH2CHO)	g	5.9E-06
	(a) Propionic Acid (CH3CH2COOH)	g	7.8E-03
	(a) Propylene (CH2CHCH3)	g	6.1E+00
	(a) Scandium (Sc)	g	1.1E-02
	(a) Selenium (Se)	g	2.8E-01
	(a) Silicon (Si)	g	2.1E+02
	(a) Sodium (Na)	g	8.2E+00
	(a) Strontium (Sr)	g	2.1E+00
	(a) Sulphur Oxides (SOx as SO2)	g	8.8E+04
	(a) Tars (unspecified)	g	6.3E-07
	(a) Thallium (Tl)	g	1.0E-02
	(a) Thorium (Th)	g	2.1E-02
	(a) Tin (Sn)	g	6.6E-03
	(a) Titanium (Ti)	g	3.7E+00
	(a) Toluene (C6H5CH3)	g	3.8E+01
	(a) Uranium (U)	g	2.1E-02
	(a) Vanadium (V)	g	5.5E+00
	(a) Water vapour	kg	2.1E+00
	(a) Xylene (C6H4(CH3)2)	g	1.3E+00
	(a) Zinc (Zn)	g	1.3E+02
	(a) Zirconium (Zr)	g	1.6E-02
	(ar) Aerosols and Halogenes (unspecified)	kBq	3.8E-02
	(ar) Carbon (C14)	kBq	1.3E+01
	(ar) Cesium (Cs134)	kBq	4.9E-04
	(ar) Cesium (Cs137)	kBq	4.9E-04
	(ar) Cobalt (Co58)	kBq	4.9E-04
	(ar) Cobalt (Co60)	kBq	4.9E-04
	(ar) Gas (unspecified)	kBq	1.2E+03
	(ar) Iodine (I131)	kBq	2.9E-03
	(ar) Iodine (I133)	kBq	5.6E-03
	(ar) Krypton (Kr85)	kBq	7.4E+01
	(ar) Lead (Pb210)	kBq	4.9E-01
	(ar) Polonium (Po210)	kBq	8.5E-01
	(ar) Potassium (K40)	kBq	1.3E-01
	(ar) Protactinium (Pa234m)	kBq	6.9E-03
	(ar) Radioactive Substance (unspecified)	kBq	7.6E+06
	(ar) Radium (Ra226)	kBq	6.0E-01
	(ar) Radium (Ra228)	kBq	6.5E-02
	(ar) Radon (Rn220)	kBq	2.0E+00
	(ar) Radon (Rn222)	kBq	5.9E+04
	(ar) Thorium (Th228)	kBq	5.5E-02
	(ar) Thorium (Th230)	kBq	1.0E-01
	(ar) Thorium (Th232)	kBq	3.5E-02
	(ar) Thorium (Th234)	kBq	6.9E-03
	(ar) Tritium (H3)	kBq	1.5E+02
	(ar) Uranium (U234)	kBq	1.7E-01
	(ar) Uranium (U235)	kBq	1.3E-03
	(ar) Uranium (U238)	kBq	3.0E-01
	(ar) Xenon (Xe133)	kBq	1.0E+03
	(s) Aluminium (Al)	g	1.1E+02
	(s) Arsenic (As)	g	4.5E-02
	(s) Cadmium (Cd)	g	2.5E+00
	(s) Calcium (Ca)	g	4.5E+02
	(s) Carbon (C)	g	3.5E+02
	(s) Chromium (Cr III, Cr VI)	g	1.7E+02
	(s) Cobalt (Co)	g	3.6E-04
	(s) Copper (Cu)	g	4.0E+01
	(s) Iron (Fe)	g	7.3E+02
	(s) Lead (Pb)	g	2.5E+00
	(s) Manganese (Mn)	g	4.5E+00
	(s) Mercury (Hg)	g	5.6E-05
	(s) Nickel (Ni)	g	2.4E+02
	(s) Nitrogen (N)	g	1.5E-03
	(s) Oils (unspecified)	g	1.2E+01
	(s) Phosphorus (P)	g	4.7E+00
	(s) Sulphur (S)	g	6.8E+01
	(s) Zinc (Zn)	g	2.9E+01
	(sr) Americium (Am241)	kBq	1.3E+02
	(sr) Americium (Am243)	kBq	2.8E+00
	(sr) Cesium (Cs135)	kBq	6.3E+04
	(sr) Cesium (Cs137)	kBq	1.8E-01
	(sr) Curium (Cm244)	kBq	2.6E+02
	(sr) Curium (Cm245)	kBq	2.9E-02
	(sr) Iodine (I129)	kBq	4.1E-03
	(sr) Neptunium (Np237)	kBq	4.0E+01
	(sr) Palladium (Pd107)	kBq	1.4E-02
	(sr) Plutonium (Pu239)	kBq	4.9E+04
	(sr) Plutonium (Pu240)	kBq	6.9E+04
	(sr) Plutonium (Pu241)	kBq	1.6E+07
	(sr) Plutonium (Pu242)	kBq	2.6E+02
	(sr) Radium (Ra226)	kBq	3.3E+02
	(sr) Samarium (Sm151)	kBq	5.8E+01
	(sr) Selenium (Se79)	kBq	4.5E-02
	(sr) Strontium (Sr90)	kBq	9.4E+03
	(sr) Technetium (Tc99)	kBq	1.9E+00
	(sr) Thorium (Th230)	kBq	3.3E+02
	(sr) Tin (Sn126)	kBq	7.9E-02
	(sr) Uranium (U234)	kBq	2.1E+02
	(sr) Uranium (U235)	kBq	3.7E+00
	(sr) Uranium (U238)	kBq	5.8E+01
	(sr) Zirconium (Zr93)	kBq	2.5E-01
	(w) Acids (H+)	g	9.2E-01
	(w) Alcohol (unspecified)	g	5.1E-02
	(w) Aldehyde (unspecified)	g	4.0E-02
	(w) Alkane (unspecified)	g	1.2E+00
	(w) Alkene (unspecified)	g	1.1E-01
	(w) Aluminium (Al3+)	g	2.6E+03
	(w) Aluminium Hydroxide (Al(OH)3)	g	6.0E-04
	(w) Ammonia (NH4+, NH3, as N)	g	5.5E+01
	(w) AOX (Adsorbable Organic Halogens)	g	8.6E-02
	(w) Aromatic Hydrocarbons (unspecified)	g	1.8E+01
	(w) Arsenic (As3+, As5+)	g	5.1E+00
	(w) Barium (Ba++)	g	2.6E+02
	(w) Barytes	g	1.6E+03
	(w) Benzene (C6H6)	g	2.9E+00
	(w) BOD5 (Biochemical Oxygen Demand)	g	1.3E+03
	(w) Boric Acid (H3BO3)	g	7.6E-01
	(w) Boron (B III)	g	1.6E-01
	(w) Cadmium (Cd++)	g	1.6E-01
	(w) Calcium (Ca++)	g	1.4E+03
	(w) Carbonates (CO3--, HCO3-, CO2, as C)	g	9.2E-01
	(w) Cesium (Cs++)	g	1.6E-03
	(w) Chlorides (Cl-)	g	6.2E+04

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	(a) Ammonia (NH3)	g eq. H+	17	7.3E+00
	(a) Hydrogen Chloride (HCl)	g eq. H+	36.5	4.7E+01
	(a) Hydrogen Fluoride (HF)	g eq. H+	20	7.4E+00
	(a) Hydrogen Sulphide (H2S)	g eq. H+	17	5.2E+00
	(a) Nitrogen Oxides (NOx as NO2)	g eq. H+	46	1.3E+03
	(a) Sulphur Oxides (SOx as SO2)	g eq. H+	32	2.7E+03
	IPCC-Greenhouse effect (direct, 100 years)	g eq. CO2	*	2.9E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	2.4E+07
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	5700	9.8E+00
	(a) Halon 1301 (CF3Br)	g eq. CO2	6900	1.1E+03
	(a) Methane (CH4)	g eq. CO2	24	3.9E+06
	(a) Nitrous Oxide (N2O)	g eq. CO2	360	1.5E+05
	IPCC-Greenhouse effect (direct, 20 years)	g eq. CO2	*	3.5E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	2.4E+07
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	3900	6.7E+00
	(a) Halon 1301 (CF3Br)	g eq. CO2	7900	1.2E+03
	(a) Methane (CH4)	g eq. CO2	64	1.0E+07
	(a) Nitrous Oxide (N2O)	g eq. CO2	330	1.3E+05
	IPCC-Greenhouse effect (direct, 500 years)	g eq. CO2	*	2.6E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	2.4E+07
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	8900	1.5E+01
	(a) Halon 1301 (CF3Br)	g eq. CO2	2700	4.2E+02
	(a) Methane (CH4)	g eq. CO2	7.5	1.2E+06
	(a) Nitrous Oxide (N2O)	g eq. CO2	190	7.8E+04
	USES 1.0-Aquatic Ecotoxicity	g eq. 1-4-dichlorobenzene	*	1.2E+04
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	5.6	1.8E+00
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.0013	1.3E-01
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	320	7.3E+00
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130	1.6E+01
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	2.6	1.9E-01
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	2.9	2.8E+01
	(a) Ethylene (C2H4)	g eq. 1-4-dichlorobenzene	0.0022	4.9E+00
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	6.1	1.2E+02
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.2	8.6E+01
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	16000	5.0E+03
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	80	3.3E+02
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	39	6.4E-04
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	9.70E-05	3.7E-03
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	11	6.0E+01
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	2.6	3.3E+02
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	3.00E-08	1.4E-09
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	3.90E-06	9.7E-06
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.40E-09	2.4E-07
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	6.80E-08	2.4E-11
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	1.40E-08	5.5E-07
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.80E-09	4.5E-09
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	16000	8.9E-01
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	5.80E-07	1.4E-04
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	3.90E-08	1.1E-06
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	190	9.7E+02
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	1	2.9E+00
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	4500	7.4E+02
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	0.7	1.6E-04
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	84	8.2E+01
	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	84	3.9E+03
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	84	6.5E-02
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	160	4.6E-04
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	0.021	1.4E-02
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	1.1	1.1E-06
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	0.18	3.9E-07
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.16	9.6E-06
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	380	7.4E+01
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.86	3.1E+01
	USES 1.0-Human Toxicity	g eq. 1-4-dichlorobenzene	*	5.2E+06
	(a) Ammonia (NH3)	g eq. 1-4-dichlorobenzene	16	2.0E+03
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	42000	1.3E+04
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	29	2.9E+03
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	3700	8.4E+01
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	23000	2.9E+03
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	7600	5.5E+02
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	350	3.3E+03
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	0.42	8.0E+00
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	67000	4.8E+06
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	29000	9.1E+03
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	9800	4.0E+04
	(a) Nitrogen Oxides (NOx as NO2)	g eq. 1-4-dichlorobenzene	0.26	1.6E+04
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	2.2	3.6E-05
	(a) Sulphur Oxides (SOx as SO2)	g eq. 1-4-dichlorobenzene	0.16	1.4E+04
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.036	1.4E+00
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	4900	2.7E+04
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	0.63	8.0E+01
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	670	3.0E+01
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	20000	5.0E+04
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	1500	5.4E-01
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	30	1.2E+03
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	350	8.7E+02
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	29000	1.6E+00
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	800	1.9E+05
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	12	3.5E+02
	(w) Ammonia (NH4+, NH3, as N)	g eq. 1-4-dichlorobenzene	17	9.4E+02
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	51	2.6E+02
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	22	6.4E+01
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	130	2.1E+01
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	32	7.2E-03
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	9.3	9.1E+00
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	67000	5.2E+01
	(w) Cobalt (Co I, Co II, Co III)	g eq. 1-4-dichlorobenzene	31	1.9E+00
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.1	1.7E+01
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	0.35	1.0E-06
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	0.026	4.2E-01
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	18000	4.2E+03
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	12	7.7E+00
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	63	7.8E+02
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	0.89	3.8E+00
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	37	3.6E-05
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.053	1.3E-01
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	1200	2.6E-03
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.11	6.6E-06
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	19	3.7E+00
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.058	2.1E+00
	USES 1.0-Terrestrial Ecotoxicity	g eq. 1-4-dichlorobenzene	*	1.3E+09
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	72000	2.3E+04
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.063	6.2E+00
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	64000000	1.5E+06
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130000000	1.6E+07
	(a) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	220000	3.4E+05
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	17000	1.2E+03
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	910000	8.7E+06
	(a) Ethylene (C2H4)	g eq. 1-4-dichlorobenzene	17	3.8E+04
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	2600	5.0E+04
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	11000	7.8E+05
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	13000000	4.1E+06
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	190000	7.8E+05

Plastics and PCBs landfilled scenario

LIFE CYCLE INVENTORY

	(w) Chlorinated Matter (unspecified, as Cl)	g	2.1E+02
	(w) Chloroform (CHCl3)	g	2.2E-04
	(w) Chromium (Cr III)	g	9.8E-01
	(w) Chromium (Cr III, Cr VI)	g	4.7E+01
	(w) Chromium (Cr VI)	g	7.7E-04
	(w) Cobalt (Co I, Co II, Co III)	g	6.0E-02
	(w) COD (Chemical Oxygen Demand)	g	3.9E+03
	(w) Copper (Cu+, Cu++)	g	1.5E+01
	(w) Cyanides (CN-)	g	1.1E+00
	(w) Dissolved Matter (unspecified)	g	6.3E+02
	(w) Dissolved Organic Carbon (DOC)	g	9.2E+01
	(w) Edetic Acid (C10H16N2O8, EDTA)	g	1.3E-03
	(w) Ethylbenzene (C6H5C2H5)	g	5.3E-02
	(w) Fluorides (F-)	g	1.7E+01
	(w) Formaldehyde (CH2O)	g	2.9E-06
	(w) Hexachloroethane (C2Cl6)	g	4.0E-10
	(w) Hydrazine (N2H4)	g	5.9E-04
	(w) Hydrocarbons (unspecified)	g	2.4E+00
	(w) Hypochlorite (ClO-)	g	6.8E-02
	(w) Hypochlorous Acid (HClO)	g	6.8E-02
	(w) Inorganic Dissolved Matter (unspecified)	g	4.0E+02
	(w) Iode (I-)	g	1.6E-01
	(w) Iron (Fe++, Fe3+)	g	4.6E+03
	(w) Lead (Pb++, Pb4+)	g	1.6E+01
	(w) Lithium Salts (Lithine)	g	6.6E-05
	(w) Magnesium (Mg++)	g	4.7E+02
	(w) Manganese (Mn II, Mn IV, Mn VII)	g	3.1E+00
	(w) Mercury (Hg+, Hg++)	g	2.3E-01
	(w) Metals (unspecified)	g	2.7E+02
	(w) Methylene Chloride (CH2Cl2)	g	6.4E-01
	(w) Molybdenum (Mo II, Mo III, Mo IV, Mo V, Mo VI)	g	1.7E-01
	(w) Morpholine (C4H9NO)	g	6.3E-03
	(w) Nickel (Ni++, Ni3+)	g	1.2E+01
	(w) Nitrates (NO3-)	g	1.1E+03
	(w) Nitrites (NO2-)	g	8.1E-01
	(w) Nitrogenous Matter (Kjeldahl, as N)	g	3.0E-01
	(w) Nitrogenous Matter (unspecified, as N)	g	2.2E+01
	(w) Oils (unspecified)	g	7.2E+02
	(w) Organic Dissolved Matter (unspecified)	g	2.9E-01
	(w) Oxalic Acid ((COOH)2)	g	2.6E-03
	(w) Phenol (C6H5OH)	g	4.3E+00
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g	1.4E+02
	(w) Phosphorous Matter (unspecified, as P)	g	1.3E+00
	(w) Phosphorus (P)	g	3.2E-02
	(w) Phosphorus Pentoxide (P2O5)	g	1.9E-02
	(w) Polycyclic Aromatic Hydrocarbons (PAH, unspecified)	g	1.6E-01
	(w) Potassium (K+)	g	2.4E+02
	(w) Rubidium (Rb+)	g	1.6E-02
	(w) Salts (unspecified)	g	1.8E+04
	(w) Saponifiable Oils and Fats	g	7.1E+01
	(w) Selenium (Se II, Se IV, Se VI)	g	5.1E-02
	(w) Silicon Dioxide (SiO2)	g	2.3E-01
	(w) Silver (Ag+)	g	9.4E-04
	(w) Sodium (Na+)	g	6.0E+03
	(w) Strontium (Sr II)	g	9.7E+01
	(w) Sulphates (SO4--)	g	2.9E+04
	(w) Sulphides (S--)	g	7.0E-01
	(w) Sulphites (SO3--)	g	4.4E-01
	(w) Sulphurated Matter (unspecified, as S)	g	2.3E-05
	(w) Suspended Matter (unspecified)	g	7.5E+03
	(w) Tars (unspecified)	g	9.0E-09
	(w) Tetrachloroethylene (C2Cl4)	g	9.7E-07
	(w) Tin (Sn++, Sn4+)	g	1.8E-04
	(w) Titanium (Ti3+, Ti4+)	g	2.5E+00
	(w) TOC (Total Organic Carbon)	g	2.5E+03
	(w) Toluene (C6H5CH3)	g	2.4E+00
	(w) Trichlorethane (1,1,1-CH3CCl3)	g	2.2E-06
	(w) Trichloroethylene (C2HCl3)	g	6.0E-05
	(w) Triethylene Glycol (C6H14O4)	g	7.4E+01
	(w) Vanadium (V3+, V5+)	g	2.0E-01
	(w) VOC (Volatile Organic Compounds)	g	1.6E+01
	(w) Water (unspecified)	litre	5.9E+02
	(w) Water: Chemically Polluted	litre	3.7E+04
	(w) Xylene (C6H4(CH3)2)	g	2.2E+00
	(w) Zinc (Zn++)	g	3.6E+01
	(wr) Antimony (Sb124)	kBq	2.9E-02
	(wr) Cesium (Cs134)	kBq	2.5E-02
	(wr) Cesium (Cs137)	kBq	3.7E-02
	(wr) Cobalt (Co58)	kBq	8.4E-02
	(wr) Cobalt (Co60)	kBq	5.2E-02
	(wr) Iodine (I131)	kBq	3.2E-03
	(wr) Manganese (Mn54)	kBq	4.2E-03
	(wr) Protactinium (Pa234m)	kBq	1.3E-01
	(wr) Radioactive Substance (unspecified)	kBq	7.0E+04
	(wr) Radium (Ra224)	kBq	7.8E-02
	(wr) Radium (Ra226)	kBq	2.5E-02
	(wr) Radium (Ra228)	kBq	1.6E-01
	(wr) Silver (Ag110m)	kBq	1.3E-01
	(wr) Thorium (Th228)	kBq	3.1E-01
	(wr) Thorium (Th230)	kBq	1.2E+01
	(wr) Thorium (Th234)	kBq	1.3E-01
	(wr) Tritium (H3)	kBq	1.5E+03
	(wr) Uranium (U234)	kBq	4.2E+00
	(wr) Uranium (U235)	kBq	1.8E-01
	(wr) Uranium (U238)	kBq	4.0E+00
	Aluminium (Al)	kg	4.2E+02
	Cardboard	kg	4.6E+02
	Copper (Cu)	kg	4.0E+02
	Polypropylene (PP)	kg	7.8E+00
	Printers for resale	kg	4.9E+03
	Printers for reuse in maintenance	kg	7.2E+02
	Recovered Matter (total)	kg	9.8E+02
	Recovered Matter (unspecified)	kg	7.1E+02
	Recovered Matter: Aluminium Scrap	kg	2.5E+01
	Recovered Matter: Cardboard	kg	2.9E+01
	Recovered Matter: Iron Scrap	kg	1.5E-02
	Recovered Matter: Steel Scrap	kg	2.2E+02
	Recovered Matter: Toner Cartridges	kg	7.5E+01
	Steel Plate	kg	6.7E+03
	Waste (hazardous)	kg	8.5E-02
	Waste (incineration)	kg	2.0E-01
	Waste (municipal and industrial)	kg	4.5E+01
	Waste (total)	kg	3.4E+02
	Waste (unspecified)	kg	9.8E-01
	Waste: Active	kg	3.2E+01
	Waste: Highly Radioactive (class C)	kg	3.7E-03
	Waste: Low Radioactive (class A)	kg	1.4E-01
	Waste: Mineral (inert)	kg	2.7E+02
	Waste: Mining	kg	1.9E+02
	Waste: Non Mineral (inert)	kg	8.1E-03
	Waste: Non Toxic Chemicals (unspecified)	kg	6.3E-02
	Waste: Radioactive (unspecified)	kg	1.5E-03
	Waste: Slags and Ash (unspecified)	kg	2.9E+01

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	11000	1.8E-01
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.035	1.3E+00
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	450000	2.5E+06
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	660000	8.4E+07
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	200000	9.1E+03
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	340000000	8.4E+08
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	600000	1.0E+08
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	45000	1.6E+01
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	2400000	9.5E+07
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	29000	7.2E+04
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	17000000	9.5E+02
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	520000	1.3E+08
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	1800000	5.3E+07
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	9.70E-06	5.0E-05
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.039	1.1E-01
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	0.025	4.1E-03
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	5.2	1.2E-03
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	1.10E-05	1.1E-05
	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.10E-05	5.1E-04
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	1.10E-05	8.5E-09
	(w) Cobalt (Co I, Co II, Co III)	g eq. 1-4-dichlorobenzene	2.00E-07	1.2E-08
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.00E-05	1.5E-04
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	2.5	7.1E-06
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	2.00E-07	3.3E-06
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	8200000	1.9E+06
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	0.078	5.0E-02
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	3.10E-05	3.8E-04
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	34	1.5E+02
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	110	1.1E-04
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.022	5.2E-02
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	2	4.4E-06
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.024	1.4E-06
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	3.40E-05	6.7E-06
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	2.50E-05	8.9E-04
	WMO-Depletion of the ozone layer (high)	g eq. CFC-11	*	2.7E+00
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	17.2	2.7E+00
	WMO-Depletion of the ozone layer (low)	g eq. CFC-11	*	1.6E+00
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	10	1.6E+00
	WMO-Photochemical oxidant formation (high)	g eq. ethylene	*	1.8E+04
	(a) Acetaldehyde (CH3CHO)	g eq. ethylene	1.22	3.3E-01
	(a) Acetone (CH3COCH3)	g eq. ethylene	0.27	3.1E-02
	(a) Acetylene (C2H2)	g eq. ethylene	0.42	2.3E+00
	(a) Aldehyde (unspecified)	g eq. ethylene	1.263	3.1E-01
	(a) Alkane (unspecified)	g eq. ethylene	1.173	7.6E+02
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	1.285	9.4E+01
	(a) Benzaldehyde (C6H5CHO)	g eq. ethylene	-0.12	-2.6E-07
	(a) Benzene (C6H6)	g eq. ethylene	0.45	4.4E+01
	(a) Butane (n-C4H10)	g eq. ethylene	1.15	3.6E+02
	(a) Butene (1-CH3CH2CHCH2)	g eq. ethylene	1.85	1.4E-01
	(a) Ethane (C2H6)	g eq. ethylene	0.3	1.7E+02
	(a) Ethanol (C2H5OH)	g eq. ethylene	0.89	1.6E-01
	(a) Ethylene (C2H4)	g eq. ethylene	1	2.2E+03
	(a) Formaldehyde (CH2O)	g eq. ethylene	0.58	1.1E+01
	(a) Heptane (C7H16)	g eq. ethylene	1.65	8.4E-01
	(a) Hexane (C6H14)	g eq. ethylene	1.51	1.6E+00
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.799	8.7E+03
	(a) Hydrocarbons (unspecified)	g eq. ethylene	0.808	1.2E+02
	(a) Methane (CH4)	g eq. ethylene	0.03	4.9E+03
	(a) Methanol (CH3OH)	g eq. ethylene	0.21	6.3E-02
	(a) Propane (C3H8)	g eq. ethylene	1.24	2.2E+02
	(a) Propionaldehyde (CH3CH2CHO)	g eq. ethylene	1.6	9.4E-06
	(a) Propylene (CH2CHCH3)	g eq. ethylene	1.63	1.0E+01
	(a) Toluene (C6H5CH3)	g eq. ethylene	0.83	3.1E+01
	WMO-Photochemical oxidant formation (low)	g eq. ethylene	*	4.6E+03
	(a) Acetaldehyde (CH3CHO)	g eq. ethylene	0.33	9.0E-02
	(a) Acetone (CH3COCH3)	g eq. ethylene	0.1	1.1E-02
	(a) Acetylene (C2H2)	g eq. ethylene	0.1	5.5E-01
	(a) Aldehyde (unspecified)	g eq. ethylene	0.079	1.9E-02
	(a) Alkane (unspecified)	g eq. ethylene	0.114	7.4E+01
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	0.481	3.5E+01
	(a) Benzaldehyde (C6H5CHO)	g eq. ethylene	-0.82	-1.8E-06
	(a) Benzene (C6H6)	g eq. ethylene	0.11	1.1E+01
	(a) Butane (n-C4H10)	g eq. ethylene	0.15	4.7E+01
	(a) Butene (1-CH3CH2CHCH2)	g eq. ethylene	0.57	4.4E-02
	(a) Ethane (C2H6)	g eq. ethylene	0.02	1.1E+01
	(a) Ethanol (C2H5OH)	g eq. ethylene	0.04	7.4E-03
	(a) Ethylene (C2H4)	g eq. ethylene	1	2.2E+03
	(a) Formaldehyde (CH2O)	g eq. ethylene	0.22	4.2E+00
	(a) Heptane (C7H16)	g eq. ethylene	0.13	6.6E-02
	(a) Hexane (C6H14)	g eq. ethylene	0.1	1.0E-01
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.195	2.1E+03
	(a) Hydrocarbons (unspecified)	g eq. ethylene	0.194	2.8E+01
	(a) Methane (CH4)	g eq. ethylene	0	0.0E+00
	(a) Methanol (CH3OH)	g eq. ethylene	0.09	2.7E-02
	(a) Propane (C3H8)	g eq. ethylene	0.16	2.8E+01
	(a) Propionaldehyde (CH3CH2CHO)	g eq. ethylene	0.28	1.7E-06
	(a) Propylene (CH2CHCH3)	g eq. ethylene	0.75	4.6E+00
	(a) Toluene (C6H5CH3)	g eq. ethylene	0.41	1.5E+01

Plastics and PCBs landfilled scenario (expanded boundary)

LIFE CYCLE INVENTORY

	Flows	Units	Environmental burden
Inputs:	(r) Barium Sulphate (BaSO4, in ground)	kg	2.7E+00
	(r) Bauxite (Al2O3, ore)	kg	3.7E-01
	(r) Bentonite (Al2O3.4SiO2.H2O, in ground)	kg	4.2E-01
	(r) Calcium Sulphate (CaSO4, ore)	kg	7.5E-02
	(r) Chromium (Cr, ore)	kg	2.3E-02
	(r) Clay (in ground)	kg	2.4E+00
	(r) Coal (in ground)	kg	2.9E+03
	(r) Copper (Cu, ore)	kg	1.6E+04
	(r) Gravel (unspecified)	kg	1.0E+01
	(r) Iron (Fe, ore)	kg	1.9E+01
	(r) Iron Sulphate (FeSO4, ore)	kg	8.5E-02
	(r) Lead (Pb, ore)	kg	1.0E+01
	(r) Lignite (in ground)	kg	1.4E+02
	(r) Limestone (CaCO3, in ground)	kg	2.1E+01
	(r) Manganese (Mn, ore)	kg	2.5E-02
	(r) Natural Gas (in ground)	kg	1.4E+03
	(r) Nickel (Ni, ore)	kg	1.0E+01
	(r) Oil (in ground)	kg	2.0E+02
	(r) Palladium (Pd, ore)	kg	9.0E-02
	(r) Pyrite (FeS2, ore)	kg	7.1E+01
	(r) Sand (in ground)	kg	5.3E+00
	(r) Silver (Ag, ore)	kg	8.5E-01
	(r) Sodium Chloride (NaCl, in ground or in sea)	kg	2.6E+00
	(r) Uranium (U, ore)	kg	1.3E-01
	(r) Zinc (Zn, ore)	kg	5.6E+00
	Explosive (unspecified)	kg	1.0E+00
	Gold (Au)	kg	1.8E-01
	Iron Scrap	kg	6.8E-01
	Land Use (II -> III)	m2a	1.1E+01
	Land Use (II -> IV)	m2a	1.5E+00
	Land Use (III -> IV)	m2a	5.3E-01
	Lead Scrap	kg	1.0E+01
	Raw Materials (unspecified)	kg	4.1E+00
	Water Used (total)	litre	4.0E+04
	Water: Unspecified Origin	litre	4.0E+04
	Wood	kg	2.5E+00
	Wood (standing)	m3	1.7E-02
Outputs:	(a) Acetaldehyde (CH3CHO)	g	5.6E-01
	(a) Acetic Acid (CH3COOH)	g	9.9E+00
	(a) Acetone (CH3COCH3)	g	5.2E-01
	(a) Acetylene (C2H2)	g	2.4E+01
	(a) Acrolein (CH2CHCHO)	g	2.4E-06
	(a) Alcohol (unspecified)	g	3.6E-02
	(a) Aldehyde (unspecified)	g	6.1E-01
	(a) Alkane (unspecified)	g	2.1E+02
	(a) Alkene (unspecified)	g	2.5E+01
	(a) Alkyne (unspecified)	g	3.8E-01
	(a) Aluminium (Al)	g	4.7E+02
	(a) Ammonia (NH3)	g	1.2E+01
	(a) Antimony (Sb)	g	9.0E-02
	(a) AOX (Adsorbable Organic Halogens)	g	3.8E-10
	(a) Aromatic Hydrocarbons (unspecified)	g	4.4E-01
	(a) Arsenic (As)	g	4.5E+00
	(a) Barium (Ba)	g	5.6E+00
	(a) Benzaldehyde (C6H5CHO)	g	8.5E-07
	(a) Benzene (C6H6)	g	5.6E+01
	(a) Benzo(a)pyrene (C20H12)	g	7.4E-02
	(a) Berylium (Be)	g	8.9E-02
	(a) Boron (B)	g	4.6E+01
	(a) Bromium (Br)	g	9.1E+00
	(a) Butane (n-C4H10)	g	5.1E+01
	(a) Butene (1-CH3CH2CHCH2)	g	1.4E-01
	(a) Cadmium (Cd)	g	5.2E-01
	(a) Calcium (Ca)	g	6.0E+01
	(a) Carbon Dioxide (CO2, fossil)	g	8.8E+06
	(a) Carbon Hexafluoride (C2F6)	g	5.7E-04
	(a) Carbon Monoxide (CO)	g	7.3E+03
	(a) Carbon Tetrafluoride (CF4)	g	1.3E-02
	(a) CFC 11 (CFCl3)	g	1.2E-03
	(a) CFC 114 (CF2ClCF2Cl)	g	3.1E-02
	(a) CFC 12 (CCl2F2)	g	2.5E-04
	(a) CFC 13 (CF3Cl)	g	1.6E-04
	(a) Chlorine (Cl2)	g	2.5E-05
	(a) Chromium (Cr III, Cr VI)	g	1.2E+00
	(a) Cobalt (Co)	g	2.7E-01
	(a) Copper (Cu)	g	7.3E+01
	(a) Cyanide (CN-)	g	1.2E-01
	(a) Dioxins (unspecified)	g	9.1E-07
	(a) Ethane (C2H6)	g	3.2E+02
	(a) Ethanol (C2H5OH)	g	1.0E+00
	(a) Ethylbenzene (C8H10)	g	6.2E-01
	(a) Ethylene (C2H4)	g	8.0E+02
	(a) Fluorides (F-)	g	2.6E-03
	(a) Fluorine (F2)	g	1.6E-03
	(a) Formaldehyde (CH2O)	g	9.5E+00
	(a) Halogenated Matter (unspecified)	g	5.0E-12
	(a) Halon 1301 (CF3Br)	g	5.6E-02
	(a) HCFC 22 (CHF2Cl)	g	2.0E-11
	(a) Heptane (C7H16)	g	1.3E+00
	(a) Hexane (C6H14)	g	2.6E+00
	(a) Hydrocarbons (except methane)	g	2.5E+03
	(a) Hydrocarbons (unspecified)	g	2.7E+01
	(a) Hydrogen (H2)	g	1.0E-04
	(a) Hydrogen Chloride (HCl)	g	2.3E+03
	(a) Hydrogen Fluoride (HF)	g	9.3E+01
	(a) Hydrogen Sulphide (H2S)	g	8.2E+01
	(a) Iodine (I)	g	2.2E+00
	(a) Iron (Fe)	g	1.9E+02
	(a) lanthanum (La)	g	1.4E-01
	(a) Lead (Pb)	g	4.8E+01
	(a) Magnesium (Mg)	g	1.6E+02
	(a) Manganese (Mn)	g	1.5E+00
	(a) Mercury (Hg)	g	2.4E-01
	(a) Metals (unspecified)	g	5.3E-03
	(a) Methane (CH4)	g	2.3E+04
	(a) Methanol (CH3OH)	g	1.6E+00
	(a) Molybdenum (Mo)	g	2.3E-01
	(a) Nickel (Ni)	g	4.0E+01
	(a) Nitrogen Oxides (NOx as NO2)	g	1.6E+04
	(a) Nitrous Oxide (N2O)	g	9.9E+01
	(a) Organic Matter (unspecified)	g	1.2E+00
	(a) Particulates (unspecified)	g	3.5E+03
	(a) Pentachlorobenzene (C6HCl5)	g	2.1E-07
	(a) Pentachlorophenol (PCP, C6Cl5OH)	g	3.3E-08
	(a) Pentane (C5H12)	g	6.6E+01
	(a) Phenol (C6H5OH)	g	4.1E-04
	(a) Phosphorus (P)	g	4.3E+00
	(a) Phosphorus Pentoxide (P2O5)	g	2.7E-03
	(a) Polycyclic Aromatic Hydrocarbons (PAH, unspecified)	g	5.3E-01
	(a) Potassium (K)	g	5.8E+01
	(a) Propane (C3H8)	g	1.2E+02
	(a) Propionaldehyde (CH3CH2CHO)	g	1.6E-06
	(a) Propionic Acid (CH3CH2COOH)	g	2.2E-03
	(a) Propylene (CH2CHCH3)	g	2.6E+01
	(a) Scandium (Sc)	g	4.9E-02
	(a) Selenium (Se)	g	9.5E-01
	(a) Silicon (Si)	g	7.2E+02

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	Classification	Units	Charact-erisation	Environmental impact
Methods:	CML-Eutrophication	g eq. PO4	*	2.2E+03
	(a) Nitrogen Oxides (NOx as NO2)	g eq. PO4	0.13	2.0E+03
	(a) Nitrous Oxide (N2O)	g eq. PO4	0.27	2.7E+01
	(w) Ammonia (NH4+, NH3, as N)	g eq. PO4	0.42	1.9E+01
	(w) COD (Chemical Oxygen Demand)	g eq. PO4	0.022	8.4E-01
	(w) Nitrogenous Matter (Kjeldahl, as N)	g eq. PO4	0.42	5.4E-01
	(w) Nitrogenous Matter (unspecified, as N)	g eq. PO4	0.42	2.6E+00
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g eq. PO4	3.06	6.9E+01
	(w) Phosphorus (P)	g eq. PO4	3.06	1.1E-01
	(w) Phosphorus Pentoxide (P2O5)	g eq. PO4	1.336	1.1E-01
	CST-Aquatic Eco-toxicity	eq. Zn water	*	3.2E+02
	(a) Arsenic (As)	eq. Zn water	0.078	3.5E-01
	(a) Cadmium (Cd)	eq. Zn water	79	4.1E+01
	(a) Chromium (Cr III, Cr VI)	eq. Zn water	0.39	4.5E-01
	(a) Copper (Cu)	eq. Zn water	0.66	4.8E+01
	(a) Lead (Pb)	eq. Zn water	1.28	6.1E+01
	(a) Mercury (Hg)	eq. Zn water	196	4.7E+01
	(a) Nickel (Ni)	eq. Zn water	0.12	4.8E+00
	(a) Zinc (Zn)	eq. Zn water	0.076	6.0E+00
	(s) Arsenic (As)	eq. Zn water	0.24	3.3E-03
	(s) Cadmium (Cd)	eq. Zn water	240	2.9E-02
	(s) Chromium (Cr III, Cr VI)	eq. Zn water	1.2	2.1E-01
	(s) Copper (Cu)	eq. Zn water	2	1.4E-03
	(s) Lead (Pb)	eq. Zn water	3.9	1.3E-02
	(s) Mercury (Hg)	eq. Zn water	600	1.3E-02
	(s) Nickel (Ni)	eq. Zn water	0.36	3.8E-04
	(s) Zinc (Zn)	eq. Zn water	0.23	1.2E-01
	(w) Arsenic (As3+, As5+)	eq. Zn water	0.52	4.3E-01
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Zn water	0.00013	4.4E-04
	(w) Cadmium (Cd++)	eq. Zn water	520	1.5E+01
	(w) Chromium (Cr III, Cr VI)	eq. Zn water	2.6	3.2E-01
	(w) Copper (Cu+, Cu++)	eq. Zn water	5.2	1.2E+01
	(w) Lead (Pb++, Pb4+)	eq. Zn water	5.2	2.4E+01
	(w) Mercury (Hg+, Hg++)	eq. Zn water	1300	1.4E+00
	(w) Nickel (Ni++, Ni3+)	eq. Zn water	0.79	1.8E+00
	(w) Oils (unspecified)	eq. Zn water	0.13	2.1E+01
	(w) Phenol (C6H5OH)	eq. Zn water	15.4	2.8E+01
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Zn water	0.01	2.2E-01
	(w) Zinc (Zn++)	eq. Zn water	1	4.9E+00
	CST-Human Toxicity	eq. Pb air	*	2.7E+05
	(a) Aldehyde (unspecified)	eq. Pb air	0.0087	5.3E-03
	(a) Arsenic (As)	eq. Pb air	9000	4.1E+04
	(a) Benzene (C6H6)	eq. Pb air	0.012	6.7E-01
	(a) Cadmium (Cd)	eq. Pb air	19000	9.8E+03
	(a) Carbon Monoxide (CO)	eq. Pb air	0.00014	1.0E+00
	(a) Chromium (Cr III, Cr VI)	eq. Pb air	3700	4.3E+03
	(a) Cobalt (Co)	eq. Pb air	12900	3.4E+03
	(a) Copper (Cu)	eq. Pb air	145	1.1E+04
	(a) Formaldehyde (CH2O)	eq. Pb air	0.0099	9.4E-02
	(a) Lead (Pb)	eq. Pb air	2300	1.1E+05
	(a) Mercury (Hg)	eq. Pb air	46000	1.1E+04
	(a) Nickel (Ni)	eq. Pb air	370	1.5E+04
	(a) Nitrogen Oxides (NOx as NO2)	eq. Pb air	0.002	3.1E+01
	(a) Particulates (unspecified)	eq. Pb air	0.0075	2.7E+01
	(a) Selenium (Se)	eq. Pb air	64000	6.1E+04
	(a) Sulphur Oxides (SOx as SO2)	eq. Pb air	0.0075	2.3E+03
	(a) Tin (Sn)	eq. Pb air	9	2.7E-01
	(a) Zinc (Zn)	eq. Pb air	27	2.1E+03
	(s) Arsenic (As)	eq. Pb air	0.7	9.7E-03
	(s) Cadmium (Cd)	eq. Pb air	1.46	1.8E-04
	(s) Chromium (Cr III, Cr VI)	eq. Pb air	0.29	5.0E-02
	(s) Cobalt (Co)	eq. Pb air	1	1.4E-04
	(s) Copper (Cu)	eq. Pb air	0.009	6.3E-06
	(s) Lead (Pb)	eq. Pb air	0.6	1.9E-03
	(s) Mercury (Hg)	eq. Pb air	3.6	7.8E-05
	(s) Nickel (Ni)	eq. Pb air	0.029	3.1E-05
	(s) Zinc (Zn)	eq. Pb air	0.0007	3.7E-04
	(w) Arsenic (As3+, As5+)	eq. Pb air	1.5	1.2E+00
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Pb air	0.022	7.5E-02
	(w) Cadmium (Cd++)	eq. Pb air	3.2	9.0E-02
	(w) Chromium (Cr III, Cr VI)	eq. Pb air	0.62	7.7E-02
	(w) Cobalt (Co I, Co II, Co III)	eq. Pb air	2.2	1.2E+00
	(w) Copper (Cu+, Cu++)	eq. Pb air	0.022	5.1E-02
	(w) Fluorides (F-)	eq. Pb air	0.045	5.2E-01
	(w) Lead (Pb++, Pb4+)	eq. Pb air	0.86	4.0E+00
	(w) Mercury (Hg+, Hg++)	eq. Pb air	7.8	8.4E-03
	(w) Nickel (Ni++, Ni3+)	eq. Pb air	0.062	1.4E-01
	(w) Phenol (C6H5OH)	eq. Pb air	0.052	9.3E-02
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Pb air	3.20E-06	7.2E-05
	(w) Selenium (Se II, Se IV, Se VI)	eq. Pb air	10.9	1.5E+01
	(w) Tin (Sn++, Sn4+)	eq. Pb air	0.0015	3.1E-06
	(w) Zinc (Zn++)	eq. Pb air	0.0032	1.6E-02
	CST-Terrestrial Eco-toxicity	eq. Zn air	*	6.4E+01
	(a) Arsenic (As)	eq. Zn air	0.75	3.4E+00
	(a) Cadmium (Cd)	eq. Zn air	3.14	1.6E+00
	(a) Chromium (Cr III, Cr VI)	eq. Zn air	0.08	9.3E-02
	(a) Cobalt (Co)	eq. Zn air	0.08	2.1E-02
	(a) Copper (Cu)	eq. Zn air	0.14	1.0E+01
	(a) Lead (Pb)	eq. Zn air	0.13	6.2E+00
	(a) Mercury (Hg)	eq. Zn air	5.94	1.4E+00
	(a) Nickel (Ni)	eq. Zn air	0.35	1.4E+01
	(a) Zinc (Zn)	eq. Zn air	0.33	2.6E+01
	(s) Arsenic (As)	eq. Zn air	2.3	3.2E-02
	(s) Cadmium (Cd)	eq. Zn air	9.6	1.2E-03
	(s) Chromium (Cr III, Cr VI)	eq. Zn air	0.26	4.5E-02
	(s) Cobalt (Co)	eq. Zn air	0.26	3.7E-05
	(s) Copper (Cu)	eq. Zn air	0.42	3.0E-04
	(s) Lead (Pb)	eq. Zn air	0.41	1.3E-03
	(s) Mercury (Hg)	eq. Zn air	18.3	4.0E-04
	(s) Nickel (Ni)	eq. Zn air	1.1	1.2E-03
	(s) Zinc (Zn)	eq. Zn air	1	5.3E-01
	EB(R*Y)-Depletion of non renewable resources	yr-1	*	5.2E+05
	(r) Barium Sulphate (BaSO4, in ground)	yr-1	26.91	7.2E+01
	(r) Bauxite (Al2O3, ore)	yr-1	0.108	4.0E-02
	(r) Chromium (Cr, ore)	yr-1	0.2133	4.8E-03
	(r) Chromium (Cr, ore)	yr-1	0.319	7.2E-03
	(r) Coal (in ground)	yr-1	0.000504	1.4E+00
	(r) Copper (Cu, ore)	yr-1	28.16	4.4E+05
	(r) Iron (Fe, ore)	yr-1	0.04	7.5E-01
	(r) Lead (Pb, ore)	yr-1	157	1.6E+03
	(r) Lignite (in ground)	yr-1	0.000504	7.2E-02
	(r) Manganese (Mn, ore)	yr-1	0.296	7.5E-03
	(r) Natural Gas (in ground)	yr-1	0.117	1.7E+02
	(r) Nickel (Ni, ore)	yr-1	59.7	6.2E+02
	(r) Oil (in ground)	yr-1	0.0557	1.1E+01
	(r) Palladium (Pd, ore)	yr-1	20545.69	1.9E+03
	(r) Silver (Ag, ore)	yr-1	92837	7.9E+04
	(r) Uranium (U, ore)	yr-1	181	2.3E+01
	(r) Zinc (Zn, ore)	yr-1	40.29	2.3E+02
	ETH-Air Acidification	g eq. H+	/	9.9E+03
	(a) Ammonia (NH3)	g eq. H+	17	7.0E-01
	(a) CFC 11 (CFCl3)	g eq. H+	34.375	3.4E-05
	(a) Hydrogen Chloride (HCl)	g eq. H+	36.5	6.3E+01
	(a) Hydrogen Fluoride (HF)	g eq. H+	20	4.7E+00
	(a) Hydrogen Sulphide (H2S)	g eq. H+	17	4.8E+00
	(a) Nitrogen Oxides (NOx as NO2)	g eq. H+	46	3.4E+02
	(a) Pentachlorophenol (PCP, C6Cl5OH)	g eq. H+	53.3	6.2E-10

Plastics and PCBs landfilled scenario (expanded boundary)

LIFE CYCLE INVENTORY

	(a) Sodium (Na)	g	3.0E+01
	(a) Strontium (Sr)	g	9.1E+00
	(a) Sulphur Oxides (SOx as SO2)	g	3.0E+05
	(a) Tars (unspecified)	g	2.7E-06
	(a) Thallium (Tl)	g	4.5E-02
	(a) Thorium (Th)	g	9.1E-02
	(a) Tin (Sn)	g	3.0E-02
	(a) Titanium (Ti)	g	1.6E+01
	(a) Toluene (C6H5CH3)	g	1.8E+01
	(a) Uranium (U)	g	8.9E-02
	(a) Vanadium (V)	g	1.0E+01
	(a) Xylene (C6H4(CH3)2)	g	7.1E+00
	(a) Zinc (Zn)	g	7.9E+01
	(a) Zirconium (Zr)	g	6.8E-02
	(ar) Aerosols and Halogenes (unspecified)	kBq	1.7E-01
	(ar) Carbon (C14)	kBq	5.5E+01
	(ar) Cesium (Cs134)	kBq	2.1E-03
	(ar) Cesium (Cs137)	kBq	2.1E-03
	(ar) Cobalt (Co58)	kBq	2.1E-03
	(ar) Cobalt (Co60)	kBq	2.1E-03
	(ar) Gas (unspecified)	kBq	5.3E+03
	(ar) Iodine (I131)	kBq	1.2E-02
	(ar) Iodine (I133)	kBq	2.4E-02
	(ar) Krypton (Kr85)	kBq	3.2E+02
	(ar) Lead (Pb210)	kBq	2.1E+00
	(ar) Polonium (Po210)	kBq	3.7E+00
	(ar) Potassium (K40)	kBq	5.6E-01
	(ar) Protactinium (Pa234m)	kBq	3.0E-02
	(ar) Radioactive Substance (unspecified)	kBq	1.6E-02
	(ar) Radium (Ra226)	kBq	2.6E+00
	(ar) Radium (Ra228)	kBq	2.8E-01
	(ar) Radon (Rn220)	kBq	8.6E+00
	(ar) Radon (Rn222)	kBq	2.5E+05
	(ar) Thorium (Th228)	kBq	2.4E-01
	(ar) Thorium (Th230)	kBq	4.3E-01
	(ar) Thorium (Th232)	kBq	1.5E-01
	(ar) Thorium (Th234)	kBq	3.0E-02
	(ar) Tritium (H3)	kBq	6.4E+02
	(ar) Uranium (U234)	kBq	7.5E-01
	(ar) Uranium (U235)	kBq	5.6E-03
	(ar) Uranium (U238)	kBq	1.3E+00
	(ar) Xenon (Xe133)	kBq	4.5E+03
	(s) Aluminium (Al)	g	3.5E+01
	(s) Arsenic (As)	g	1.4E-02
	(s) Cadmium (Cd)	g	1.2E-04
	(s) Calcium (Ca)	g	1.4E+02
	(s) Carbon (C)	g	1.0E+02
	(s) Chromium (Cr III, Cr VI)	g	1.7E-01
	(s) Cobalt (Co)	g	1.4E-04
	(s) Copper (Cu)	g	7.0E-04
	(s) Iron (Fe)	g	6.6E+01
	(s) Lead (Pb)	g	3.2E-03
	(s) Manganese (Mn)	g	1.4E+00
	(s) Mercury (Hg)	g	2.2E-05
	(s) Nickel (Ni)	g	1.1E-03
	(s) Nitrogen (N)	g	2.3E-03
	(s) Oils (unspecified)	g	4.6E+00
	(s) Phosphorus (P)	g	1.5E+00
	(s) Sulphur (S)	g	2.1E+01
	(s) Zinc (Zn)	g	5.3E-01
	(sr) Americium (Am241)	kBq	5.5E+02
	(sr) Americium (Am243)	kBq	1.2E+01
	(sr) Cesium (Cs135)	kBq	2.7E+05
	(sr) Cesium (Cs137)	kBq	7.5E-01
	(sr) Curium (Cm244)	kBq	1.1E+03
	(sr) Curium (Cm245)	kBq	1.3E-01
	(sr) Iodine (I129)	kBq	1.8E-02
	(sr) Neptunium (Np237)	kBq	1.7E+02
	(sr) Palladium (Pd107)	kBq	6.1E-02
	(sr) Plutonium (Pu239)	kBq	2.1E+05
	(sr) Plutonium (Pu240)	kBq	3.0E+05
	(sr) Plutonium (Pu241)	kBq	6.9E+07
	(sr) Plutonium (Pu242)	kBq	1.1E+03
	(sr) Radium (Ra226)	kBq	1.4E+03
	(sr) Samarium (Sm151)	kBq	2.5E+02
	(sr) Selenium (Se79)	kBq	1.9E-01
	(sr) Strontium (Sr90)	kBq	4.0E+04
	(sr) Technetium (Tc99)	kBq	8.2E+00
	(sr) Thorium (Th230)	kBq	1.4E+03
	(sr) Tin (Sn126)	kBq	3.4E-01
	(sr) Uranium (U234)	kBq	8.9E+02
	(sr) Uranium (U235)	kBq	1.6E+01
	(sr) Uranium (U238)	kBq	2.5E+02
	(sr) Zirconium (Zr93)	kBq	1.1E+00
	(w) Acids (H+)	g	9.3E-01
	(w) Alcohol (unspecified)	g	2.2E-01
	(w) Aldehyde (unspecified)	g	1.1E-02
	(w) Alkane (unspecified)	g	1.3E+00
	(w) Alkene (unspecified)	g	1.2E-01
	(w) Aluminium (Al3+)	g	4.3E+02
	(w) Aluminium Hydroxide (Al(OH)3)	g	2.6E-03
	(w) Ammonia (NH4+, NH3, as N)	g	4.6E+01
	(w) AOX (Adsorbable Organic Halogens)	g	3.9E-01
	(w) Aromatic Hydrocarbons (unspecified)	g	6.2E+00
	(w) Arsenic (As3+, As5+)	g	8.3E-01
	(w) Barium (Ba++)	g	6.1E+01
	(w) Barytes	g	4.9E+02
	(w) Benzene (C6H6)	g	1.8E+00
	(w) BOD5 (Biochemical Oxygen Demand)	g	3.4E+00
	(w) Boric Acid (H3BO3)	g	3.3E+00
	(w) Boron (B III)	g	4.7E-01
	(w) Cadmium (Cd++)	g	2.8E-02
	(w) Calcium (Ca++)	g	8.7E+02
	(w) Carbonates (CO3--, HCO3-, CO2, as C)	g	4.0E+00
	(w) Cesium (Cs++)	g	6.7E-03
	(w) Chlorides (Cl-)	g	3.2E+04
	(w) Chlorinated Matter (unspecified, as Cl)	g	7.2E+01
	(w) Chloroform (CHCl3)	g	6.3E-05
	(w) Chromium (Cr III)	g	2.6E+00
	(w) Chromium (Cr III, Cr VI)	g	1.2E-01
	(w) Chromium (Cr VI)	g	8.3E-04
	(w) Cobalt (Co I, Co II, Co III)	g	5.3E-01
	(w) COD (Chemical Oxygen Demand)	g	3.8E+01
	(w) Copper (Cu+, Cu++)	g	2.3E+00
	(w) Cyanides (CN-)	g	3.5E+00
	(w) Dissolved Matter (unspecified)	g	1.9E+03
	(w) Dissolved Organic Carbon (DOC)	g	2.3E+01
	(w) Edetic Acid (C10H16N2O8, EDTA)	g	5.6E-03
	(w) Ethylbenzene (C6H5C2H5)	g	2.0E-01
	(w) Fluorides (F-)	g	1.2E+01
	(w) Formaldehyde (CH2O)	g	1.5E-05
	(w) Hexachloroethane (C2Cl6)	g	1.1E-10
	(w) Hydrazine (N2H4)	g	2.6E-03
	(w) Hydrocarbons (unspecified)	g	1.7E-01
	(w) Hypochlorite (ClO-)	g	1.9E-02
	(w) Hypochlorous Acid (HClO)	g	1.9E-02
	(w) Inorganic Dissolved Matter (unspecified)	g	2.9E-01
	(w) Iode (I-)	g	8.2E-01
	(w) Iron (Fe++, Fe3+)	g	4.0E+02

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	(a) Sulphur Oxides (SOx as SO2)	g eq. H+	32	9.5E+03
	IPCC-Greenhouse effect (direct, 100 years)	g eq. CO2	*	9.4E+06
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	8.8E+06
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	5700	7.5E+01
	(a) CFC 11 (CFCl3)	g eq. CO2	4600	5.3E+00
	(a) CFC 114 (CF2ClCF2Cl)	g eq. CO2	9800	3.0E+02
	(a) CFC 12 (CCl2F2)	g eq. CO2	10600	2.6E+00
	(a) CFC 13 (CF3Cl)	g eq. CO2	14000	2.2E+00
	(a) Halon 1301 (CF3Br)	g eq. CO2	6900	3.8E+02
	(a) HCFC 22 (CHF2Cl)	g eq. CO2	1900	3.8E-08
	(a) Methane (CH4)	g eq. CO2	24	5.5E+05
	(a) Nitrous Oxide (N2O)	g eq. CO2	360	3.6E+04
	IPCC-Greenhouse effect (direct, 20 years)	g eq. CO2	*	1.0E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	8.8E+06
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	3900	5.2E+01
	(a) CFC 11 (CFCl3)	g eq. CO2	6300	7.3E+00
	(a) CFC 114 (CF2ClCF2Cl)	g eq. CO2	7500	2.3E+02
	(a) CFC 12 (CCl2F2)	g eq. CO2	10200	2.5E+00
	(a) CFC 13 (CF3Cl)	g eq. CO2	10000	1.6E+00
	(a) Halon 1301 (CF3Br)	g eq. CO2	7900	4.4E+02
	(a) HCFC 22 (CHF2Cl)	g eq. CO2	5200	1.0E-07
	(a) Methane (CH4)	g eq. CO2	64	1.5E+06
	(a) Nitrous Oxide (N2O)	g eq. CO2	330	3.3E+04
	IPCC-Greenhouse effect (direct, 500 years)	g eq. CO2	*	9.0E+06
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	8.8E+06
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	8900	1.2E+02
	(a) CFC 11 (CFCl3)	g eq. CO2	1600	1.9E+00
	(a) CFC 114 (CF2ClCF2Cl)	g eq. CO2	8700	2.7E+02
	(a) CFC 12 (CCl2F2)	g eq. CO2	5200	1.3E+00
	(a) CFC 13 (CF3Cl)	g eq. CO2	16300	2.5E+00
	(a) Halon 1301 (CF3Br)	g eq. CO2	2700	1.5E+02
	(a) HCFC 22 (CHF2Cl)	g eq. CO2	590	1.2E-08
	(a) Methane (CH4)	g eq. CO2	7.5	1.7E+05
	(a) Nitrous Oxide (N2O)	g eq. CO2	190	1.9E+04
	USES 1.0-Aquatic Ecotoxicity	g eq. 1-4-dichlorobenzene	*	9.1E+03
	(a) Acrolein (CH2CHCHO)	g eq. 1-4-dichlorobenzene	160	3.8E-04
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	5.6	2.5E+01
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.0013	7.3E-02
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	320	2.4E+01
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130	6.7E+01
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	2.6	6.9E-01
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	2.9	2.1E+02
	(a) Ethylene (C2H4)	g eq. 1-4-dichlorobenzene	0.0022	1.8E+00
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	6.1	5.8E+01
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.2	5.8E+01
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	16000	3.8E+03
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	80	3.2E+03
	(a) Pentachlorobenzene (C6HCl5)	g eq. 1-4-dichlorobenzene	0.95	1.9E-07
	(a) Pentachlorophenol (PCP, C6Cl5OH)	g eq. 1-4-dichlorobenzene	100	3.3E-06
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	39	1.6E-02
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	9.70E-05	1.8E-03
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	11	1.1E+02
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	2.6	2.0E+02
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	3.00E-08	4.2E-10
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	3.90E-06	4.8E-10
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.40E-09	2.4E-10
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	6.80E-08	9.6E-12
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	1.40E-08	9.9E-12
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.80E-09	5.8E-12
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	16000	3.5E-01
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	5.80E-07	6.1E-10
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	3.90E-08	2.1E-08
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	190	1.6E+02
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	1	1.8E+00
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	4500	1.3E+02
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	0.7	4.4E-05
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	84	2.2E+02
	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	84	1.0E+01
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	84	7.0E-02
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	160	2.3E-03
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	0.021	4.0E-03
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	1.1	3.0E-07
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	0.18	1.1E-07
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.16	2.7E-06
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	380	7.8E+02
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.86	4.2E+00
	USES 1.0-Human Toxicity	g eq. 1-4-dichlorobenzene	*	4.0E+06
	(a) Acrolein (CH2CHCHO)	g eq. 1-4-dichlorobenzene	2300	5.5E-03
	(a) Ammonia (NH3)	g eq. 1-4-dichlorobenzene	16	1.9E+02
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	42000	1.9E+05
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	29	1.6E+03
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	3700	2.7E+02
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	23000	1.2E+04
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	7600	2.0E+03
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	350	2.6E+04
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	0.42	4.0E+00
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	67000	3.2E+06
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	29000	6.9E+03
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	9800	3.9E+05
	(a) Nitrogen Oxides (NOx as NO2)	g eq. 1-4-dichlorobenzene	0.26	4.1E+03
	(a) Pentachlorobenzene (C6HCl5)	g eq. 1-4-dichlorobenzene	250	5.1E-05
	(a) Pentachlorophenol (PCP, C6Cl5OH)	g eq. 1-4-dichlorobenzene	200	6.6E-06
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	2.2	9.0E-04
	(a) Sulphur Oxides (SOx as SO2)	g eq. 1-4-dichlorobenzene	0.16	4.8E+04
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.036	6.6E-01
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	4900	5.1E+04
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	0.63	4.9E+01
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	670	9.3E+00
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	20000	2.5E+00
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	1500	2.1E-01
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	30	2.1E-02
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	350	1.1E+00
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	29000	6.3E-01
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	800	8.4E-01
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	12	6.3E+00
	(w) Ammonia (NH4+, NH3, as N)	g eq. 1-4-dichlorobenzene	17	7.8E+02
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	51	4.2E+01
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	22	4.0E+01
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	130	3.7E+00
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	32	2.0E-03
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	9.3	2.4E+01
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	67000	5.6E+01
	(w) Cobalt (Co I, Co II, Co III)	g eq. 1-4-dichlorobenzene	31	1.6E+01
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.1	2.5E+00
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	0.35	5.1E-06
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	0.026	1.2E-01
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	18000	1.9E+01
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	12	2.3E+00
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	63	1.4E+02
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	0.89	1.6E+00
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	37	1.0E-05
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.053	6.1E-02
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	1200	7.3E-04
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.11	1.8E-06
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	19	3.9E+01
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.058	2.8E-01
	USES 1.0-Terrestrial Ecotoxicity	g eq. 1-4-dichlorobenzene	*	2.1E+08
	(a) Acrolein (CH2CHCHO)	g eq. 1-4-dichlorobenzene	680	1.6E-03
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	72000	3.3E+05

Plastics and PCBs landfilled scenario (expanded boundary)

LIFE CYCLE INVENTORY

	(w) Lead (Pb++, Pb4+)	g	4.6E+00
	(w) Lithium Salts (Lithine)	g	2.9E-04
	(w) Magnesium (Mg++)	g	3.4E+02
	(w) Manganese (Mn II, Mn IV, Mn VII)	g	1.4E+01
	(w) Mercury (Hg+, Hg++)	g	1.1E-03
	(w) Metals (unspecified)	g	2.2E-01
	(w) Methylene Chloride (CH2Cl2)	g	1.9E-01
	(w) Molybdenum (Mo II, Mo III, Mo IV, Mo V, Mo VI)	g	9.4E-01
	(w) Morpholine (C4H9NO)	g	2.7E-02
	(w) Nickel (Ni++, Ni3+)	g	2.3E+00
	(w) Nitrates (NO3-)	g	1.6E+01
	(w) Nitrites (NO2-)	g	3.8E-01
	(w) Nitrogenous Matter (Kjeldahl, as N)	g	1.3E+00
	(w) Nitrogenous Matter (unspecified, as N)	g	6.1E+00
	(w) Oils (unspecified)	g	1.6E+02
	(w) Organic Dissolved Matter (unspecified)	g	2.3E-01
	(w) Oxalic Acid ((COOH)2)	g	1.1E-02
	(w) Phenol (C6H5OH)	g	1.8E+00
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g	2.2E+01
	(w) Phosphorus (P)	g	3.5E-02
	(w) Phosphorus Pentoxide (P2O5)	g	8.1E-02
	(w) Polycyclic Aromatic Hydrocarbons (PAH, unspecified)	g	1.3E-01
	(w) Potassium (K+)	g	1.7E+02
	(w) Rubidium (Rb+)	g	6.7E-02
	(w) Salts (unspecified)	g	5.6E+02
	(w) Saponifiable Oils and Fats	g	5.8E+01
	(w) Selenium (Se II, Se IV, Se VI)	g	1.4E+00
	(w) Silicon Dioxide (SiO2)	g	6.4E-02
	(w) Silver (Ag+)	g	4.5E-03
	(w) Sodium (Na+)	g	5.9E+03
	(w) Strontium (Sr II)	g	8.4E+01
	(w) Sulphates (SO4--)	g	1.1E+04
	(w) Sulphides (S--)	g	2.6E-01
	(w) Sulphites (SO3--)	g	2.4E-01
	(w) Sulphurated Matter (unspecified, as S)	g	9.8E-05
	(w) Suspended Matter (unspecified)	g	2.0E+03
	(w) Tars (unspecified)	g	3.9E-08
	(w) Tetrachloroethylene (C2Cl4)	g	2.7E-07
	(w) Tin (Sn++, Sn4+)	g	2.1E-03
	(w) Titanium (Ti3+, Ti4+)	g	1.5E+01
	(w) TOC (Total Organic Carbon)	g	4.8E+02
	(w) Toluene (C6H5CH3)	g	1.1E+00
	(w) Trichlorethane (1,1,1-CH3CCl3)	g	6.1E-07
	(w) Trichloroethylene (C2HCl3)	g	1.7E-05
	(w) Triethylene Glycol (C6H14O4)	g	2.2E+01
	(w) Vanadium (V3+, V5+)	g	2.0E+00
	(w) VOC (Volatile Organic Compounds)	g	2.3E+00
	(w) Water (unspecified)	litre	2.6E+03
	(w) Water: Chemically Polluted	litre	3.3E+02
	(w) Xylene (C6H4(CH3)2)	g	6.7E+00
	(w) Zinc (Zn++)	g	4.9E+00
	(wr) Antimony (Sb124)	kBq	1.2E-01
	(wr) Cesium (Cs134)	kBq	1.1E-01
	(wr) Cesium (Cs137)	kBq	1.6E-01
	(wr) Cobalt (Co58)	kBq	3.6E-01
	(wr) Cobalt (Co60)	kBq	2.3E-01
	(wr) Iodine (I131)	kBq	1.4E-02
	(wr) Manganese (Mn54)	kBq	1.8E-02
	(wr) Protactinium (Pa234m)	kBq	5.5E-01
	(wr) Radioactive Substance (unspecified)	kBq	1.5E-04
	(wr) Radium (Ra224)	kBq	3.4E-01
	(wr) Radium (Ra226)	kBq	1.1E+03
	(wr) Radium (Ra228)	kBq	6.7E-01
	(wr) Silver (Ag110m)	kBq	5.4E-01
	(wr) Thorium (Th228)	kBq	1.3E+00
	(wr) Thorium (Th230)	kBq	5.1E+01
	(wr) Thorium (Th234)	kBq	5.5E-01
	(wr) Tritium (H3)	kBq	6.6E+03
	(wr) Uranium (U234)	kBq	1.8E+01
	(wr) Uranium (U235)	kBq	7.9E-01
	(wr) Uranium (U238)	kBq	1.7E+01
	Mass of printers recycled in alternate scenario	kg	1.5E+04
	Recovered Matter (total)	kg	5.4E+00
	Recovered Matter (unspecified)	kg	5.3E+00
	Recovered Matter: Iron Scrap	kg	6.5E-02
	Waste (hazardous)	kg	3.7E-01
	Waste (incineration)	kg	1.3E-01
	Waste (municipal and industrial)	kg	4.5E-01
	Waste (total)	kg	9.7E+02
	Waste (unspecified)	kg	4.2E+00
	Waste: Highly Radioactive (class C)	kg	1.6E-02
	Waste: Low Radioactive (class A)	kg	5.8E-01
	Waste: Mineral (inert)	kg	8.4E+02
	Waste: Mining	kg	8.3E+02
	Waste: Non Mineral (inert)	kg	3.5E-02
	Waste: Non Toxic Chemicals (unspecified)	kg	1.2E-04
	Waste: Radioactive (unspecified)	kg	6.5E-03
	Waste: Slags and Ash (unspecified)	kg	1.2E+02

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.063	3.5E+00
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	64000000	4.7E+06
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	1.3E+08	6.7E+07
	(a) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	220000	2.6E+05
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	17000	4.5E+03
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	910000	6.7E+07
	(a) Ethylene (C2H4)	g eq. 1-4-dichlorobenzene	17	1.4E+04
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	2600	2.5E+04
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	11000	5.3E+05
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	13000000	3.1E+06
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	190000	7.6E+06
	(a) Pentachlorobenzene (C6HCl5)	g eq. 1-4-dichlorobenzene	11000	2.3E-03
	(a) Pentachlorophenol (PCP, C6Cl5OH)	g eq. 1-4-dichlorobenzene	2400000	8.0E-02
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	11000	4.5E+00
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.035	6.4E-01
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	450000	4.7E+06
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	660000	5.2E+07
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	200000	2.8E+03
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	3.4E+08	4.2E+04
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	600000	1.0E+05
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	45000	6.3E+00
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	2400000	1.7E+03
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	29000	9.3E+01
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	17000000	3.7E+02
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	520000	5.5E+02
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	1800000	9.5E+05
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	9.70E-06	8.1E-06
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.039	7.1E-02
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	0.025	7.0E-04
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	5.2	3.2E-04
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	1.10E-05	2.9E-05
	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.10E-05	1.4E-06
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	1.10E-05	9.1E-09
	(w) Cobalt (Co I, Co II, Co III)	g eq. 1-4-dichlorobenzene	2.00E-07	1.1E-07
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.00E-05	2.3E-05
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	2.5	3.7E-05
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	2.00E-07	9.3E-07
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	8200000	8.8E+03
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	0.078	1.5E-02
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	3.10E-05	7.1E-05
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	34	6.1E+01
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	110	3.0E-05
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.022	2.5E-02
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	2	1.2E-06
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.024	4.0E-07
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	3.40E-05	6.9E-05
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	2.50E-05	1.2E-04
	WMO-Depletion of the ozone layer (high)	g eq. CFC-11	*	9.8E-01
	(a) CFC 11 (CFCl3)	g eq. CFC-11	1	1.2E-03
	(a) CFC 114 (CF2ClCF2Cl)	g eq. CFC-11	0.85	2.6E-02
	(a) CFC 12 (CCl2F2)	g eq. CFC-11	1.06	2.6E-04
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	17.2	9.5E-01
	(a) HCFC 22 (CHF2Cl)	g eq. CFC-11	0.08	1.6E-12
	WMO-Depletion of the ozone layer (low)	g eq. CFC-11	*	5.7E-01
	(a) CFC 11 (CFCl3)	g eq. CFC-11	1	1.2E-03
	(a) CFC 114 (CF2ClCF2Cl)	g eq. CFC-11	0.57	1.7E-02
	(a) CFC 12 (CCl2F2)	g eq. CFC-11	0.82	2.0E-04
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	10	5.6E-01
	(a) HCFC 22 (CHF2Cl)	g eq. CFC-11	0.032	6.3E-13
	WMO-Photochemical oxidant formation (high)	g eq. ethylene	*	4.2E+03
	(a) Acetaldehyde (CH3CHO)	g eq. ethylene	1.22	6.9E-01
	(a) Acetone (CH3COCH3)	g eq. ethylene	0.27	1.4E-01
	(a) Acetylene (C2H2)	g eq. ethylene	0.42	9.9E+00
	(a) Alcohol (unspecified)	g eq. ethylene	0.55	2.0E-02
	(a) Aldehyde (unspecified)	g eq. ethylene	1.263	7.7E-01
	(a) Alkane (unspecified)	g eq. ethylene	1.173	2.4E+02
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	1.285	5.6E-01
	(a) Benzaldehyde (C6H5CHO)	g eq. ethylene	-0.12	-1.0E-07
	(a) Benzene (C6H6)	g eq. ethylene	0.45	2.5E+01
	(a) Butane (n-C4H10)	g eq. ethylene	1.15	5.9E+01
	(a) Butene (1-CH3CH2CHCH2)	g eq. ethylene	1.85	2.5E-01
	(a) Ethane (C2H6)	g eq. ethylene	0.3	9.6E+01
	(a) Ethanol (C2H5OH)	g eq. ethylene	0.89	9.1E-01
	(a) Ethylene (C2H4)	g eq. ethylene	1	8.0E+02
	(a) Formaldehyde (CH2O)	g eq. ethylene	0.58	5.5E+00
	(a) Heptane (C7H16)	g eq. ethylene	1.65	2.1E+00
	(a) Hexane (C6H14)	g eq. ethylene	1.51	3.9E+00
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.799	2.0E+03
	(a) Hydrocarbons (unspecified)	g eq. ethylene	0.808	2.2E+01
	(a) Methane (CH4)	g eq. ethylene	0.03	6.9E+02
	(a) Methanol (CH3OH)	g eq. ethylene	0.21	3.4E-01
	(a) Propane (C3H8)	g eq. ethylene	1.24	1.5E+02
	(a) Propionaldehyde (CH3CH2CHO)	g eq. ethylene	1.6	2.6E-06
	(a) Propylene (CH2CHCH3)	g eq. ethylene	1.63	4.2E+01
	(a) Toluene (C6H5CH3)	g eq. ethylene	0.83	1.5E+01
	WMO-Photochemical oxidant formation (low)	g eq. ethylene	*	1.4E+03
	(a) Acetaldehyde (CH3CHO)	g eq. ethylene	0.33	1.9E-01
	(a) Acetone (CH3COCH3)	g eq. ethylene	0.1	5.2E-02
	(a) Acetylene (C2H2)	g eq. ethylene	0.1	2.4E+00
	(a) Alcohol (unspecified)	g eq. ethylene	0.065	2.3E-03
	(a) Aldehyde (unspecified)	g eq. ethylene	0.079	4.8E-02
	(a) Alkane (unspecified)	g eq. ethylene	0.114	2.4E+01
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	0.481	2.1E-01
	(a) Benzaldehyde (C6H5CHO)	g eq. ethylene	-0.82	-7.0E-07
	(a) Benzene (C6H6)	g eq. ethylene	0.11	6.2E+00
	(a) Butane (n-C4H10)	g eq. ethylene	0.15	7.7E+00
	(a) Butene (1-CH3CH2CHCH2)	g eq. ethylene	0.57	7.8E-02
	(a) Ethane (C2H6)	g eq. ethylene	0.02	6.4E+00
	(a) Ethanol (C2H5OH)	g eq. ethylene	0.04	4.1E-02
	(a) Ethylene (C2H4)	g eq. ethylene	1	8.0E+02
	(a) Formaldehyde (CH2O)	g eq. ethylene	0.22	2.1E+00
	(a) Heptane (C7H16)	g eq. ethylene	0.13	1.7E-01
	(a) Hexane (C6H14)	g eq. ethylene	0.1	2.6E-01
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.195	5.0E+02
	(a) Hydrocarbons (unspecified)	g eq. ethylene	0.194	5.2E+00
	(a) Methane (CH4)	g eq. ethylene	0	0.0E+00
	(a) Methanol (CH3OH)	g eq. ethylene	0.09	1.5E-01
	(a) Propane (C3H8)	g eq. ethylene	0.16	1.9E+01
	(a) Propionaldehyde (CH3CH2CHO)	g eq. ethylene	0.28	4.6E-07
	(a) Propylene (CH2CHCH3)	g eq. ethylene	0.75	1.9E+01
	(a) Toluene (C6H5CH3)	g eq. ethylene	0.41	7.5E+00

100% landfilling scenario

LIFE CYCLE INVENTORY

	Flows	Units	Environmental burdens
Inputs:	(r) Coal (in ground)	kg	7.7E-01
	(r) Lignite (in ground)	kg	9.9E-01
	(r) Natural Gas (in ground)	kg	3.7E+00
	(r) Oil (in ground)	kg	9.0E+01
	(r) Uranium (U, ore)	kg	9.4E-05
	Diesel Oil	kg	5.5E+01
	Waste: Faulty Printers	kg	2.2E+04
	Wood	kg	7.5E-03
Outputs:	(a) Benzene (C6H6)	g	5.5E-02
	(a) Benzo(a)pyrene (C20H12)	g	2.8E-04
	(a) Cadmium (Cd)	g	1.5E-03
	(a) Carbon Dioxide (CO2, fossil)	g	1.7E+05
	(a) Carbon Monoxide (CO)	g	5.7E+02
	(a) Hydrocarbons (except methane)	g	3.0E+02
	(a) Lead (Pb)	g	6.2E-03
	(a) Methane (CH4)	g	1.8E+05
	(a) Nitrogen Oxides (NOx as NO2)	g	2.2E+03
	(a) Nitrous Oxide (N2O)	g	2.4E+01
	(a) Particulates (unspecified)	g	1.4E+02
	(a) Sulphur Oxides (SOx as SO2)	g	1.4E+02
	(a) Zinc (Zn)	g	3.8E+00
	(s) Cadmium (Cd)	g	3.3E+00
	(s) Carbon (C)	g	1.0E+02
	(s) Chromium (Cr III, Cr VI)	g	1.9E+03
	(s) Copper (Cu)	g	5.9E+02
	(s) Iron (Fe)	g	7.5E+03
	(s) Lead (Pb)	g	3.3E+00
	(s) Nickel (Ni)	g	3.3E+02
	(s) Zinc (Zn)	g	3.7E+01
	(w) Calcium (Ca++)	g	1.4E+01
	(w) Nitrates (NO3-)	g	2.2E+01
	(w) VOC (Volatile Organic Compounds)	g	2.3E+02
	(w) Water: Chemically Polluted	litre	5.9E-01
	Waste: Active	kg	2.4E+02

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	Classification	Units	Charact-erisation	Environmental impact
Methods:	CML-Eutrophication	g eq. PO4	*	2.9E+02
	(a) Nitrogen Oxides (NOx as NO2)	g eq. PO4	0.13	2.8E+02
	(a) Nitrous Oxide (N2O)	g eq. PO4	0.27	6.6E+00
	CST-Aquatic Eco-toxicity	eq. Zn water	*	4.4E+03
	(a) Cadmium (Cd)	eq. Zn water	79	1.1E-01
	(a) Lead (Pb)	eq. Zn water	1.28	7.9E-03
	(a) Zinc (Zn)	eq. Zn water	0.076	2.9E-01
	(s) Cadmium (Cd)	eq. Zn water	240	8.0E+02
	(s) Chromium (Cr III, Cr VI)	eq. Zn water	1.2	2.2E+03
	(s) Copper (Cu)	eq. Zn water	2	1.2E+03
	(s) Lead (Pb)	eq. Zn water	3.9	1.3E+01
	(s) Nickel (Ni)	eq. Zn water	0.36	1.2E+02
	(s) Zinc (Zn)	eq. Zn water	0.23	8.5E+00
	CST-Human Toxicity	eq. Pb air	*	7.2E+02
	(a) Benzene (C6H6)	eq. Pb air	0.012	6.6E-04
	(a) Cadmium (Cd)	eq. Pb air	19000	2.8E+01
	(a) Carbon Monoxide (CO)	eq. Pb air	0.00014	7.9E-02
	(a) Lead (Pb)	eq. Pb air	2300	1.4E+01
	(a) Nitrogen Oxides (NOx as NO2)	eq. Pb air	0.002	4.3E+00
	(a) Particulates (unspecified)	eq. Pb air	0.0075	1.0E+00
	(a) Sulphur Oxides (SOx as SO2)	eq. Pb air	0.0075	1.1E+00
	(a) Zinc (Zn)	eq. Pb air	27	1.0E+02
	(s) Cadmium (Cd)	eq. Pb air	1.46	4.9E+00
	(s) Chromium (Cr III, Cr VI)	eq. Pb air	0.29	5.4E+02
	(s) Copper (Cu)	eq. Pb air	0.009	5.3E+00
	(s) Lead (Pb)	eq. Pb air	0.6	2.0E+00
	(s) Nickel (Ni)	eq. Pb air	0.029	9.5E+00
	(s) Zinc (Zn)	eq. Pb air	0.0007	2.6E-02
	CST-Terrestrial Eco-toxicity	eq. Zn air	*	1.2E+03
	(a) Cadmium (Cd)	eq. Zn air	3.14	4.6E-03
	(a) Lead (Pb)	eq. Zn air	0.13	8.0E-04
	(a) Zinc (Zn)	eq. Zn air	0.33	1.3E+00
	(s) Cadmium (Cd)	eq. Zn air	9.6	3.2E+01
	(s) Chromium (Cr III, Cr VI)	eq. Zn air	0.26	4.9E+02
	(s) Copper (Cu)	eq. Zn air	0.42	2.5E+02
	(s) Lead (Pb)	eq. Zn air	0.41	1.4E+00
	(s) Nickel (Ni)	eq. Zn air	1.1	3.6E+02
	(s) Zinc (Zn)	eq. Zn air	1	3.7E+01
	EB(R*Y)-Depletion of non renewable resources	yr-1	*	5.5E+00
	(r) Coal (in ground)	yr-1	0.0005037	3.9E-04
	(r) Lignite (in ground)	yr-1	0.0005037	5.0E-04
	(r) Natural Gas (in ground)	yr-1	0.117	4.3E-01
	(r) Oil (in ground)	yr-1	0.0557	5.0E+00
	(r) Uranium (U, ore)	yr-1	181	1.7E-02
	ETH-Air Acidification	g eq. H+	/	5.1E+01
	(a) Nitrogen Oxides (NOx as NO2)	g eq. H+	46	4.7E+01
	(a) Sulphur Oxides (SOx as SO2)	g eq. H+	32	4.5E+00
	IPCC-Greenhouse effect (direct, 100 years)	g eq. CO2	*	4.5E+06
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	1.7E+05
	(a) Methane (CH4)	g eq. CO2	24	4.3E+06
	(a) Nitrous Oxide (N2O)	g eq. CO2	360	8.8E+03
	IPCC-Greenhouse effect (direct, 20 years)	g eq. CO2	*	1.2E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	1.7E+05
	(a) Methane (CH4)	g eq. CO2	64	1.1E+07
	(a) Nitrous Oxide (N2O)	g eq. CO2	330	8.0E+03
	IPCC-Greenhouse effect (direct, 500 years)	g eq. CO2	*	1.5E+06
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	1.7E+05
	(a) Methane (CH4)	g eq. CO2	7.5	1.3E+06
	(a) Nitrous Oxide (N2O)	g eq. CO2	190	4.6E+03
	USES 1.0-Aquatic Ecotoxicity	g eq. 1-4-dichlorobenzene	*	1.0E+01
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.0013	7.2E-05
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	320	8.9E-02
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130	1.9E-01
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.2	7.4E-03
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	2.6	9.9E+00
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	3.90E-06	1.3E-05
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.40E-09	2.6E-06
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	1.40E-08	8.3E-06
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.80E-09	6.0E-09
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	5.80E-07	1.9E-04
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	3.90E-08	1.4E-06
	USES 1.0-Human Toxicity	g eq. 1-4-dichlorobenzene	*	3.5E+05
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	29	1.6E+00
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	3700	1.0E+00
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	23000	3.3E+01
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	67000	4.1E+02
	(a) Nitrogen Oxides (NOx as NO2)	g eq. 1-4-dichlorobenzene	0.26	5.6E+02
	(a) Sulphur Oxides (SOx as SO2)	g eq. 1-4-dichlorobenzene	0.16	2.3E+01
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	0.63	2.4E+00
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	20000	6.7E+04
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	30	1.8E+04
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	350	1.2E+03
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	800	2.6E+05
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	12	4.4E+02
	USES 1.0-Terrestrial Ecotoxicity	g eq. 1-4-dichlorobenzene	*	3.9E+09
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.063	3.5E-03
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	64000000	1.8E+04
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130000000	1.9E+05
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	11000	6.8E+01
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	660000	2.5E+06
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	340000000	1.1E+09
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	600000	1.1E+09
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	2400000	1.4E+09
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	29000	9.7E+04
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	520000	1.7E+08
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	1800000	6.7E+07
	WMO-Depletion of the ozone layer (high)	g eq. CFC-11	*	0.0E+00
	WMO-Depletion of the ozone layer (low)	g eq. CFC-11	*	0.0E+00
	WMO-Photochemical oxidant formation (high)	g eq. ethylene	*	5.6E+03
	(a) Benzene (C6H6)	g eq. ethylene	0.45	2.5E-02
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.799	2.4E+02
	(a) Methane (CH4)	g eq. ethylene	0.03	5.3E+03
	WMO-Photochemical oxidant formation (low)	g eq. ethylene	*	5.9E+01
	(a) Benzene (C6H6)	g eq. ethylene	0.11	6.1E-03
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.195	5.9E+01
	(a) Methane (CH4)	g eq. ethylene	0	0.0E+00

100% landfilling scenario (expanded boundary)

LIFE CYCLE INVENTORY

	Flows	Units	Environmental burdens
Inputs:	(r) Barium Sulphate (BaSO4, in ground)	kg	4.2E+00
	(r) Bauxite (Al2O3, ore)	kg	1.5E+02
	(r) Bentonite (Al2O3.4SiO2.H2O, in ground)	kg	8.2E-01
	(r) Calcium Sulphate (CaSO4, ore)	kg	7.5E-02
	(r) Chromium (Cr, ore)	kg	2.3E-02
	(r) Clay (in ground)	kg	4.0E+00
	(r) Coal (in ground)	kg	1.1E+04
	(r) Copper (Cu, ore)	kg	7.1E+04
	(r) Gravel (unspecified)	kg	1.0E+01
	(r) Iron (Fe, ore)	kg	6.4E+03
	(r) Iron Sulphate (FeSO4, ore)	kg	8.5E-02
	(r) Lead (Pb, ore)	kg	1.0E+01
	(r) Lignite (in ground)	kg	1.1E+03
	(r) Limestone (CaCO3, in ground)	kg	3.9E+01
	(r) Manganese (Mn, ore)	kg	2.5E-02
	(r) Natural Gas (in ground)	kg	2.3E+03
	(r) Nickel (Ni, ore)	kg	1.0E+01
	(r) Oil (in ground)	kg	1.1E+03
	(r) Palladium (Pd, ore)	kg	9.0E-02
	(r) Pyrite (FeS2, ore)	kg	2.8E+02
	(r) Sand (in ground)	kg	1.2E+01
	(r) Silver (Ag, ore)	kg	8.5E-01
	(r) Sodium Chloride (NaCl, in ground or in sea)	kg	5.5E+00
	(r) Sulphur (S, in ground)	kg	4.1E-01
	(r) Uranium (U, ore)	kg	1.9E-01
	(r) Zinc (Zn, ore)	kg	5.6E+00
	Cardboard	kg	4.6E+02
	Explosive (unspecified)	kg	1.0E+00
	Fluorspar (CaF2)	kg	1.1E+00
	Gold (Au)	kg	1.8E-01
	Iron Scrap	kg	8.2E+02
	Land Use (II -> III)	m2a	1.1E+01
	Land Use (II -> IV)	m2a	1.5E+00
	Land Use (III -> IV)	m2a	5.3E-01
	Lead Scrap	kg	1.0E+01
	Lime (quick, CaO)	kg	1.9E+03
	Raw Materials (unspecified)	kg	3.7E+02
	Water Used (total)	litre	1.9E+05
	Water: Unspecified Origin	litre	1.9E+05
	Wood	kg	1.0E+02
	Wood (standing)	m3	1.7E-02
Outputs:	(a) Acetaldehyde (CH3CHO)	g	5.6E-01
	(a) Acetic Acid (CH3COOH)	g	9.9E+00
	(a) Acetone (CH3COCH3)	g	5.2E-01
	(a) Acetylene (C2H2)	g	2.4E+01
	(a) Acrolein (CH2CHCHO)	g	2.4E-06
	(a) Alcohol (unspecified)	g	3.6E-02
	(a) Aldehyde (unspecified)	g	6.3E-01
	(a) Alkane (unspecified)	g	3.4E+02
	(a) Alkene (unspecified)	g	2.5E+01
	(a) Alkyne (unspecified)	g	3.8E-01
	(a) Aluminium (Al)	g	4.7E+02
	(a) Ammonia (NH3)	g	2.9E+01
	(a) Antimony (Sb)	g	9.0E-02
	(a) AOX (Adsorbable Organic Halogens)	g	3.8E-10
	(a) Aromatic Hydrocarbons (unspecified)	g	3.9E+01
	(a) Arsenic (As)	g	4.6E+00
	(a) Barium (Ba)	g	5.6E+00
	(a) Benzaldehyde (C6H5CHO)	g	8.5E-07
	(a) Benzene (C6H6)	g	7.8E+01
	(a) Benzo(a)pyrene (C20H12)	g	7.4E-02
	(a) Berylium (Be)	g	8.9E-02
	(a) Boron (B)	g	4.6E+01
	(a) Bromium (Br)	g	9.1E+00
	(a) Butane (n-C4H10)	g	5.1E+01
	(a) Butene (1-CH3CH2CHCH2)	g	1.4E-01
	(a) Cadmium (Cd)	g	1.2E+00
	(a) Calcium (Ca)	g	6.0E+01
	(a) Carbon Dioxide (CO2, fossil)	g	3.1E+07
	(a) Carbon Hexafluoride (C2F6)	g	5.7E-04
	(a) Carbon Monoxide (CO)	g	1.3E+05
	(a) Carbon Tetrafluoride (CF4)	g	1.7E+01
	(a) CFC 11 (CFCl3)	g	1.2E-03
	(a) CFC 114 (CF2ClCF2Cl)	g	3.1E-02
	(a) CFC 12 (CCl2F2)	g	2.5E-04
	(a) CFC 13 (CF3Cl)	g	1.6E-04
	(a) Chlorine (Cl2)	g	2.5E-05
	(a) Chromium (Cr III, Cr VI)	g	2.1E+00
	(a) Cobalt (Co)	g	2.7E-01
	(a) Copper (Cu)	g	8.1E+01
	(a) Cyanide (CN-)	g	1.2E-01
	(a) Dioxins (unspecified)	g	9.1E-07
	(a) Ethane (C2H6)	g	3.2E+02
	(a) Ethanol (C2H5OH)	g	1.0E+00
	(a) Ethylbenzene (C8H10)	g	6.2E-01
	(a) Ethylene (C2H4)	g	8.0E+02
	(a) Fluorides (F-)	g	3.4E+01
	(a) Fluorine (F2)	g	1.6E-03
	(a) Formaldehyde (CH2O)	g	9.5E+00
	(a) Halogenated Matter (unspecified)	g	7.5E-04
	(a) Halon 1301 (CF3Br)	g	3.1E-01
	(a) HCFC 22 (CHF2Cl)	g	2.0E-11
	(a) Heptane (C7H16)	g	1.3E+00
	(a) Hexane (C6H14)	g	2.6E+00
	(a) Hydrocarbons (except methane)	g	1.2E+04
	(a) Hydrocarbons (unspecified)	g	2.7E+01
	(a) Hydrogen (H2)	g	1.0E-04
	(a) Hydrogen Chloride (HCl)	g	3.1E+03
	(a) Hydrogen Fluoride (HF)	g	1.9E+02
	(a) Hydrogen Sulphide (H2S)	g	1.5E+02
	(a) Iodine (I)	g	2.2E+00
	(a) Iron (Fe)	g	2.0E+02
	(a) Ianthanum (La)	g	1.4E-01
	(a) Lead (Pb)	g	8.5E+01
	(a) Magnesium (Mg)	g	1.6E+02
	(a) Manganese (Mn)	g	1.3E+01
	(a) Mercury (Hg)	g	3.5E-01
	(a) Metals (unspecified)	g	1.8E+02
	(a) Methane (CH4)	g	1.0E+05
	(a) Methanol (CH3OH)	g	1.6E+00
	(a) Molybdenum (Mo)	g	2.3E-01
	(a) Nickel (Ni)	g	5.2E+01
	(a) Nitrogen Oxides (NOx as NO2)	g	5.0E+04
	(a) Nitrous Oxide (N2O)	g	2.2E+02
	(a) Organic Matter (unspecified)	g	1.2E+00
	(a) Particulates (unspecified)	g	1.5E+04
	(a) Pentachlorobenzene (C6HCl5)	g	2.1E-07
	(a) Pentachlorophenol (PCP, C6Cl5OH)	g	3.3E-08
	(a) Pentane (C5H12)	g	6.6E+01
	(a) Phenol (C6H5OH)	g	4.1E-04
	(a) Phosphorus (P)	g	5.4E+00
	(a) Phosphorus Pentoxide (P2O5)	g	2.7E-03
	(a) Polycyclic Aromatic Hydrocarbons (PAH, except naphthalene)	g	1.7E+00
	(a) Polycyclic Aromatic Hydrocarbons (PAH, unspecified)	g	7.2E-01
	(a) Potassium (K)	g	5.8E+01
	(a) Propane (C3H8)	g	1.2E+02
	(a) Propionaldehyde (CH3CH2CHO)	g	1.6E-06
	(a) Propionic Acid (CH3CH2COOH)	g	2.2E-03
	(a) Propylene (CH2CHCH3)	g	2.6E+01
	(a) Scandium (Sc)	g	4.9E-02
	(a) Selenium (Se)	g	9.5E-01
	(a) Silicon (Si)	g	7.7E+02
	(a) Sodium (Na)	g	3.0E+01
	(a) Strontium (Sr)	g	9.1E+00
	(a) Sulphur Oxides (SOx as SO2)	g	4.0E+05
	(a) Tars (unspecified)	g	2.7E-06
	(a) Thallium (Tl)	g	3.1E-01
	(a) Thorium (Th)	g	9.1E-02
	(a) Tin (Sn)	g	3.0E-02
	(a) Titanium (Ti)	g	1.6E+01
	(a) Toluene (C6H5CH3)	g	1.8E+01
	(a) Uranium (U)	g	8.9E-02
	(a) Vanadium (V)	g	1.0E+01

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	Classification	Units	Charact-erisation	Environmental impact
Methods:	CML-Eutrophication	g eq. PO4	*	7.8E+03
	(a) Nitrogen Oxides (NOx as NO2)	g eq. PO4	0.13	6.5E+03
	(a) Nitrous Oxide (N2O)	g eq. PO4	0.27	5.8E+01
	(w) Ammonia (NH4+, NH3, as N)	g eq. PO4	0.42	4.6E+01
	(w) COD (Chemical Oxygen Demand)	g eq. PO4	0.022	7.0E+01
	(w) Nitrogenous Matter (Kjeldahl, as N)	g eq. PO4	0.42	5.4E-01
	(w) Nitrogenous Matter (unspecified, as N)	g eq. PO4	0.42	1.9E+01
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g eq. PO4	3.06	1.1E+03
	(w) Phosphorus (P)	g eq. PO4	3.06	1.1E-01
	(w) Phosphorus Pentoxide (P2O5)	g eq. PO4	1.336	1.1E-01
	CST-Aquatic Eco-toxicity	eq. Zn water	*	2.5E+03
	(a) Arsenic (As)	eq. Zn water	0.078	3.6E-01
	(a) Cadmium (Cd)	eq. Zn water	79	9.8E+01
	(a) Chromium (Cr III, Cr VI)	eq. Zn water	0.39	8.2E-01
	(a) Copper (Cu)	eq. Zn water	0.66	5.3E+01
	(a) Lead (Pb)	eq. Zn water	1.28	1.1E+02
	(a) Mercury (Hg)	eq. Zn water	196	6.8E+01
	(a) Nickel (Ni)	eq. Zn water	0.12	6.2E+00
	(a) Zinc (Zn)	eq. Zn water	0.076	1.0E+01
	(s) Arsenic (As)	eq. Zn water	0.24	5.3E-03
	(s) Cadmium (Cd)	eq. Zn water	240	1.0E-01
	(s) Chromium (Cr III, Cr VI)	eq. Zn water	1.2	3.3E-01
	(s) Copper (Cu)	eq. Zn water	2	4.8E-03
	(s) Lead (Pb)	eq. Zn water	3.9	4.2E-02
	(s) Mercury (Hg)	eq. Zn water	600	4.4E-02
	(s) Nickel (Ni)	eq. Zn water	0.36	1.3E-03
	(s) Zinc (Zn)	eq. Zn water	0.23	1.9E-01
	(w) Arsenic (As3+, As5+)	eq. Zn water	0.52	1.4E+01
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Zn water	0.00013	1.5E-01
	(w) Cadmium (Cd++)	eq. Zn water	520	3.7E+02
	(w) Chromium (Cr III, Cr VI)	eq. Zn water	2.6	4.1E+02
	(w) Copper (Cu+, Cu++)	eq. Zn water	5.2	3.6E+02
	(w) Lead (Pb++, Pb4+)	eq. Zn water	5.2	3.8E+02
	(w) Mercury (Hg+, Hg++)	eq. Zn water	1300	1.4E+02
	(w) Nickel (Ni++, Ni3+)	eq. Zn water	0.79	5.3E+01
	(w) Oils (unspecified)	eq. Zn water	0.13	1.6E+02
	(w) Phenol (C6H5OH)	eq. Zn water	15.4	1.2E+02
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Zn water	0.01	3.7E+00
	(w) Zinc (Zn++)	eq. Zn water	1	1.4E+02
	CST-Human Toxicity	eq. Pb air	*	3.9E+05
	(a) Aldehyde (unspecified)	eq. Pb air	0.0087	5.4E-03
	(a) Arsenic (As)	eq. Pb air	9000	4.1E+04
	(a) Benzene (C6H6)	eq. Pb air	0.012	9.4E-01
	(a) Cadmium (Cd)	eq. Pb air	19000	2.4E+04
	(a) Carbon Monoxide (CO)	eq. Pb air	0.00014	1.9E+01
	(a) Chromium (Cr III, Cr VI)	eq. Pb air	3700	7.8E+03
	(a) Cobalt (Co)	eq. Pb air	12900	3.4E+03
	(a) Copper (Cu)	eq. Pb air	145	1.2E+04
	(a) Formaldehyde (CH2O)	eq. Pb air	0.0099	9.4E-02
	(a) Lead (Pb)	eq. Pb air	2300	2.0E+05
	(a) Mercury (Hg)	eq. Pb air	46000	1.6E+04
	(a) Nickel (Ni)	eq. Pb air	370	1.9E+04
	(a) Nitrogen Oxides (NOx as NO2)	eq. Pb air	0.002	1.0E+02
	(a) Particulates (unspecified)	eq. Pb air	0.0075	1.1E+02
	(a) Selenium (Se)	eq. Pb air	64000	6.1E+04
	(a) Sulphur Oxides (SOx as SO2)	eq. Pb air	0.0075	3.0E+03
	(a) Tin (Sn)	eq. Pb air	9	2.7E-01
	(a) Zinc (Zn)	eq. Pb air	27	3.6E+03
	(s) Arsenic (As)	eq. Pb air	0.7	1.5E-02
	(s) Cadmium (Cd)	eq. Pb air	1.46	6.1E-04
	(s) Chromium (Cr III, Cr VI)	eq. Pb air	0.29	8.0E-02
	(s) Cobalt (Co)	eq. Pb air	1	4.8E-04
	(s) Copper (Cu)	eq. Pb air	0.009	2.1E-05
	(s) Lead (Pb)	eq. Pb air	0.6	6.5E-03
	(s) Mercury (Hg)	eq. Pb air	3.6	2.7E-04
	(s) Nickel (Ni)	eq. Pb air	0.029	1.0E-04
	(s) Zinc (Zn)	eq. Pb air	0.0007	5.9E-04
	(w) Arsenic (As3+, As5+)	eq. Pb air	1.5	4.2E+01
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Pb air	0.022	2.5E+01
	(w) Cadmium (Cd++)	eq. Pb air	3.2	2.3E+00
	(w) Chromium (Cr III, Cr VI)	eq. Pb air	0.62	9.7E+01
	(w) Cobalt (Co I, Co II, Co III)	eq. Pb air	2.2	1.2E+00
	(w) Copper (Cu+, Cu++)	eq. Pb air	0.022	1.5E+00
	(w) Fluorides (F-)	eq. Pb air	0.045	7.1E-01
	(w) Lead (Pb++, Pb4+)	eq. Pb air	0.86	6.3E+01
	(w) Mercury (Hg+, Hg++)	eq. Pb air	7.8	8.4E-01
	(w) Nickel (Ni++, Ni3+)	eq. Pb air	0.062	4.2E+00
	(w) Phenol (C6H5OH)	eq. Pb air	0.052	4.2E-01
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Pb air	3.20E-06	1.2E-03
	(w) Selenium (Se II, Se IV, Se VI)	eq. Pb air	10.9	1.5E+01
	(w) Tin (Sn++, Sn4+)	eq. Pb air	0.0015	3.1E-06
	(w) Zinc (Zn++)	eq. Pb air	0.0032	4.5E-01
	CST-Terrestrial Eco-toxicity	eq. Zn air	*	9.5E+01
	(a) Arsenic (As)	eq. Zn air	0.75	3.4E+00
	(a) Cadmium (Cd)	eq. Zn air	3.14	3.9E+00
	(a) Chromium (Cr III, Cr VI)	eq. Zn air	0.08	1.7E-01
	(a) Cobalt (Co)	eq. Zn air	0.08	2.1E-02
	(a) Copper (Cu)	eq. Zn air	0.14	1.1E+01
	(a) Lead (Pb)	eq. Zn air	0.13	1.1E+01
	(a) Mercury (Hg)	eq. Zn air	5.94	2.1E+00
	(a) Nickel (Ni)	eq. Zn air	0.35	1.8E+01
	(a) Zinc (Zn)	eq. Zn air	0.33	4.4E+01
	(s) Arsenic (As)	eq. Zn air	2.3	5.0E-02
	(s) Cadmium (Cd)	eq. Zn air	9.6	4.0E-03
	(s) Chromium (Cr III, Cr VI)	eq. Zn air	0.26	7.1E-02
	(s) Cobalt (Co)	eq. Zn air	0.26	1.2E-04
	(s) Copper (Cu)	eq. Zn air	0.42	1.0E-03
	(s) Lead (Pb)	eq. Zn air	0.41	4.5E-03
	(s) Mercury (Hg)	eq. Zn air	18.3	1.3E-03
	(s) Nickel (Ni)	eq. Zn air	1.1	3.9E-03
	(s) Zinc (Zn)	eq. Zn air	1	8.5E-01
	EB(R*Y)-Depletion of non renewable resources	yr-1	*	2.1E+06
	(r) Barium Sulphate (BaSO4, in ground)	yr-1	26.91	1.1E+02
	(r) Bauxite (Al2O3, ore)	yr-1	0.108	1.7E+01
	(r) Chromium (Cr, ore)	yr-1	0.2133	4.8E-03
	(r) Chromium (Cr, ore)	yr-1	0.319	7.2E-03
	(r) Coal (in ground)	yr-1	0.0005037	5.6E+00
	(r) Copper (Cu, ore)	yr-1	28.16	2.0E+06
	(r) Iron (Fe, ore)	yr-1	0.04	2.6E+02
	(r) Lead (Pb, ore)	yr-1	157	1.6E+03
	(r) Lignite (in ground)	yr-1	0.0005037	5.7E-01
	(r) Manganese (Mn, ore)	yr-1	0.296	7.5E-03
	(r) Natural Gas (in ground)	yr-1	0.117	2.7E+02
	(r) Nickel (Ni, ore)	yr-1	59.7	6.2E+02
	(r) Oil (in ground)	yr-1	0.0557	6.1E+01
	(r) Palladium (Pd, ore)	yr-1	20545.694	1.9E+03
	(r) Silver (Ag, ore)	yr-1	92837	7.9E+04
	(r) Sulphur (S, in ground)	yr-1	4.408	1.8E+00
	(r) Uranium (U, ore)	yr-1	181	3.4E+01
	(r) Zinc (Zn, ore)	yr-1	40.29	2.3E+02
	ETH-Air Acidification	g eq. H+	/	1.4E+04
	(a) Ammonia (NH3)	g eq. H+	17	1.7E+00
	(a) CFC 11 (CFCl3)	g eq. H+	34.375	3.4E-05
	(a) Hydrogen Chloride (HCl)	g eq. H+	36.5	8.4E+01
	(a) Hydrogen Fluoride (HF)	g eq. H+	20	9.6E+00
	(a) Hydrogen Sulphide (H2S)	g eq. H+	17	9.0E+00
	(a) Nitrogen Oxides (NOx as NO2)	g eq. H+	46	1.1E+03
	(a) Pentachlorophenol (PCP, C6Cl5OH)	g eq. H+	53.3	6.2E-10
	(a) Sulphur Oxides (SOx as SO2)	g eq. H+	32	1.3E+04
	IPCC-Greenhouse effect (direct, 100 years)	g eq. CO2	*	3.3E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	3.1E+07
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	5700	9.4E+04
	(a) CFC 11 (CFCl3)	g eq. CO2	4600	5.3E+00
	(a) CFC 114 (CF2ClCF2Cl)	g eq. CO2	9800	3.0E+02
	(a) CFC 12 (CCl2F2)	g eq. CO2	10600	2.6E+00
	(a) CFC 13 (CF3Cl)	g eq. CO2	14000	2.2E+00
	(a) Halon 1301 (CF3Br)	g eq. CO2	6900	2.1E+03
	(a) HCFC 22 (CHF2Cl)	g eq. CO2	1900	3.8E-08
	(a) Methane (CH4)	g eq. CO2	24	2.4E+06
	(a) Nitrous Oxide (N2O)	g eq. CO2	360	7.8E+04
	IPCC-Greenhouse effect (direct, 20 years)	g eq. CO2	*	3.7E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	3.1E+07
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	3900	6.5E+04

100% landfilling scenario (expanded boundary)

LIFE CYCLE INVENTORY

	(a) Xylene (C6H4(CH3)2)	g	7.1E+00
	(a) Zinc (Zn)	g	1.3E+02
	(a) Zirconium (Zr)	g	6.8E-02
	(ar) Aerosols and Halogenes (unspecified)	kBq	1.7E-01
	(ar) Carbon (C14)	kBq	5.5E+01
	(ar) Cesium (Cs134)	kBq	2.1E-03
	(ar) Cesium (Cs137)	kBq	2.1E-03
	(ar) Cobalt (Co58)	kBq	2.1E-03
	(ar) Cobalt (Co60)	kBq	2.1E-03
	(ar) Gas (unspecified)	kBq	5.3E+03
	(ar) Iodine (I131)	kBq	1.2E-02
	(ar) Iodine (I133)	kBq	2.4E-02
	(ar) Krypton (Kr85)	kBq	3.2E+02
	(ar) Lead (Pb210)	kBq	2.1E+00
	(ar) Polonium (Po210)	kBq	3.7E+00
	(ar) Potassium (K40)	kBq	5.6E-01
	(ar) Protactinium (Pa234m)	kBq	3.0E-02
	(ar) Radioactive Substance (unspecified)	kBq	3.4E+06
	(ar) Radium (Ra226)	kBq	2.6E+00
	(ar) Radium (Ra228)	kBq	2.8E-01
	(ar) Radon (Rn220)	kBq	8.6E+00
	(ar) Radon (Rn222)	kBq	2.5E+05
	(ar) Thorium (Th228)	kBq	2.4E-01
	(ar) Thorium (Th230)	kBq	4.3E-01
	(ar) Thorium (Th232)	kBq	1.5E-01
	(ar) Thorium (Th234)	kBq	3.0E-02
	(ar) Tritium (H3)	kBq	6.4E+02
	(ar) Uranium (U234)	kBq	7.5E-01
	(ar) Uranium (U235)	kBq	5.6E-03
	(ar) Uranium (U238)	kBq	1.3E+00
	(ar) Xenon (Xe133)	kBq	4.5E+03
	(s) Aluminium (Al)	g	5.5E+01
	(s) Arsenic (As)	g	2.2E-02
	(s) Cadmium (Cd)	g	4.2E-04
	(s) Calcium (Ca)	g	2.2E+02
	(s) Carbon (C)	g	1.7E+02
	(s) Chromium (Cr III, Cr VI)	g	2.7E-01
	(s) Cobalt (Co)	g	4.8E-04
	(s) Copper (Cu)	g	2.4E-03
	(s) Iron (Fe)	g	1.1E+02
	(s) Lead (Pb)	g	1.1E-02
	(s) Manganese (Mn)	g	2.2E+00
	(s) Mercury (Hg)	g	7.4E-05
	(s) Nickel (Ni)	g	3.6E-03
	(s) Nitrogen (N)	g	2.3E-03
	(s) Oils (unspecified)	g	1.6E+01
	(s) Phosphorus (P)	g	1.5E+00
	(s) Sulphur (S)	g	3.3E+01
	(s) Zinc (Zn)	g	8.5E-01
	(sr) Americium (Am241)	kBq	5.5E+02
	(sr) Americium (Am243)	kBq	1.2E+01
	(sr) Cesium (Cs135)	kBq	2.7E+05
	(sr) Cesium (Cs137)	kBq	7.5E-01
	(sr) Curium (Cm244)	kBq	1.1E+03
	(sr) Curium (Cm245)	kBq	1.3E-01
	(sr) Iodine (I129)	kBq	1.8E-02
	(sr) Neptunium (Np237)	kBq	1.7E+02
	(sr) Palladium (Pd107)	kBq	6.1E-02
	(sr) Plutonium (Pu239)	kBq	2.1E+05
	(sr) Plutonium (Pu240)	kBq	3.0E+05
	(sr) Plutonium (Pu241)	kBq	6.9E+07
	(sr) Plutonium (Pu242)	kBq	1.1E+03
	(sr) Radium (Ra226)	kBq	1.4E+03
	(sr) Samarium (Sm151)	kBq	2.5E+02
	(sr) Selenium (Se79)	kBq	1.9E-01
	(sr) Strontium (Sr90)	kBq	4.0E+04
	(sr) Technetium (Tc99)	kBq	8.2E+00
	(sr) Thorium (Th230)	kBq	1.4E+03
	(sr) Tin (Sn126)	kBq	3.4E-01
	(sr) Uranium (U234)	kBq	8.9E+02
	(sr) Uranium (U235)	kBq	1.6E+01
	(sr) Uranium (U238)	kBq	2.5E+02
	(sr) Zirconium (Zr93)	kBq	1.1E+00
	(w) Acids (H+)	g	1.5E+00
	(w) Alcohol (unspecified)	g	2.2E-01
	(w) Aldehyde (unspecified)	g	1.1E-02
	(w) Alkane (unspecified)	g	1.3E+00
	(w) Alkene (unspecified)	g	1.2E-01
	(w) Aluminium (Al3+)	g	1.4E+04
	(w) Aluminium Hydroxide (Al(OH)3)	g	2.6E-03
	(w) Ammonia (NH4+, NH3, as N)	g	1.1E+02
	(w) AOX (Adsorbable Organic Halogens)	g	3.9E+00
	(w) Aromatic Hydrocarbons (unspecified)	g	3.4E+01
	(w) Arsenic (As3+, As5+)	g	2.8E+01
	(w) Barium (Ba++)	g	1.2E+03
	(w) Barytes	g	7.7E+02
	(w) Benzene (C6H6)	g	3.5E+00
	(w) BOD5 (Biochemical Oxygen Demand)	g	1.1E+03
	(w) Boric Acid (H3BO3)	g	3.3E+00
	(w) Boron (B III)	g	4.7E-01
	(w) Cadmium (Cd++)	g	7.2E-01
	(w) Calcium (Ca++)	g	1.8E+03
	(w) Carbonates (CO3--, HCO3-, CO2, as C)	g	4.0E+00
	(w) Cesium (Cs++)	g	6.7E-03
	(w) Chlorides (Cl-)	g	1.4E+05
	(w) Chlorinated Matter (unspecified, as Cl)	g	7.2E+01
	(w) Chloroform (CHCl3)	g	6.3E-05
	(w) Chromium (Cr III)	g	2.6E+00
	(w) Chromium (Cr III, Cr VI)	g	1.6E+02
	(w) Chromium (Cr VI)	g	1.6E-03
	(w) Cobalt (Co I, Co II, Co III)	g	5.3E-01
	(w) COD (Chemical Oxygen Demand)	g	3.2E+03
	(w) Copper (Cu+, Cu++)	g	7.0E+01
	(w) Cyanides (CN-)	g	3.9E+00
	(w) Dissolved Matter (unspecified)	g	2.1E+03
	(w) Dissolved Organic Carbon (DOC)	g	3.7E+01
	(w) Edetic Acid (C10H16N2O8, EDTA)	g	5.6E-03
	(w) Ethylbenzene (C6H5C2H5)	g	2.0E-01
	(w) Fluorides (F-)	g	1.6E+01
	(w) Formaldehyde (CH2O)	g	1.5E-05
	(w) Hexachloroethane (C2Cl6)	g	1.1E-10
	(w) Hydrazine (N2H4)	g	2.6E-03
	(w) Hydrocarbons (unspecified)	g	1.7E-01
	(w) Hypochlorite (ClO-)	g	1.9E-02
	(w) Hypochlorous Acid (HClO)	g	1.9E-02
	(w) Inorganic Dissolved Matter (unspecified)	g	1.4E+03
	(w) Iode (I-)	g	8.2E-01
	(w) Iron (Fe++, Fe3+)	g	6.3E+03
	(w) Lead (Pb++, Pb4+)	g	7.3E+01
	(w) Lithium Salts (Lithine)	g	2.9E-04
	(w) Magnesium (Mg++)	g	7.6E+02
	(w) Manganese (Mn II, Mn IV, Mn VII)	g	1.4E+01
	(w) Mercury (Hg+, Hg++)	g	1.1E-01
	(w) Metals (unspecified)	g	1.5E+03
	(w) Methylene Chloride (CH2Cl2)	g	1.9E-01
	(w) Molybdenum (Mo II, Mo III, Mo IV, Mo V, Mo VI)	g	9.4E-01
	(w) Morpholine (C4H9NO)	g	2.7E-02
	(w) Nickel (Ni++, Ni3+)	g	6.8E+01
	(w) Nitrates (NO3-)	g	7.6E+01
	(w) Nitrites (NO2-)	g	1.2E+00
	(w) Nitrogenous Matter (Kjeldahl, as N)	g	1.3E+00
	(w) Nitrogenous Matter (unspecified, as N)	g	4.6E+01
	(w) Oils (unspecified)	g	1.3E+03
	(w) Organic Dissolved Matter (unspecified)	g	2.3E-01
	(w) Organic Matter (unspecified)	g	7.0E-02
	(w) Oxalic Acid ((COOH)2)	g	1.1E-02
	(w) Phenol (C6H5OH)	g	8.1E+00
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g	3.7E+02
	(w) Phosphorus (P)	g	3.5E-02
	(w) Phosphorus Pentoxide (P2O5)	g	8.1E-02
	(w) Polycyclic Aromatic Hydrocarbons (PAH, unspecified)	g	1.3E+00
	(w) Potassium (K+)	g	3.8E+02
	(w) Rubidium (Rb+)	g	6.7E-02
	(w) Salts (unspecified)	g	5.4E+04
	(w) Saponifiable Oils and Fats	g	1.2E+02

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	(a) CFC 11 (CFCl3)	g eq. CO2	6300	7.3E+00
	(a) CFC 114 (CF2ClCF2Cl)	g eq. CO2	7500	2.3E+02
	(a) CFC 12 (CCl2F2)	g eq. CO2	10200	2.5E+00
	(a) CFC 13 (CF3Cl)	g eq. CO2	10000	1.6E+00
	(a) Halon 1301 (CF3Br)	g eq. CO2	7900	2.4E+03
	(a) HCFC 22 (CHF2Cl)	g eq. CO2	5200	1.0E-07
	(a) Methane (CH4)	g eq. CO2	64	6.4E+06
	(a) Nitrous Oxide (N2O)	g eq. CO2	330	7.1E+04
	IPCC-Greenhouse effect (direct, 500 years)	g eq. CO2	*	3.2E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	3.1E+07
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	8900	1.5E+05
	(a) CFC 11 (CFCl3)	g eq. CO2	1600	1.9E+00
	(a) CFC 114 (CF2ClCF2Cl)	g eq. CO2	8700	2.7E+02
	(a) CFC 12 (CCl2F2)	g eq. CO2	5200	1.3E+00
	(a) CFC 13 (CF3Cl)	g eq. CO2	16300	2.5E+00
	(a) Halon 1301 (CF3Br)	g eq. CO2	2700	8.3E+02
	(a) HCFC 22 (CHF2Cl)	g eq. CO2	590	1.2E-08
	(a) Methane (CH4)	g eq. CO2	7.5	7.5E+05
	(a) Nitrous Oxide (N2O)	g eq. CO2	190	4.1E+04
	USES 1.0-Aquatic Ecotoxicity	g eq. 1-4-dichlorobenzene	*	3.4E+04
	(a) Acrolein (CH2CHCHO)	g eq. 1-4-dichlorobenzene	160	3.8E-04
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	5.6	2.6E+01
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.0013	1.0E-01
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	320	2.4E+01
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130	1.6E+02
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	2.6	6.9E-01
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	2.9	2.3E+02
	(a) Ethylene (C2H4)	g eq. 1-4-dichlorobenzene	0.0022	1.8E+00
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	6.1	5.8E+01
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.2	1.0E+02
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	16000	5.6E+03
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	80	4.2E+03
	(a) Pentachlorobenzene (C6HCl5)	g eq. 1-4-dichlorobenzene	0.95	1.9E-07
	(a) Pentachlorophenol (PCP, C6Cl5OH)	g eq. 1-4-dichlorobenzene	100	3.3E-06
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	39	1.6E-02
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	9.70E-05	1.8E-03
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	11	1.1E+02
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	2.6	3.5E+02
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	3.00E-08	6.6E-10
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	3.90E-06	1.6E-09
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.40E-09	3.8E-10
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	6.80E-08	3.2E-11
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	1.40E-08	3.3E-11
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.80E-09	2.0E-11
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	16000	1.2E+00
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	5.80E-07	2.1E-09
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	3.90E-08	3.3E-08
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	190	5.3E+03
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	1	3.5E+00
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	4500	3.2E+03
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	0.7	4.4E-05
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	84	2.2E+02
	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	84	1.3E+04
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	84	1.3E-01
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	160	2.3E-03
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	0.021	4.0E-03
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	1.1	3.0E-07
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	0.18	1.1E-07
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.16	2.7E-06
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	380	7.8E+02
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.86	1.2E+02
	USES 1.0-Human Toxicity	g eq. 1-4-dichlorobenzene	*	6.6E+06
	(a) Acrolein (CH2CHCHO)	g eq. 1-4-dichlorobenzene	2300	5.5E-03
	(a) Ammonia (NH3)	g eq. 1-4-dichlorobenzene	16	4.7E+02
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	42000	1.9E+05
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	29	2.3E+03
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	3700	2.7E+02
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	23000	2.9E+04
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	7600	2.0E+03
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	350	2.8E+04
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	0.42	4.0E+00
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	67000	5.7E+06
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	29000	1.0E+04
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	9800	5.1E+05
	(a) Nitrogen Oxides (NOx as NO2)	g eq. 1-4-dichlorobenzene	0.26	1.3E+04
	(a) Pentachlorobenzene (C6HCl5)	g eq. 1-4-dichlorobenzene	250	5.1E-05
	(a) Pentachlorophenol (PCP, C6Cl5OH)	g eq. 1-4-dichlorobenzene	200	6.6E-06
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	2.2	9.0E-04
	(a) Sulphur Oxides (SOx as SO2)	g eq. 1-4-dichlorobenzene	0.16	6.4E+04
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.036	6.6E-01
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	4900	5.1E+04
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	0.63	8.4E+01
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	670	1.5E+01
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	20000	8.3E+00
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	1500	7.2E-01
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	30	7.1E-02
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	350	3.8E+00
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	29000	2.1E+04
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	800	2.9E+00
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	12	1.0E+01
	(w) Ammonia (NH4+, NH3, as N)	g eq. 1-4-dichlorobenzene	17	1.9E+03
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	51	1.4E+03
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	22	7.7E+01
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	130	9.3E+01
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	32	2.0E-03
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	9.3	2.4E+01
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	67000	1.1E+02
	(w) Cobalt (Co I, Co II, Co III)	g eq. 1-4-dichlorobenzene	31	1.6E+01
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.1	7.6E+00
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	0.35	5.1E-06
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	0.026	1.9E+00
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	18000	1.9E+03
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	12	2.3E+00
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	63	4.3E+03
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	0.89	7.2E+00
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	37	1.0E-05
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.053	2.7E-01
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	1200	7.3E-04
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.11	1.8E-06
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	19	3.9E+01
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.058	8.1E+00
	USES 1.0-Terrestrial Ecotoxicity	g eq. 1-4-dichlorobenzene	*	3.5E+08
	(a) Acrolein (CH2CHCHO)	g eq. 1-4-dichlorobenzene	680	1.6E-03
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	72000	3.3E+05
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.063	4.9E+00
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	64000000	4.7E+06
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130000000	1.6E+08
	(a) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	220000	4.6E+05
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	17000	4.5E+03
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	910000	7.4E+07
	(a) Ethylene (C2H4)	g eq. 1-4-dichlorobenzene	17	1.4E+04
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	2600	2.5E+04
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	11000	9.3E+05
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	13000000	4.5E+06
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	190000	9.9E+06
	(a) Pentachlorobenzene (C6HCl5)	g eq. 1-4-dichlorobenzene	11000	2.3E-03
	(a) Pentachlorophenol (PCP, C6Cl5OH)	g eq. 1-4-dichlorobenzene	2400000	8.0E-02
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	11000	4.5E+00
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.035	6.4E-01
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	450000	4.7E+06
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	660000	8.9E+07
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	200000	4.4E+03
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	340000000	1.4E+05
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	600000	1.6E+05
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	45000	2.1E+01
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	2400000	5.7E+03
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	29000	3.2E+02
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	17000000	1.3E+03
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	5200000	1.9E+03
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	1800000	1.5E+06
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	9.70E-06	2.7E-04
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.039	1.4E-01
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	0.025	1.8E-02
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	5.2	3.2E-04
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	1.10E-05	2.9E-05

100% landfilling scenario (expanded boundary)

LIFE CYCLE INVENTORY

	(w) Selenium (Se II, Se IV, Se VI)	g	1.4E+00
	(w) Silicon Dioxide (SiO2)	g	6.4E-02
	(w) Silver (Ag+)	g	4.5E-03
	(w) Sodium (Na+)	g	1.1E+04
	(w) Strontium (Sr II)	g	1.6E+02
	(w) Sulphates (SO4--)	g	7.6E+04
	(w) Sulphides (S--)	g	1.6E+00
	(w) Sulphites (SO3--)	g	6.7E-01
	(w) Sulphurated Matter (unspecified, as S)	g	9.8E-05
	(w) Suspended Matter (unspecified)	g	5.7E+03
	(w) Tars (unspecified)	g	3.9E-08
	(w) Tetrachloroethylene (C2Cl4)	g	2.7E-07
	(w) Tin (Sn++, Sn4+)	g	2.1E-03
	(w) Titanium (Ti3+, Ti4+)	g	1.5E+01
	(w) TOC (Total Organic Carbon)	g	1.8E+03
	(w) Toluene (C6H5CH3)	g	5.0E+00
	(w) Trichlorethane (1,1,1-CH3CCl3)	g	6.1E-07
	(w) Trichloroethylene (C2HCl3)	g	1.7E-05
	(w) Triethylene Glycol (C6H14O4)	g	2.2E+01
	(w) Vanadium (V3+, V5+)	g	2.0E+00
	(w) VOC (Volatile Organic Compounds)	g	2.3E+00
	(w) Water (unspecified)	litre	2.6E+03
	(w) Water: Chemically Polluted	litre	3.4E+04
	(w) Xylene (C6H4(CH3)2)	g	6.7E+00
	(w) Zinc (Zn++)	g	1.4E+02
	(wr) Antimony (Sb124)	kBq	1.2E-01
	(wr) Cesium (Cs134)	kBq	1.1E-01
	(wr) Cesium (Cs137)	kBq	1.6E-01
	(wr) Cobalt (Co58)	kBq	3.6E-01
	(wr) Cobalt (Co60)	kBq	2.3E-01
	(wr) Iodine (I131)	kBq	1.4E-02
	(wr) Manganese (Mn54)	kBq	1.8E-02
	(wr) Protactinium (Pa234m)	kBq	5.5E-01
	(wr) Radioactive Substance (unspecified)	kBq	3.1E+04
	(wr) Radium (Ra224)	kBq	3.4E-01
	(wr) Radium (Ra226)	kBq	1.1E+03
	(wr) Radium (Ra228)	kBq	6.7E-01
	(wr) Silver (Ag110m)	kBq	5.4E-01
	(wr) Thorium (Th228)	kBq	1.3E+00
	(wr) Thorium (Th230)	kBq	5.1E+01
	(wr) Thorium (Th234)	kBq	5.5E-01
	(wr) Tritium (H3)	kBq	6.6E+03
	(wr) Uranium (U234)	kBq	1.8E+01
	(wr) Uranium (U235)	kBq	7.9E-01
	(wr) Uranium (U238)	kBq	1.7E+01
	Mass of printers recycled in alternate scenario	kg	1.5E+04
	Recovered Matter (total)	kg	3.7E+03
	Recovered Matter (unspecified)	kg	3.5E+03
	Recovered Matter: Aluminium Scrap	kg	5.0E-01
	Recovered Matter: Iron Scrap	kg	6.5E-02
	Recovered Matter: Steel Scrap	kg	2.2E+02
	Waste (hazardous)	kg	4.1E-01
	Waste (incineration)	kg	1.3E-01
	Waste (municipal and industrial)	kg	1.9E+00
	Waste (total)	kg	1.5E+03
	Waste (unspecified)	kg	4.2E+00
	Waste: Highly Radioactive (class C)	kg	1.6E-02
	Waste: Low Radioactive (class A)	kg	5.8E-01
	Waste: Mineral (inert)	kg	1.3E+03
	Waste: Mining	kg	8.3E+02
	Waste: Non Mineral (inert)	kg	3.5E-02
	Waste: Non Toxic Chemicals (unspecified)	kg	1.2E-04
	Waste: Radioactive (unspecified)	kg	6.5E-03
	Waste: Slags and Ash (unspecified)	kg	1.2E+02

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.10E-05	1.7E-03
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	1.10E-05	1.7E-08
	(w) Cobalt (Co I, Co II, Co III)	g eq. 1-4-dichlorobenzene	2.00E-07	1.1E-07
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.00E-05	7.0E-04
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	2.5	3.7E-05
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	2.00E-07	1.5E-05
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	8200000	8.8E+05
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	0.078	1.5E-02
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	3.10E-05	2.1E-03
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	34	2.7E+02
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	110	3.0E-05
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.022	1.1E-01
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	2	1.2E-06
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.024	4.0E-07
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	3.40E-05	6.9E-05
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	2.50E-05	3.5E-03
	WMO-Depletion of the ozone layer (high)	g eq. CFC-11	*	5.3E+00
	(a) CFC 11 (CFCl3)	g eq. CFC-11	1	1.2E-03
	(a) CFC 114 (CF2ClCF2Cl)	g eq. CFC-11	0.85	2.6E-02
	(a) CFC 12 (CCl2F2)	g eq. CFC-11	1.06	2.6E-04
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	17.2	5.3E+00
	(a) HCFC 22 (CHF2Cl)	g eq. CFC-11	0.08	1.6E-12
	WMO-Depletion of the ozone layer (low)	g eq. CFC-11	*	3.1E+00
	(a) CFC 11 (CFCl3)	g eq. CFC-11	1	1.2E-03
	(a) CFC 114 (CF2ClCF2Cl)	g eq. CFC-11	0.57	1.7E-02
	(a) CFC 12 (CCl2F2)	g eq. CFC-11	0.82	2.0E-04
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	10	3.1E+00
	(a) HCFC 22 (CHF2Cl)	g eq. CFC-11	0.032	6.3E-13
	WMO-Photochemical oxidant formation (high)	g eq. ethylene	*	1.4E+04
	(a) Acetaldehyde (CH3CHO)	g eq. ethylene	1.22	6.9E-01
	(a) Acetone (CH3COCH3)	g eq. ethylene	0.27	1.4E-01
	(a) Acetylene (C2H2)	g eq. ethylene	0.42	9.9E+00
	(a) Alcohol (unspecified)	g eq. ethylene	0.55	2.0E-02
	(a) Aldehyde (unspecified)	g eq. ethylene	1.263	7.9E-01
	(a) Alkane (unspecified)	g eq. ethylene	1.173	4.0E+02
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	1.285	5.0E+01
	(a) Benzaldehyde (C6H5CHO)	g eq. ethylene	-0.12	-1.0E-07
	(a) Benzene (C6H6)	g eq. ethylene	0.45	3.5E+01
	(a) Butane (n-C4H10)	g eq. ethylene	1.15	5.9E+01
	(a) Butene (1-CH3CH2CHCH2)	g eq. ethylene	1.85	2.5E-01
	(a) Ethane (C2H6)	g eq. ethylene	0.3	9.6E+01
	(a) Ethanol (C2H5OH)	g eq. ethylene	0.89	9.1E-01
	(a) Ethylene (C2H4)	g eq. ethylene	1	8.0E+02
	(a) Formaldehyde (CH2O)	g eq. ethylene	0.58	5.5E+00
	(a) Heptane (C7H16)	g eq. ethylene	1.65	2.1E+00
	(a) Hexane (C6H14)	g eq. ethylene	1.51	3.9E+00
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.799	9.4E+03
	(a) Hydrocarbons (unspecified)	g eq. ethylene	0.808	2.2E+01
	(a) Methane (CH4)	g eq. ethylene	0.03	3.0E+03
	(a) Methanol (CH3OH)	g eq. ethylene	0.21	3.4E-01
	(a) Propane (C3H8)	g eq. ethylene	1.24	1.5E+02
	(a) Propionaldehyde (CH3CH2CHO)	g eq. ethylene	1.6	2.6E-06
	(a) Propylene (CH2CHCH3)	g eq. ethylene	1.63	4.2E+01
	(a) Toluene (C6H5CH3)	g eq. ethylene	0.83	1.5E+01
	WMO-Photochemical oxidant formation (low)	g eq. ethylene	*	3.2E+03
	(a) Acetaldehyde (CH3CHO)	g eq. ethylene	0.33	1.9E-01
	(a) Acetone (CH3COCH3)	g eq. ethylene	0.1	5.2E-02
	(a) Acetylene (C2H2)	g eq. ethylene	0.1	2.4E+00
	(a) Alcohol (unspecified)	g eq. ethylene	0.065	2.3E-03
	(a) Aldehyde (unspecified)	g eq. ethylene	0.079	4.9E-02
	(a) Alkane (unspecified)	g eq. ethylene	0.114	3.8E+01
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	0.481	1.9E+01
	(a) Benzaldehyde (C6H5CHO)	g eq. ethylene	-0.82	-7.0E-07
	(a) Benzene (C6H6)	g eq. ethylene	0.11	8.6E+00
	(a) Butane (n-C4H10)	g eq. ethylene	0.15	7.7E+00
	(a) Butene (1-CH3CH2CHCH2)	g eq. ethylene	0.57	7.8E-02
	(a) Ethane (C2H6)	g eq. ethylene	0.02	6.4E+00
	(a) Ethanol (C2H5OH)	g eq. ethylene	0.04	4.1E-02
	(a) Ethylene (C2H4)	g eq. ethylene	1	8.0E+02
	(a) Formaldehyde (CH2O)	g eq. ethylene	0.22	2.1E+00
	(a) Heptane (C7H16)	g eq. ethylene	0.13	1.7E-01
	(a) Hexane (C6H14)	g eq. ethylene	0.1	2.6E-01
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.195	2.3E+03
	(a) Hydrocarbons (unspecified)	g eq. ethylene	0.194	5.2E+00
	(a) Methane (CH4)	g eq. ethylene	0	0.0E+00
	(a) Methanol (CH3OH)	g eq. ethylene	0.09	1.5E-01
	(a) Propane (C3H8)	g eq. ethylene	0.16	1.9E+01
	(a) Propionaldehyde (CH3CH2CHO)	g eq. ethylene	0.28	4.6E-07
	(a) Propylene (CH2CHCH3)	g eq. ethylene	0.75	1.9E+01
	(a) Toluene (C6H5CH3)	g eq. ethylene	0.41	7.5E+00

Plastics and PCBs recovered: Collection stage

LIFE CYCLE INVENTORY

	Flow	Units	Product collection
Inputs:	(r) Barium Sulphate (BaSO4, in ground)	kg	1.4E-01
	(r) Bauxite (Al2O3, ore)	kg	5.0E-04
	(r) Bentonite (Al2O3.4SiO2.H2O, in ground)	kg	1.3E-02
	(r) Calcium Sulphate (CaSO4, ore)	kg	6.4E-04
	(r) Chromium (Cr, ore)	kg	2.7E-05
	(r) Clay (in ground)	kg	3.7E-02
	(r) Coal (in ground)	kg	2.3E+01
	(r) Copper (Cu, ore)	kg	1.4E-04
	(r) Gravel (unspecified)	kg	8.7E-02
	(r) Iron (Fe, ore)	kg	4.5E-01
	(r) Iron Sulphate (FeSO4, ore)	kg	7.2E-04
	(r) Lead (Pb, ore)	kg	4.2E-05
	(r) Lignite (in ground)	kg	2.2E-01
	(r) Limestone (CaCO3, in ground)	kg	2.5E-01
	(r) Manganese (Mn, ore)	kg	1.6E-05
	(r) Natural Gas (in ground)	kg	8.6E+01
	(r) Nickel (Ni, ore)	kg	9.0E-06
	(r) Oil (in ground)	kg	9.2E-01
	(r) Pyrite (FeS2, ore)	kg	2.2E-01
	(r) Sand (in ground)	kg	6.1E-03
	(r) Silver (Ag, ore)	kg	6.7E-07
	(r) Sodium Chloride (NaCl, in ground or in sea)	kg	2.1E-02
	(r) Uranium (U, ore)	kg	1.0E-03
	(r) Zinc (Zn, ore)	kg	9.9E-07
	Diesel Oil	kg	1.9E+02
	Explosive (unspecified)	kg	8.6E-03
	Iron Scrap	kg	5.8E-03
	Land Use (II -> III)	m2a	9.5E-02
	Land Use (II -> IV)	m2a	1.3E-02
	Land Use (III -> IV)	m2a	4.5E-03
	Raw Materials (unspecified)	kg	3.5E-02
	Traded-in printers (high-street)	kg	1.0E+03
	Traded-in printers (out-of-town)	kg	2.1E+04
	Water Used (total)	litre	1.6E+02
	Water: Unspecified Origin	litre	1.6E+02
	Wood	kg	4.3E-03
	Wood (standing)	m3	1.5E-04
Outputs:	(a) Acetaldehyde (CH3CHO)	g	6.6E-03
	(a) Acetic Acid (CH3COOH)	g	5.3E-01
	(a) Acetone (CH3COCH3)	g	3.6E-03
	(a) Acetylene (C2H2)	g	2.0E-01
	(a) Aldehyde (unspecified)	g	6.3E-03
	(a) Alkane (unspecified)	g	1.0E+01
	(a) Alkene (unspecified)	g	2.2E-01
	(a) Alkyne (unspecified)	g	2.3E-04
	(a) Aluminium (Al)	g	3.9E+00
	(a) Ammonia (NH3)	g	8.4E-02
	(a) Antimony (Sb)	g	7.4E-04
	(a) AOX (Adsorbable Organic Halogens)	g	3.2E-12
	(a) Aromatic Hydrocarbons (unspecified)	g	3.0E-03
	(a) Arsenic (As)	g	7.8E-03
	(a) Barium (Ba)	g	4.6E-02
	(a) Benzaldehyde (C6H5CHO)	g	4.1E-08
	(a) Benzene (C6H6)	g	1.8E+00
	(a) Benzo(a)pyrene (C20H12)	g	1.6E-03
	(a) Beryllium (Be)	g	7.6E-04
	(a) Boron (B)	g	3.7E-01
	(a) Bromium (Br)	g	7.4E-02
	(a) Butane (n-C4H10)	g	2.9E+00
	(a) Butene (1-CH3CH2CHCH2)	g	2.0E-03
	(a) Cadmium (Cd)	g	1.2E-02
	(a) Calcium (Ca)	g	4.9E-01
	(a) Carbon Dioxide (CO2, fossil)	g	8.4E+05
	(a) Carbon Monoxide (CO)	g	1.6E+03
	(a) Carbon Tetrafluoride (CF4)	g	3.3E-05
	(a) Chlorine (Cl2)	g	2.1E-07
	(a) Chromium (Cr III, Cr VI)	g	9.9E-03
	(a) Cobalt (Co)	g	2.0E-03
	(a) Copper (Cu)	g	7.5E-03
	(a) Cyanide (CN-)	g	1.1E-03
	(a) Dioxins (unspecified)	g	8.9E-09
	(a) Ethane (C2H6)	g	1.2E+01
	(a) Ethanol (C2H5OH)	g	6.4E-03
	(a) Ethylbenzene (C8H10)	g	2.0E-03
	(a) Ethylene (C2H4)	g	4.3E+01
	(a) Fluorides (F-)	g	2.2E-05
	(a) Fluorine (F2)	g	1.4E-05
	(a) Formaldehyde (CH2O)	g	3.8E-01
	(a) Halogenated Matter (unspecified)	g	4.2E-14
	(a) Halon 1301 (CF3Br)	g	2.1E-04
	(a) Heptane (C7H16)	g	1.5E-02
	(a) Hexane (C6H14)	g	3.0E-02
	(a) Hydrocarbons (except methane)	g	7.7E+02
	(a) Hydrocarbons (unspecified)	g	2.3E-01
	(a) Hydrogen (H2)	g	8.7E-07
	(a) Hydrogen Chloride (HCl)	g	1.8E+01
	(a) Hydrogen Fluoride (HF)	g	6.8E-01
	(a) Hydrogen Sulphide (H2S)	g	1.8E+00
	(a) Iodine (I)	g	1.9E-02
	(a) Iron (Fe)	g	1.6E+00
	(a) Ianthanum (La)	g	1.2E-03
	(a) Lead (Pb)	g	8.0E-02
	(a) Magnesium (Mg)	g	1.4E+00
	(a) Manganese (Mn)	g	2.7E-02
	(a) Mercury (Hg)	g	1.8E-03
	(a) Metals (unspecified)	g	4.5E-05
	(a) Methane (CH4)	g	3.9E+02
	(a) Methanol (CH3OH)	g	1.1E-02
	(a) Molybdenum (Mo)	g	1.8E-03
	(a) Nickel (Ni)	g	2.5E-02
	(a) Nitrogen Oxides (NOx as NO2)	g	8.0E+03
	(a) Nitrous Oxide (N2O)	g	8.5E+01
	(a) Organic Matter (unspecified)	g	1.1E-02
	(a) Particulates (unspecified)	g	4.3E+02
	(a) Pentane (C5H12)	g	4.2E+00
	(a) Phenol (C6H5OH)	g	3.1E-07
	(a) Phosphorus (P)	g	3.4E-02
	(a) Phosphorus Pentoxide (P2O5)	g	2.3E-05
	(a) Polycyclic Aromatic Hydrocarbons (PAH, uns	g	3.4E-02
	(a) Potassium (K)	g	5.3E-01
	(a) Propane (C3H8)	g	3.6E+00
	(a) Propionaldehyde (CH3CH2CHO)	g	1.1E-07
	(a) Propionic Acid (CH3CH2COOH)	g	1.5E-04
	(a) Propylene (CH2CHCH3)	g	2.2E-01
	(a) Scandium (Sc)	g	4.1E-04
	(a) Selenium (Se)	g	8.8E-03
	(a) Silicon (Si)	g	5.8E+00
	(a) Sodium (Na)	g	2.5E-01
	(a) Strontium (Sr)	g	7.6E-02
	(a) Sulphur Oxides (SOx as SO2)	g	7.6E+02
	(a) Tars (unspecified)	g	2.3E-08

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	Classification	Units	Charact-erisation	Environmental impacts
Methods:	CML-Air Acidification	g eq. H+	/	2.0E+02
	(a) Ammonia (NH3)	g eq. H+	17	5.0E-03
	(a) Hydrogen Chloride (HCl)	g eq. H+	36.5	5.0E-01
	(a) Hydrogen Fluoride (HF)	g eq. H+	20	3.4E-02
	(a) Hydrogen Sulphide (H2S)	g eq. H+	17	1.1E-01
	(a) Nitrogen Oxides (NOx as NO2)	g eq. H+	46	1.7E+02
	(a) Sulphur Oxides (SOx as SO2)	g eq. H+	32	2.4E+01
	CML-Eutrophication	g eq. PO4	*	1.1E+03
	(a) Nitrogen Oxides (NOx as NO2)	g eq. PO4	0.13	1.0E+03
	(a) Nitrous Oxide (N2O)	g eq. PO4	0.27	2.3E+01
	(w) Ammonia (NH4+, NH3, as N)	g eq. PO4	0.42	1.4E-01
	(w) COD (Chemical Oxygen Demand)	g eq. PO4	0.022	2.9E-02
	(w) Nitrogenous Matter (Kjeldahl, as N)	g eq. PO4	0.42	4.6E-03
	(w) Nitrogenous Matter (unspecified, as N)	g eq. PO4	0.42	2.5E-02
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g eq. PO4	3.06	3.3E-02
	(w) Phosphorus (P)	g eq. PO4	3.06	2.2E-03
	(w) Phosphorus Pentoxide (P2O5)	g eq. PO4	1.336	9.2E-04
	CST-Aquatic Eco-toxicity	eq. Zn water	*	4.8E+00
	(a) Arsenic (As)	eq. Zn water	0.078	6.1E-04
	(a) Cadmium (Cd)	eq. Zn water	79	9.1E-01
	(a) Chromium (Cr III, Cr VI)	eq. Zn water	0.39	3.9E-03
	(a) Copper (Cu)	eq. Zn water	0.66	4.9E-03
	(a) Lead (Pb)	eq. Zn water	1.28	1.0E-01
	(a) Mercury (Hg)	eq. Zn water	196	3.5E-01
	(a) Nickel (Ni)	eq. Zn water	0.12	3.0E-03
	(a) Zinc (Zn)	eq. Zn water	0.076	2.2E+00
	(s) Arsenic (As)	eq. Zn water	0.24	1.7E-04
	(s) Cadmium (Cd)	eq. Zn water	240	7.7E-05
	(s) Chromium (Cr III, Cr VI)	eq. Zn water	1.2	1.1E-02
	(s) Copper (Cu)	eq. Zn water	2	3.2E-06
	(s) Lead (Pb)	eq. Zn water	3.9	2.9E-05
	(s) Mercury (Hg)	eq. Zn water	600	3.5E-05
	(s) Nickel (Ni)	eq. Zn water	0.36	8.8E-07
	(s) Zinc (Zn)	eq. Zn water	0.23	6.1E-03
	(w) Arsenic (As3+, As5+)	eq. Zn water	0.52	1.1E-03
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Zn water	0.00013	1.4E-05
	(w) Cadmium (Cd++)	eq. Zn water	520	1.1E-01
	(w) Chromium (Cr III, Cr VI)	eq. Zn water	2.6	2.8E-03
	(w) Copper (Cu+, Cu++)	eq. Zn water	5.2	2.3E-02
	(w) Lead (Pb++, Pb4+)	eq. Zn water	5.2	1.6E-01
	(w) Mercury (Hg+, Hg++)	eq. Zn water	1300	5.2E-04
	(w) Nickel (Ni++, Ni3+)	eq. Zn water	0.79	5.0E-03
	(w) Oils (unspecified)	eq. Zn water	0.13	4.7E-01
	(w) Phenol (C6H5OH)	eq. Zn water	15.4	4.2E-01
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Zn water	0.01	1.1E-04
	(w) Zinc (Zn++)	eq. Zn water	1	3.6E-02
	CST-Human Toxicity	eq. Pb air	*	2.0E+03
	(a) Aldehyde (unspecified)	eq. Pb air	0.0087	5.5E-05
	(a) Arsenic (As)	eq. Pb air	9000	7.0E+01
	(a) Benzene (C6H6)	eq. Pb air	0.012	2.2E-02
	(a) Cadmium (Cd)	eq. Pb air	19000	2.2E+02
	(a) Carbon Monoxide (CO)	eq. Pb air	0.00014	2.3E-01
	(a) Chromium (Cr III, Cr VI)	eq. Pb air	3700	3.7E+01
	(a) Cobalt (Co)	eq. Pb air	12900	2.5E+01
	(a) Copper (Cu)	eq. Pb air	145	1.1E+00
	(a) Formaldehyde (CH2O)	eq. Pb air	0.0099	3.8E-03
	(a) Lead (Pb)	eq. Pb air	2000	1.8E+02
	(a) Mercury (Hg)	eq. Pb air	46000	8.2E+01
	(a) Nickel (Ni)	eq. Pb air	370	9.1E+00
	(a) Nitrogen Oxides (NOx as NO2)	eq. Pb air	0.002	1.6E+01
	(a) Particulates (unspecified)	eq. Pb air	0.0075	3.2E+00
	(a) Selenium (Se)	eq. Pb air	64000	5.6E+02
	(a) Sulphur Oxides (SOx as SO2)	eq. Pb air	0.0075	5.7E+00
	(a) Tin (Sn)	eq. Pb air	9	2.2E-03
	(a) Zinc (Zn)	eq. Pb air	27	7.7E+02
	(s) Arsenic (As)	eq. Pb air	0.7	4.9E-04
	(s) Cadmium (Cd)	eq. Pb air	1.46	4.7E-07
	(s) Chromium (Cr III, Cr VI)	eq. Pb air	0.29	2.6E-03
	(s) Cobalt (Co)	eq. Pb air	1	3.2E-07
	(s) Copper (Cu)	eq. Pb air	0.009	1.5E-08
	(s) Lead (Pb)	eq. Pb air	0.6	4.5E-06
	(s) Mercury (Hg)	eq. Pb air	3.6	2.1E-07
	(s) Nickel (Ni)	eq. Pb air	0.029	7.1E-08
	(s) Zinc (Zn)	eq. Pb air	0.0007	1.9E-05
	(w) Arsenic (As3+, As5+)	eq. Pb air	1.5	3.2E-03
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Pb air	0.022	2.4E-03
	(w) Cadmium (Cd++)	eq. Pb air	3.2	6.7E-04
	(w) Chromium (Cr III, Cr VI)	eq. Pb air	0.62	6.6E-04
	(w) Cobalt (Co I, Co II, Co III)	eq. Pb air	2.2	2.5E-03
	(w) Copper (Cu+, Cu++)	eq. Pb air	0.022	9.6E-05
	(w) Fluorides (F-)	eq. Pb air	0.045	1.2E-02
	(w) Lead (Pb++, Pb4+)	eq. Pb air	0.86	2.7E-02
	(w) Mercury (Hg+, Hg++)	eq. Pb air	7.8	3.1E-06
	(w) Nickel (Ni++, Ni3+)	eq. Pb air	0.062	3.9E-04
	(w) Phenol (C6H5OH)	eq. Pb air	0.052	1.4E-03
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Pb air	3.20E-06	3.4E-08
	(w) Selenium (Se II, Se IV, Se VI)	eq. Pb air	10.9	2.0E-02
	(w) Tin (Sn++, Sn4+)	eq. Pb air	0.0015	9.7E-09
	(w) Zinc (Zn++)	eq. Pb air	0.0032	1.1E-04
	CST-Terrestrial Eco-toxicity	eq. Zn air	*	9.5E+00
	(a) Arsenic (As)	eq. Zn air	0.75	5.9E-03
	(a) Cadmium (Cd)	eq. Zn air	3.14	3.6E-02
	(a) Chromium (Cr III, Cr VI)	eq. Zn air	0.08	7.9E-04
	(a) Cobalt (Co)	eq. Zn air	0.08	1.6E-04
	(a) Copper (Cu)	eq. Zn air	0.14	1.0E-03
	(a) Lead (Pb)	eq. Zn air	0.13	1.0E-02
	(a) Mercury (Hg)	eq. Zn air	5.94	1.1E-02
	(a) Nickel (Ni)	eq. Zn air	0.35	8.6E-03
	(a) Zinc (Zn)	eq. Zn air	0.33	9.4E+00
	(s) Arsenic (As)	eq. Zn air	2.3	1.6E-03
	(s) Cadmium (Cd)	eq. Zn air	9.6	3.1E-06
	(s) Chromium (Cr III, Cr VI)	eq. Zn air	0.26	2.3E-03
	(s) Cobalt (Co)	eq. Zn air	0.26	8.4E-08
	(s) Copper (Cu)	eq. Zn air	0.42	6.8E-07
	(s) Lead (Pb)	eq. Zn air	0.41	3.0E-06
	(s) Mercury (Hg)	eq. Zn air	18.3	1.1E-06
	(s) Nickel (Ni)	eq. Zn air	1.1	2.7E-06
	(s) Zinc (Zn)	eq. Zn air	1	2.7E-02
	EB(R*Y)-Depletion of non renewable resources	yr-1	*	1.4E+01
	(r) Barium Sulphate (BaSO4, in ground)	yr-1	26.91	3.7E+00
	(r) Bauxite (Al2O3, ore)	yr-1	0.108	5.4E-05
	(r) Chromium (Cr, ore)	yr-1	0.2133	5.7E-06
	(r) Chromium (Cr, ore)	yr-1	0.319	8.5E-06
	(r) Coal (in ground)	yr-1	0.0005037	1.1E-02
	(r) Copper (Cu, ore)	yr-1	28.16	3.8E-03
	(r) Iron (Fe, ore)	yr-1	0.04	1.8E-02
	(r) Lead (Pb, ore)	yr-1	157	6.6E-03
	(r) Lignite (in ground)	yr-1	0.0005037	1.1E-04
	(r) Manganese (Mn, ore)	yr-1	0.296	4.6E-06
	(r) Natural Gas (in ground)	yr-1	0.117	1.0E+01
	(r) Nickel (Ni, ore)	yr-1	59.7	5.4E-04

Plastics and PCBs recovered: Collection stage

LIFE CYCLE INVENTORY

	(a) Thallium (Tl)	g	3.8E-04
	(a) Thorium (Th)	g	7.8E-04
	(a) Tin (Sn)	g	2.4E-04
	(a) Titanium (Ti)	g	1.4E-01
	(a) Toluene (C6H5CH3)	g	7.5E-01
	(a) Uranium (U)	g	7.5E-04
	(a) Vanadium (V)	g	7.2E-02
	(a) Xylene (C6H4(CH3)2)	g	4.5E-02
	(a) Zinc (Zn)	g	2.8E+01
	(a) Zirconium (Zr)	g	5.8E-04
	(ar) Aerosols and Halogenes (unspecified)	kBq	1.4E-03
	(ar) Carbon (C14)	kBq	4.7E-01
	(ar) Cesium (Cs134)	kBq	1.8E-05
	(ar) Cesium (Cs137)	kBq	1.8E-05
	(ar) Cobalt (Co58)	kBq	1.8E-05
	(ar) Cobalt (Co60)	kBq	1.8E-05
	(ar) Gas (unspecified)	kBq	4.5E+01
	(ar) Iodine (I131)	kBq	1.0E-04
	(ar) Iodine (I133)	kBq	2.0E-04
	(ar) Krypton (Kr85)	kBq	2.7E+00
	(ar) Lead (Pb210)	kBq	1.8E-02
	(ar) Polonium (Po210)	kBq	3.1E-02
	(ar) Potassium (K40)	kBq	4.8E-03
	(ar) Protactinium (Pa234m)	kBq	2.5E-04
	(ar) Radioactive Substance (unspecified)	kBq	1.4E-04
	(ar) Radium (Ra226)	kBq	2.2E-02
	(ar) Radium (Ra228)	kBq	2.4E-03
	(ar) Radon (Rn220)	kBq	7.3E-02
	(ar) Radon (Rn222)	kBq	2.1E+03
	(ar) Thorium (Th228)	kBq	2.0E-03
	(ar) Thorium (Th230)	kBq	3.7E-03
	(ar) Thorium (Th232)	kBq	1.3E-03
	(ar) Thorium (Th234)	kBq	2.5E-04
	(ar) Tritium (H3)	kBq	5.4E+00
	(ar) Uranium (U234)	kBq	6.4E-03
	(ar) Uranium (U235)	kBq	4.8E-05
	(ar) Uranium (U238)	kBq	1.1E-02
	(ar) Xenon (Xe133)	kBq	3.8E+01
	(s) Aluminium (Al)	g	1.8E+00
	(s) Arsenic (As)	g	7.1E-04
	(s) Cadmium (Cd)	g	3.2E-07
	(s) Calcium (Ca)	g	7.1E+00
	(s) Carbon (C)	g	5.3E+00
	(s) Chromium (Cr III, Cr VI)	g	8.9E-03
	(s) Cobalt (Co)	g	3.2E-07
	(s) Copper (Cu)	g	1.6E-06
	(s) Iron (Fe)	g	3.5E+00
	(s) Lead (Pb)	g	7.4E-06
	(s) Manganese (Mn)	g	7.1E-02
	(s) Mercury (Hg)	g	5.9E-08
	(s) Nickel (Ni)	g	2.4E-06
	(s) Nitrogen (N)	g	2.8E-05
	(s) Oils (unspecified)	g	1.0E-02
	(s) Phosphorus (P)	g	8.9E-02
	(s) Sulphur (S)	g	1.1E+00
	(s) Zinc (Zn)	g	2.7E-02
	(sr) Americium (Am241)	kBq	4.7E+00
	(sr) Americium (Am243)	kBq	1.0E-01
	(sr) Cesium (Cs135)	kBq	2.3E+03
	(sr) Cesium (Cs137)	kBq	6.4E-03
	(sr) Curium (Cm244)	kBq	9.5E+00
	(sr) Curium (Cm245)	kBq	1.1E-03
	(sr) Iodine (I129)	kBq	1.5E-04
	(sr) Neptunium (Np237)	kBq	1.5E+00
	(sr) Palladium (Pd107)	kBq	5.2E-04
	(sr) Plutonium (Pu239)	kBq	1.8E+03
	(sr) Plutonium (Pu240)	kBq	2.5E+03
	(sr) Plutonium (Pu241)	kBq	5.9E+05
	(sr) Plutonium (Pu242)	kBq	9.6E+00
	(sr) Radium (Ra226)	kBq	1.2E+01
	(sr) Samarium (Sm151)	kBq	2.1E+00
	(sr) Selenium (Se79)	kBq	1.7E-03
	(sr) Strontium (Sr90)	kBq	3.4E+02
	(sr) Technetium (Tc99)	kBq	7.0E-02
	(sr) Thorium (Th230)	kBq	1.2E+01
	(sr) Tin (Sn126)	kBq	2.9E-03
	(sr) Uranium (U234)	kBq	7.6E+00
	(sr) Uranium (U235)	kBq	1.4E-01
	(sr) Uranium (U238)	kBq	2.1E+00
	(sr) Zirconium (Zr93)	kBq	9.2E-03
	(w) Acids (H+)	g	7.9E-03
	(w) Alcohol (unspecified)	g	1.9E-03
	(w) Aldehyde (unspecified)	g	7.6E-04
	(w) Alkane (unspecified)	g	2.7E-02
	(w) Alkene (unspecified)	g	2.5E-03
	(w) Aluminium (Al3+)	g	1.2E+00
	(w) Aluminium Hydroxide (Al(OH)3)	g	2.2E-05
	(w) Ammonia (NH4+, NH3, as N)	g	3.4E-01
	(w) AOX (Adsorbable Organic Halogens)	g	1.8E-04
	(w) Aromatic Hydrocarbons (unspecified)	g	1.7E-01
	(w) Arsenic (As3+, As5+)	g	2.2E-03
	(w) Barium (Ba++)	g	2.7E-01
	(w) Barytes	g	2.5E+01
	(w) Benzene (C6H6)	g	2.7E-02
	(w) BOD5 (Biochemical Oxygen Demand)	g	1.1E-01
	(w) Boric Acid (H3BO3)	g	2.8E-02
	(w) Boron (B III)	g	3.4E-03
	(w) Cadmium (Cd++)	g	2.1E-04
	(w) Calcium (Ca++)	g	9.6E+00
	(w) Carbonates (CO3--, HCO3-, CO2, as C)	g	3.4E-02
	(w) Cesium (Cs++)	g	5.7E-05
	(w) Chlorides (Cl-)	g	2.5E+02
	(w) Chlorinated Matter (unspecified, as Cl)	g	4.0E+00
	(w) Chloroform (CHCl3)	g	4.3E-06
	(w) Chromium (Cr III)	g	1.9E-02
	(w) Chromium (Cr III, Cr VI)	g	1.1E-03
	(w) Chromium (Cr VI)	g	3.5E-07
	(w) Cobalt (Co I, Co II, Co III)	g	1.1E-03
	(w) COD (Chemical Oxygen Demand)	g	1.3E+00
	(w) Copper (Cu+, Cu++)	g	4.4E-03
	(w) Cyanides (CN-)	g	3.1E-02
	(w) Dissolved Matter (unspecified)	g	1.5E+01
	(w) Dissolved Organic Carbon (DOC)	g	1.4E+00
	(w) Edetic Acid (C10H16N2O8, EDTA)	g	4.7E-05
	(w) Ethylbenzene (C6H5C2H5)	g	1.7E-03
	(w) Fluorides (F-)	g	2.7E-01
	(w) Formaldehyde (CH2O)	g	5.4E-08
	(w) Hexachloroethane (C2Cl6)	g	7.5E-12
	(w) Hydrazine (N2H4)	g	2.2E-05
	(w) Hydrocarbons (unspecified)	g	1.6E-04
	(w) Hypochlorite (ClO-)	g	1.3E-03
	(w) Hypochlorous Acid (HClO)	g	1.3E-03
	(w) Inorganic Dissolved Matter (unspecified)	g	2.5E-03

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	(r) Oil (in ground)	yr-1	0.0557	5.1E-02
	(r) Silver (Ag, ore)	yr-1	92837	6.2E-02
	(r) Uranium (U, ore)	yr-1	181	1.8E-01
	(r) Zinc (Zn, ore)	yr-1	40.29	4.0E-05
	ETH-Air Acidification	g eq. H+	/	2.0E+02
	(a) Ammonia (NH3)	g eq. H+	17	5.0E-03
	(a) Hydrogen Chloride (HCl)	g eq. H+	36.5	5.0E-01
	(a) Hydrogen Fluoride (HF)	g eq. H+	20	3.4E-02
	(a) Hydrogen Sulphide (H2S)	g eq. H+	17	1.1E-01
	(a) Nitrogen Oxides (NOx as NO2)	g eq. H+	46	1.7E+02
	(a) Sulphur Oxides (SOx as SO2)	g eq. H+	32	2.4E+01
	IPCC-Greenhouse effect (direct, 100 years)	g eq. CO2	*	8.8E+05
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	8.4E+05
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	5700	1.9E-01
	(a) Halon 1301 (CF3Br)	g eq. CO2	6900	1.5E+00
	(a) Methane (CH4)	g eq. CO2	24	9.3E+03
	(a) Nitrous Oxide (N2O)	g eq. CO2	360	3.0E+04
	IPCC-Greenhouse effect (direct, 20 years)	g eq. CO2	*	9.0E+05
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	8.4E+05
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	3900	1.3E-01
	(a) Halon 1301 (CF3Br)	g eq. CO2	7900	1.7E+00
	(a) Methane (CH4)	g eq. CO2	64	2.5E+04
	(a) Nitrous Oxide (N2O)	g eq. CO2	330	2.8E+04
	IPCC-Greenhouse effect (direct, 500 years)	g eq. CO2	*	8.6E+05
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	8.4E+05
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	8900	2.9E-01
	(a) Halon 1301 (CF3Br)	g eq. CO2	2700	5.7E-01
	(a) Methane (CH4)	g eq. CO2	7.5	2.9E+03
	(a) Nitrous Oxide (N2O)	g eq. CO2	190	1.6E+04
	USES 1.0-Aquatic Ecotoxicity	g eq. 1-4-dichlorobenzene	*	1.2E+02
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	5.6	4.4E-02
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.0013	2.4E-03
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	320	5.2E-01
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130	1.5E+00
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	2.6	5.1E-03
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	2.9	2.2E-02
	(a) Ethylene (C2H4)	g eq. 1-4-dichlorobenzene	0.0022	9.5E-02
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	6.1	2.3E+00
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.2	9.6E-02
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	16000	2.9E+01
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	80	2.0E+00
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	39	1.2E-05
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	9.70E-05	7.3E-05
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	11	8.0E-01
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	2.6	7.4E+01
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	3.00E-08	2.1E-11
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	3.90E-06	1.3E-12
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.40E-09	1.2E-11
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	6.80E-08	2.2E-14
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	1.40E-08	2.3E-14
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.80E-09	1.3E-14
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	16000	9.4E-04
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	5.80E-07	1.4E-12
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	3.90E-08	1.0E-09
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	190	4.1E-01
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	1	2.7E-02
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	4500	9.4E-01
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	0.7	3.0E-06
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	84	1.6E+00
	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	84	8.9E-02
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	84	2.9E-05
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	160	8.7E-06
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	0.021	2.6E-04
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	1.1	2.0E-08
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	0.18	7.5E-09
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.16	1.8E-07
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	380	2.7E+00
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.86	3.1E-02
	USES 1.0-Human Toxicity	g eq. 1-4-dichlorobenzene	*	8.9E+03
	(a) Ammonia (NH3)	g eq. 1-4-dichlorobenzene	16	1.4E+00
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	42000	3.3E+02
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	29	5.3E+01
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	3700	6.0E+00
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	23000	2.7E+02
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	7600	1.5E+01
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	350	2.6E+00
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	0.42	1.6E-01
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	67000	5.4E+03
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	29000	5.2E+01
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	9800	2.4E+02
	(a) Nitrogen Oxides (NOx as NO2)	g eq. 1-4-dichlorobenzene	0.26	2.1E+03
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	2.2	6.9E-07
	(a) Sulphur Oxides (SOx as SO2)	g eq. 1-4-dichlorobenzene	0.16	1.2E+02
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.036	2.7E-02
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	4900	3.5E+02
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	0.63	1.8E+01
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	670	4.7E-01
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	20000	6.4E-03
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	1500	4.9E-04
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	30	4.9E-05
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	350	2.6E-03
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	29000	1.7E-03
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	800	2.0E-03
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	12	3.2E-01
	(w) Ammonia (NH4+, NH3, as N)	g eq. 1-4-dichlorobenzene	17	5.8E+00
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	51	1.1E-01
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	22	6.0E-01
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	130	2.7E-02
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	32	1.4E-04
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	9.3	1.7E-01
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	67000	2.3E-02
	(w) Cobalt (Co I, Co II, Co III)	g eq. 1-4-dichlorobenzene	31	3.6E-02
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.1	4.8E-03
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	0.35	1.9E-08
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	0.026	8.0E-04
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	18000	7.1E-03
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	12	1.5E-01
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	63	4.0E-01
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	0.89	2.4E-02
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	37	6.8E-07
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.053	1.3E-03
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	1200	5.0E-05
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.11	1.3E-07
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	19	1.4E-01
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.058	2.1E-03
	USES 1.0-Terrestrial Ecotoxicity	g eq. 1-4-dichlorobenzene	*	2.0E+07
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	72000	5.6E+02
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.063	1.2E-01
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	64000000	1.0E+05
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130000000	1.5E+06
	(a) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	220000	2.2E+03
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	17000	3.3E+01
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	910000	6.8E+03

Plastics and PCBs recovered: Collection stage

LIFE CYCLE INVENTORY

	(w) Iode (I-)	g	5.8E-03
	(w) Iron (Fe++, Fe3+)	g	1.3E+00
	(w) Lead (Pb++, Pb4+)	g	3.1E-02
	(w) Lithium Salts (Lithine)	g	2.4E-06
	(w) Magnesium (Mg++)	g	8.9E-01
	(w) Manganese (Mn II, Mn IV, Mn VII)	g	9.4E-02
	(w) Mercury (Hg+, Hg++)	g	4.0E-07
	(w) Metals (unspecified)	g	1.9E-03
	(w) Methylene Chloride (CH2Cl2)	g	1.2E-02
	(w) Molybdenum (Mo II, Mo III, Mo IV, Mo V, Mo	g	2.1E-03
	(w) Morpholine (C4H9NO)	g	2.3E-04
	(w) Nickel (Ni++, Ni3+)	g	6.4E-03
	(w) Nitrates (NO3-)	g	7.2E-02
	(w) Nitrites (NO2-)	g	3.2E-04
	(w) Nitrogenous Matter (Kjeldahl, as N)	g	1.1E-02
	(w) Nitrogenous Matter (unspecified, as N)	g	5.9E-02
	(w) Oils (unspecified)	g	3.6E+00
	(w) Organic Dissolved Matter (unspecified)	g	2.0E-03
	(w) Oxalic Acid ((COOH)2)	g	9.5E-05
	(w) Phenol (C6H5OH)	g	2.7E-02
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3P	g	1.1E-02
	(w) Phosphorus (P)	g	7.3E-04
	(w) Phosphorus Pentoxide (P2O5)	g	6.9E-04
	(w) Polycyclic Aromatic Hydrocarbons (PAH, un	g	1.1E-03
	(w) Potassium (K+)	g	7.8E-01
	(w) Rubidium (Rb+)	g	5.7E-04
	(w) Salts (unspecified)	g	8.8E-01
	(w) Saponifiable Oils and Fats	g	2.8E-01
	(w) Selenium (Se II, Se IV, Se VI)	g	1.9E-03
	(w) Silicon Dioxide (SiO2)	g	4.4E-03
	(w) Silver (Ag+)	g	3.4E-05
	(w) Sodium (Na+)	g	4.0E+01
	(w) Strontium (Sr II)	g	5.0E-01
	(w) Sulphates (SO4--)	g	7.7E+01
	(w) Sulphides (S--)	g	1.4E-03
	(w) Sulphites (SO3--)	g	9.1E-05
	(w) Sulphurated Matter (unspecified, as S)	g	8.4E-07
	(w) Suspended Matter (unspecified)	g	9.0E+01
	(w) Tars (unspecified)	g	3.3E-10
	(w) Tetrachloroethylene (C2Cl4)	g	1.8E-08
	(w) Tin (Sn++, Sn4+)	g	6.5E-06
	(w) Titanium (Ti3+, Ti4+)	g	4.7E-02
	(w) TOC (Total Organic Carbon)	g	2.1E+01
	(w) Toluene (C6H5CH3)	g	2.4E-02
	(w) Trichlorethane (1,1,1-CH3CCl3)	g	4.2E-08
	(w) Trichloroethylene (C2HCl3)	g	1.1E-06
	(w) Triethylene Glycol (C6H14O4)	g	1.4E+00
	(w) Vanadium (V3+, V5+)	g	7.2E-03
	(w) VOC (Volatile Organic Compounds)	g	2.0E-02
	(w) Water (unspecified)	litre	2.2E+01
	(w) Water: Chemically Polluted	litre	2.8E+00
	(w) Xylene (C6H4(CH3)2)	g	6.8E-02
	(w) Zinc (Zn++)	g	3.6E-02
	(wr) Antimony (Sb124)	kBq	1.1E-03
	(wr) Cesium (Cs134)	kBq	9.3E-04
	(wr) Cesium (Cs137)	kBq	1.4E-03
	(wr) Cobalt (Co58)	kBq	3.1E-03
	(wr) Cobalt (Co60)	kBq	1.9E-03
	(wr) Iodine (I131)	kBq	1.2E-04
	(wr) Manganese (Mn54)	kBq	1.5E-04
	(wr) Protactinium (Pa234m)	kBq	4.7E-03
	(wr) Radioactive Substance (unspecified)	kBq	1.3E-06
	(wr) Radium (Ra224)	kBq	2.9E-03
	(wr) Radium (Ra226)	kBq	9.0E+00
	(wr) Radium (Ra228)	kBq	5.7E-03
	(wr) Silver (Ag110m)	kBq	4.6E-03
	(wr) Thorium (Th228)	kBq	1.1E-02
	(wr) Thorium (Th230)	kBq	4.4E-01
	(wr) Thorium (Th234)	kBq	4.7E-03
	(wr) Tritium (H3)	kBq	5.6E+01
	(wr) Uranium (U234)	kBq	1.5E-01
	(wr) Uranium (U235)	kBq	6.7E-03
	(wr) Uranium (U238)	kBq	1.4E-01
	Recovered Matter (total)	kg	4.6E-02
	Recovered Matter (unspecified)	kg	4.5E-02
	Recovered Matter: Iron Scrap	kg	5.5E-04
	Traded-in printers	kg	2.2E+04
	Waste (hazardous)	kg	3.1E-03
	Waste (incineration)	kg	1.1E-03
	Waste (municipal and industrial)	kg	3.8E-03
	Waste (total)	kg	8.2E+00
	Waste (unspecified)	kg	3.6E-02
	Waste: Highly Radioactive (class C)	kg	1.4E-04
	Waste: Low Radioactive (class A)	kg	5.0E-03
	Waste: Mineral (inert)	kg	7.1E+00
	Waste: Mining	kg	7.0E+00
	Waste: Non Mineral (inert)	kg	3.0E-04
	Waste: Non Toxic Chemicals (unspecified)	kg	9.9E-07
	Waste: Radioactive (unspecified)	kg	5.6E-05
	Waste: Slags and Ash (unspecified)	kg	1.1E+00

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	(a) Ethylene (C2H4)	g eq. 1-4-dichlorobenzene	17	7.4E+02
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	2600	9.9E+02
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	11000	8.8E+02
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	13000000	2.3E+04
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	190000	4.7E+03
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	11000	3.4E-03
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.035	2.6E-02
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	450000	3.3E+04
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	660000	1.9E+07
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	200000	1.4E+02
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	340000000	1.1E+02
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	600000	5.3E+03
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	45000	1.5E-02
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	2400000	3.9E+00
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	29000	2.2E-01
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	17000000	1.0E+00
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	520000	1.3E+00
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	1800000	4.8E+04
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	9.70E-06	2.1E-08
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.039	1.1E-03
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	0.025	5.2E-06
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	5.2	2.2E-05
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	1.10E-05	2.0E-07
	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.10E-05	1.2E-08
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	1.10E-05	3.8E-12
	(w) Cobalt (Co I, Co II, Co III)	g eq. 1-4-dichlorobenzene	2.00E-07	2.3E-10
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.00E-05	4.4E-08
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	2.5	1.4E-07
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	2.00E-07	6.2E-09
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	8200000	3.2E+00
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	0.078	9.6E-04
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	3.10E-05	2.0E-07
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	34	9.2E-01
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	110	2.0E-06
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.022	5.3E-04
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	2	8.3E-08
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.024	2.7E-08
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	3.40E-05	2.4E-07
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	2.50E-05	8.9E-07
	WMO-Depletion of the ozone layer (high)	g eq. CFC-11	*	3.6E-03
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	17.2	3.6E-03
	WMO-Depletion of the ozone layer (low)	g eq. CFC-11	*	2.1E-03
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	10	2.1E-03
	WMO-Photochemical oxidant formation (high)	g eq. ethylene	*	7.0E+02
	(a) Acetaldehyde (CH3CHO)	g eq. ethylene	1.22	8.1E-03
	(a) Acetone (CH3COCH3)	g eq. ethylene	0.27	9.7E-04
	(a) Acetylene (C2H2)	g eq. ethylene	0.42	8.4E-02
	(a) Aldehyde (unspecified)	g eq. ethylene	1.263	7.9E-03
	(a) Alkane (unspecified)	g eq. ethylene	1.173	1.2E+01
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	1.285	3.8E-03
	(a) Benzaldehyde (C6H5CHO)	g eq. ethylene	-0.12	-4.9E-09
	(a) Benzene (C6H6)	g eq. ethylene	0.45	8.3E-01
	(a) Butane (n-C4H10)	g eq. ethylene	1.15	3.3E+00
	(a) Butene (1-CH3CH2CHCH2)	g eq. ethylene	1.85	3.6E-03
	(a) Ethane (C2H6)	g eq. ethylene	0.3	3.5E+00
	(a) Ethanol (C2H5OH)	g eq. ethylene	0.89	5.7E-03
	(a) Ethylene (C2H4)	g eq. ethylene	1	4.3E+01
	(a) Formaldehyde (CH2O)	g eq. ethylene	0.58	2.2E-01
	(a) Heptane (C7H16)	g eq. ethylene	1.65	2.4E-02
	(a) Hexane (C6H14)	g eq. ethylene	1.51	4.5E-02
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.799	6.2E+02
	(a) Hydrocarbons (unspecified)	g eq. ethylene	0.808	1.8E-01
	(a) Methane (CH4)	g eq. ethylene	0.03	1.2E+01
	(a) Methanol (CH3OH)	g eq. ethylene	0.21	2.2E-03
	(a) Propane (C3H8)	g eq. ethylene	1.24	4.5E+00
	(a) Propionaldehyde (CH3CH2CHO)	g eq. ethylene	1.6	1.8E-07
	(a) Propylene (CH2CHCH3)	g eq. ethylene	1.63	3.6E-01
	(a) Toluene (C6H5CH3)	g eq. ethylene	0.83	6.2E-01
	WMO-Photochemical oxidant formation (low)	g eq. ethylene	*	2.0E+02
	(a) Acetaldehyde (CH3CHO)	g eq. ethylene	0.33	2.2E-03
	(a) Acetone (CH3COCH3)	g eq. ethylene	0.1	3.6E-04
	(a) Acetylene (C2H2)	g eq. ethylene	0.1	2.0E-02
	(a) Aldehyde (unspecified)	g eq. ethylene	0.079	5.0E-04
	(a) Alkane (unspecified)	g eq. ethylene	0.114	1.1E+00
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	0.481	1.4E-03
	(a) Benzaldehyde (C6H5CHO)	g eq. ethylene	-0.82	-3.3E-08
	(a) Benzene (C6H6)	g eq. ethylene	0.11	2.0E-01
	(a) Butane (n-C4H10)	g eq. ethylene	0.15	4.3E-01
	(a) Butene (1-CH3CH2CHCH2)	g eq. ethylene	0.57	1.1E-03
	(a) Ethane (C2H6)	g eq. ethylene	0.02	2.3E-01
	(a) Ethanol (C2H5OH)	g eq. ethylene	0.04	2.5E-04
	(a) Ethylene (C2H4)	g eq. ethylene	1	4.3E+01
	(a) Formaldehyde (CH2O)	g eq. ethylene	0.22	8.4E-02
	(a) Heptane (C7H16)	g eq. ethylene	0.13	1.9E-03
	(a) Hexane (C6H14)	g eq. ethylene	0.1	3.0E-03
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.195	1.5E+02
	(a) Hydrocarbons (unspecified)	g eq. ethylene	0.194	4.4E-02
	(a) Methane (CH4)	g eq. ethylene	0	0.0E+00
	(a) Methanol (CH3OH)	g eq. ethylene	0.09	9.5E-04
	(a) Propane (C3H8)	g eq. ethylene	0.16	5.8E-01
	(a) Propionaldehyde (CH3CH2CHO)	g eq. ethylene	0.28	3.1E-08
	(a) Propylene (CH2CHCH3)	g eq. ethylene	0.75	1.7E-01
	(a) Toluene (C6H5CH3)	g eq. ethylene	0.41	3.1E-01

Plastics and PCBs recovered: Processing stage

LIFE CYCLE INVENTORY

	Flow	Units	Processing
Inputs:	(r) 1-methoxy propan-2-ol	kg	1.2E-01
	(r) Barium Sulphate (BaSO4, in ground)	kg	7.2E+00
	(r) Bauxite (Al2O3, ore)	kg	2.8E-02
	(r) Bentonite (Al2O3.4SiO2.H2O, in ground)	kg	6.8E-01
	(r) Calcium Sulphate (CaSO4, ore)	kg	1.9E-02
	(r) Chromium (Cr, ore)	kg	1.4E-03
	(r) Clay (in ground)	kg	1.7E+00
	(r) Coal (in ground)	kg	7.1E+02
	(r) Commercial butane	g	1.7E+02
	(r) Copper (Cu, ore)	kg	7.0E-03
	(r) Gravel (unspecified)	kg	2.6E+00
	(r) Iron (Fe, ore)	kg	2.2E+01
	(r) Iron Sulphate (FeSO4, ore)	kg	2.2E-02
	(r) Kerosine	kg	1.0E-01
	(r) Lead (Pb, ore)	kg	2.2E-03
	(r) Lignite (in ground)	kg	2.5E+01
	(r) Limestone (CaCO3, in ground)	kg	1.2E+03
	(r) Manganese (Mn, ore)	kg	8.1E-04
	(r) Natural Gas (in ground)	kg	4.5E+03
	(r) Nickel (Ni, ore)	kg	4.7E-04
	(r) Oil (in ground)	kg	6.9E+01
	(r) Propan-2-ol	kg	9.8E-02
	(r) Pyrite (FeS2, ore)	kg	1.2E+01
	(r) Sand (in ground)	kg	2.8E-01
	(r) Silver (Ag, ore)	kg	3.5E-05
	(r) Sodium Chloride (NaCl, in ground or in sea)	kg	3.0E+01
	(r) Sulphur (S, in ground)	kg	4.9E-02
	(r) Uranium (U, ore)	kg	3.2E-02
	(r) Water	kg	2.1E+00
	(r) Zinc (Zn, ore)	kg	5.1E-05
	Diesel Oil	kg	9.5E+01
	Explosive (unspecified)	kg	2.6E-01
	Gasoline (leaded)	kg	2.2E+00
	Gasoline (unleaded)	kg	2.0E+00
	Iron Scrap	kg	1.7E-01
	Land Use (II -> III)	m2a	2.8E+00
	Land Use (II -> IV)	m2a	3.8E-01
	Land Use (III -> IV)	m2a	1.3E-01
	Raw Materials (unspecified)	kg	1.0E+00
	Traded-in printers	kg	2.2E+04
	Water Used (total)	litre	1.0E+04
	Water: Unspecified Origin	litre	1.0E+04
	Wood	kg	3.2E-01
	Wood (standing)	m3	4.3E-03
Outputs:	(a) 1-methoxy propan-2-ol	kg	1.2E-01
	(a) Acetaldehyde (CH3CHO)	g	2.8E-01
	(a) Acetic Acid (CH3COOH)	g	2.7E+01
	(a) Acetone (CH3COCH3)	g	1.2E-01
	(a) Acetylene (C2H2)	g	6.0E+00
	(a) Aldehyde (unspecified)	g	2.3E-01
	(a) Alkane (unspecified)	g	5.1E+02
	(a) Alkene (unspecified)	g	7.1E+00
	(a) Alkyne (unspecified)	g	1.2E-02
	(a) Aluminium (Al)	g	1.2E+02
	(a) Ammonia (NH3)	g	3.7E+01
	(a) Antimony (Sb)	g	2.2E-02
	(a) AOX (Adsorbable Organic Halogens)	g	9.6E-11
	(a) Aromatic Hydrocarbons (unspecified)	g	5.1E+00
	(a) Arsenic (As)	g	2.4E-01
	(a) Barium (Ba)	g	1.4E+00
	(a) Benzaldehyde (C6H5CHO)	g	2.1E-06
	(a) Benzene (C6H6)	g	8.7E+01
	(a) Benzo(a)pyrene (C20H12)	g	2.2E-02
	(a) Beryllium (Be)	g	2.3E-02
	(a) Boron (B)	g	1.1E+01
	(a) Bromium (Br)	g	2.2E+00
	(a) Butane (n-C4H10)	g	3.1E+02
	(a) Butene (1-CH3CH2CHCH2)	g	7.9E-02
	(a) Cadmium (Cd)	g	7.8E-01
	(a) Calcium (Ca)	g	1.5E+01
	(a) Carbon Dioxide (CO2, fossil)	g	2.5E+07
	(a) Carbon Monoxide (CO)	g	7.8E+03
	(a) Carbon Tetrafluoride (CF4)	g	1.7E-03
	(a) Chlorine (Cl2)	g	6.3E-06
	(a) Chromium (Cr III, Cr VI)	g	3.1E-01
	(a) Cobalt (Co)	g	6.1E-02
	(a) Copper (Cu)	g	2.4E-01
	(a) Cyanide (CN-)	g	3.6E-02
	(a) Dioxins (unspecified)	g	5.3E-05
	(a) Ethane (C2H6)	g	5.7E+02
	(a) Ethanol (C2H5OH)	g	2.0E-01
	(a) Ethylbenzene (C8H10)	g	7.9E-02
	(a) Ethylene (C2H4)	g	2.2E+03
	(a) Fluorides (F-)	g	6.7E-04
	(a) Fluorine (F2)	g	4.2E-04
	(a) Formaldehyde (CH2O)	g	1.9E+01
	(a) Halogenated Matter (unspecified)	g	9.5E-03
	(a) Halon 1301 (CF3Br)	g	1.3E-02
	(a) Heptane (C7H16)	g	5.3E-01
	(a) Hexane (C6H14)	g	1.1E+00
	(a) Hydrocarbons (except methane)	g	4.1E+03
	(a) Hydrocarbons (unspecified)	g	1.5E+02
	(a) Hydrogen (H2)	g	2.6E-05
	(a) Hydrogen Chloride (HCl)	g	7.5E+03
	(a) Hydrogen Fluoride (HF)	g	3.2E+01
	(a) Hydrogen Sulphide (H2S)	g	8.3E+01
	(a) Iodine (I)	g	5.6E-01
	(a) Iron (Fe)	g	4.8E+01
	(a) Kerosine	kg	1.1E-01
	(a) lanthanum (La)	g	3.6E-02
	(a) Lead (Pb)	g	5.7E+00
	(a) Magnesium (Mg)	g	4.1E+01
	(a) Manganese (Mn)	g	1.2E+00
	(a) Mercury (Hg)	g	5.4E+00
	(a) Metals (unspecified)	g	1.3E+01
	(a) Methane (CH4)	g	2.2E+04
	(a) Methanol (CH3OH)	g	3.3E-01
	(a) Molybdenum (Mo)	g	5.5E-02
	(a) Nickel (Ni)	g	8.8E-01
	(a) Nitrogen Oxides (NOx as NO2)	g	2.0E+04
	(a) Nitrous Oxide (N2O)	g	1.1E+02
	(a) Organic Matter (unspecified)	g	3.2E-01
	(a) Particulates (unspecified)	g	1.1E+04
	(a) Pentane (C5H12)	g	2.2E+02
	(a) Phenol (C6H5OH)	g	1.6E-05
	(a) Phosphorus (P)	g	1.0E+00
	(a) Phosphorus Pentoxide (P2O5)	g	6.9E-04
	(a) Platinum (Pt)	g	4.0E-05
	(a) Polycyclic Aromatic Hydrocarbons (PAH, unspecified)	g	1.8E+00
	(a) Potassium (K)	g	1.8E+01
	(a) Propan-2-ol	kg	9.8E-02
	(a) Propane (C3H8)	g	1.8E+02
	(a) Propionaldehyde (CH3CH2CHO)	g	5.8E-06
	(a) Propionic Acid (CH3CH2COOH)	g	7.7E-03
	(a) Propylene (CH2CHCH3)	g	6.7E+00
	(a) Scandium (Sc)	g	1.2E-02
	(a) Selenium (Se)	g	2.9E-01
	(a) Silicon (Si)	g	1.7E+02
	(a) Sodium (Na)	g	7.5E+00
	(a) Strontium (Sr)	g	2.3E+00
	(a) Sulphur Oxides (SOx as SO2)	g	1.1E+04
	(a) Tars (unspecified)	g	6.9E-07
	(a) Thallium (Tl)	g	1.1E-02
	(a) Thorium (Th)	g	2.3E-02
	(a) Tin (Sn)	g	7.3E-03
	(a) Titanium (Ti)	g	4.0E+00
	(a) Toluene (C6H5CH3)	g	3.8E+01
	(a) Uranium (U)	g	2.3E-02
	(a) Vanadium (V)	g	2.2E+00
	(a) Water vapour	kg	2.1E+00
	(a) Xylene (C6H4(CH3)2)	g	1.4E+00
	(a) Zinc (Zn)	g	8.4E+01
	(a) Zirconium (Zr)	g	1.7E-02
	(ar) Aerosols and Halogenes (unspecified)	kBq	4.2E-02
	(ar) Carbon (C14)	kBq	1.4E+01
	(ar) Cesium (Cs134)	kBq	5.3E-04
	(ar) Cesium (Cs137)	kBq	5.3E-04
	(ar) Cobalt (Co58)	kBq	5.3E-04
	(ar) Cobalt (Co60)	kBq	5.3E-04
	(ar) Gas (unspecified)	kBq	1.3E+03
	(ar) Iodine (I131)	kBq	3.1E-03
	(ar) Iodine (I133)	kBq	6.1E-03

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	Classification	Units	Charact-erisation	Environmental impacts
Methods:	CML-Air Acidification	g eq. H+	/	1.0E+03
	(a) Ammonia (NH3)	g eq. H+	17	2.2E+00
	(a) Hydrogen Chloride (HCl)	g eq. H+	36.5	2.0E+02
	(a) Hydrogen Fluoride (HF)	g eq. H+	20	1.6E+00
	(a) Hydrogen Sulphide (H2S)	g eq. H+	17	4.9E+00
	(a) Nitrogen Oxides (NOx as NO2)	g eq. H+	46	4.4E+02
	(a) Sulphur Oxides (SOx as SO2)	g eq. H+	32	3.5E+02
	CML-Eutrophication	g eq. PO4	*	2.7E+03
	(a) Nitrogen Oxides (NOx as NO2)	g eq. PO4	0.13	2.6E+03
	(a) Nitrous Oxide (N2O)	g eq. PO4	0.27	2.9E+01
	(w) Ammonia (NH4+, NH3, as N)	g eq. PO4	0.42	1.2E+01
	(w) COD (Chemical Oxygen Demand)	g eq. PO4	0.022	1.7E+00
	(w) Nitrogenous Matter (Kjeldahl, as N)	g eq. PO4	0.42	1.4E-01
	(w) Nitrogenous Matter (unspecified, as N)	g eq. PO4	0.42	1.9E+00
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g eq. PO4	3.06	2.7E+00
	(w) Phosphorus (P)	g eq. PO4	3.06	1.0E-01
	(w) Phosphorus Pentoxide (P2O5)	g eq. PO4	1.336	2.8E-02
	CST-Aquatic Eco-toxicity	eq. Zn water	*	2.3E+04
	(a) Arsenic (As)	eq. Zn water	0.078	1.8E-02
	(a) Cadmium (Cd)	eq. Zn water	79	6.1E+01
	(a) Chromium (Cr III, Cr VI)	eq. Zn water	0.39	1.2E-01
	(a) Copper (Cu)	eq. Zn water	0.66	1.6E-01
	(a) Lead (Pb)	eq. Zn water	1.28	7.3E+00
	(a) Mercury (Hg)	eq. Zn water	196	1.1E+03
	(a) Nickel (Ni)	eq. Zn water	0.12	1.1E-01
	(a) Zinc (Zn)	eq. Zn water	0.076	6.4E+00
	(s) Arsenic (As)	eq. Zn water	0.24	8.8E-03
	(s) Cadmium (Cd)	eq. Zn water	240	4.0E-03
	(s) Chromium (Cr III, Cr VI)	eq. Zn water	1.2	5.5E-01
	(s) Copper (Cu)	eq. Zn water	2	1.7E-04
	(s) Lead (Pb)	eq. Zn water	3.9	1.5E-03
	(s) Mercury (Hg)	eq. Zn water	600	1.8E-03
	(s) Nickel (Ni)	eq. Zn water	0.36	4.6E-05
	(s) Zinc (Zn)	eq. Zn water	0.23	3.2E-01
	(w) Arsenic (As3+, As5+)	eq. Zn water	0.52	6.7E-02
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Zn water	0.00013	8.6E-04
	(w) Cadmium (Cd++)	eq. Zn water	520	3.0E+03
	(w) Chromium (Cr III, Cr VI)	eq. Zn water	2.6	4.8E-01
	(w) Copper (Cu+, Cu++)	eq. Zn water	5.2	3.8E+02
	(w) Lead (Pb++, Pb4+)	eq. Zn water	5.2	3.0E+02
	(w) Mercury (Hg+, Hg++)	eq. Zn water	1300	1.7E+04
	(w) Nickel (Ni++, Ni3+)	eq. Zn water	0.79	2.8E-01
	(w) Oils (unspecified)	eq. Zn water	0.13	2.9E+01
	(w) Phenol (C6H5OH)	eq. Zn water	15.4	2.2E+01
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Zn water	0.01	8.8E-03
	(w) Zinc (Zn++)	eq. Zn water	1	1.3E+03
	CST-Human Toxicity	eq. Pb air	*	3.0E+05
	(a) Aldehyde (unspecified)	eq. Pb air	0.0087	2.0E-03
	(a) Arsenic (As)	eq. Pb air	9000	2.1E+03
	(a) Benzene (C6H6)	eq. Pb air	0.012	1.0E+00
	(a) Cadmium (Cd)	eq. Pb air	19000	1.5E+04
	(a) Carbon Monoxide (CO)	eq. Pb air	0.00014	1.1E+00
	(a) Chromium (Cr III, Cr VI)	eq. Pb air	3700	1.1E+03
	(a) Cobalt (Co)	eq. Pb air	12900	7.9E+02
	(a) Copper (Cu)	eq. Pb air	145	3.5E+01
	(a) Formaldehyde (CH2O)	eq. Pb air	0.0099	1.9E-01
	(a) Lead (Pb)	eq. Pb air	2300	1.3E+04
	(a) Mercury (Hg)	eq. Pb air	46000	2.5E+05
	(a) Nickel (Ni)	eq. Pb air	370	3.3E+02
	(a) Nitrogen Oxides (NOx as NO2)	eq. Pb air	0.002	4.0E+01
	(a) Particulates (unspecified)	eq. Pb air	0.0075	8.0E+01
	(a) Selenium (Se)	eq. Pb air	64000	1.9E+04
	(a) Sulphur Oxides (SOx as SO2)	eq. Pb air	0.0075	8.3E+01
	(a) Tin (Sn)	eq. Pb air	9	6.5E-02
	(a) Zinc (Zn)	eq. Pb air	27	2.3E+03
	(s) Arsenic (As)	eq. Pb air	0.7	2.6E-02
	(s) Cadmium (Cd)	eq. Pb air	1.46	2.4E-05
	(s) Chromium (Cr III, Cr VI)	eq. Pb air	0.29	1.3E-01
	(s) Cobalt (Co)	eq. Pb air	1	1.7E-05
	(s) Copper (Cu)	eq. Pb air	0.009	7.6E-07
	(s) Lead (Pb)	eq. Pb air	0.6	2.3E-04
	(s) Mercury (Hg)	eq. Pb air	3.6	1.1E-05
	(s) Nickel (Ni)	eq. Pb air	0.029	3.7E-06
	(s) Zinc (Zn)	eq. Pb air	0.0007	9.7E-04
	(w) Arsenic (As3+, As5+)	eq. Pb air	1.5	1.9E-01
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Pb air	0.022	1.4E-01
	(w) Cadmium (Cd++)	eq. Pb air	3.2	1.8E+01
	(w) Chromium (Cr III, Cr VI)	eq. Pb air	0.62	1.1E-01
	(w) Cobalt (Co I, Co II, Co III)	eq. Pb air	2.2	1.3E-01
	(w) Copper (Cu+, Cu++)	eq. Pb air	0.022	1.6E+00
	(w) Fluorides (F-)	eq. Pb air	0.045	5.9E-01
	(w) Lead (Pb++, Pb4+)	eq. Pb air	0.86	5.0E+01
	(w) Mercury (Hg+, Hg++)	eq. Pb air	7.8	1.0E+02
	(w) Nickel (Ni++, Ni3+)	eq. Pb air	0.062	2.2E-02
	(w) Phenol (C6H5OH)	eq. Pb air	0.052	7.3E-02
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Pb air	3.20E-06	2.8E-06
	(w) Selenium (Se II, Se IV, Se VI)	eq. Pb air	10.9	6.0E-01
	(w) Tin (Sn++, Sn4+)	eq. Pb air	0.0015	2.9E-07
	(w) Zinc (Zn++)	eq. Pb air	0.0032	4.2E+00
	CST-Terrestrial Eco-toxicity	eq. Zn air	*	6.5E+01
	(a) Arsenic (As)	eq. Zn air	0.75	1.8E-01
	(a) Cadmium (Cd)	eq. Zn air	3.14	2.4E+00
	(a) Chromium (Cr III, Cr VI)	eq. Zn air	0.08	2.5E-02
	(a) Cobalt (Co)	eq. Zn air	0.08	4.9E-03
	(a) Copper (Cu)	eq. Zn air	0.14	3.4E-02
	(a) Lead (Pb)	eq. Zn air	0.13	7.4E-01
	(a) Mercury (Hg)	eq. Zn air	5.94	3.2E+01
	(a) Nickel (Ni)	eq. Zn air	0.35	3.1E-01
	(a) Zinc (Zn)	eq. Zn air	0.33	2.8E+01
	(s) Arsenic (As)	eq. Zn air	2.3	8.5E-02
	(s) Cadmium (Cd)	eq. Zn air	9.6	1.6E-04
	(s) Chromium (Cr III, Cr VI)	eq. Zn air	0.26	1.2E-01
	(s) Cobalt (Co)	eq. Zn air	0.26	4.4E-06
	(s) Copper (Cu)	eq. Zn air	0.42	3.5E-05
	(s) Lead (Pb)	eq. Zn air	0.41	1.6E-04
	(s) Mercury (Hg)	eq. Zn air	18.3	5.6E-05
	(s) Nickel (Ni)	eq. Zn air	1.1	1.4E-04
	(s) Zinc (Zn)	eq. Zn air	1	1.4E+00
	EB(R*Y)-Depletion of non renewable resources	yr-1	*	7.4E+02
	(r) Barium Sulphate (BaSO4, in ground)	yr-1	26.91	1.9E+02
	(r) Bauxite (Al2O3, ore)	yr-1	0.108	3.0E-03
	(r) Chromium (Cr, ore)	yr-1	0.2133	3.0E-04
	(r) Chromium (Cr, ore)	yr-1	0.319	4.4E-04
	(r) Coal (in ground)	yr-1	0.0005037	3.6E-01
	(r) Copper (Cu, ore)	yr-1	28.16	2.0E-01
	(r) Iron (Fe, ore)	yr-1	0.04	9.0E-01
	(r) Lead (Pb, ore)	yr-1	157	3.5E-01
	(r) Lignite (in ground)	yr-1	0.0005037	1.2E-02
	(r) Manganese (Mn, ore)	yr-1	0.296	2.4E-04
	(r) Natural Gas (in ground)	yr-1	0.117	5.3E+02
	(r) Nickel (Ni, ore)	yr-1	59.7	2.8E-02
	(r) Oil (in ground)	yr-1	0.0557	3.9E+00
	(r) Silver (Ag, ore)	yr-1	92837	3.2E+00
	(r) Sulphur (S, in ground)	yr-1	4.408	2.2E-01
	(r) Uranium (U, ore)	yr-1	181	5.8E+00
	(r) Zinc (Zn, ore)	yr-1	40.29	2.1E-03
	ETH-Air Acidification	g eq. H+	/	1.0E+03
	(a) Ammonia (NH3)	g eq. H+	17	2.2E+00
	(a) Hydrogen Chloride (HCl)	g eq. H+	36.5	2.0E+02
	(a) Hydrogen Fluoride (HF)	g eq. H+	20	1.6E+00
	(a) Hydrogen Sulphide (H2S)	g eq. H+	17	4.9E+00
	(a) Nitrogen Oxides (NOx as NO2)	g eq. H+	46	4.4E+02
	(a) Sulphur Oxides (SOx as SO2)	g eq. H+	32	3.5E+02
	IPCC-Greenhouse effect (direct, 100 years)	g eq. CO2	*	2.6E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	2.5E+07
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	5700	9.7E+00
	(a) Halon 1301 (CF3Br)	g eq. CO2	6900	9.1E+01
	(a) Methane (CH4)	g eq. CO2	24	5.4E+05
	(a) Nitrous Oxide (N2O)	g eq. CO2	360	3.8E+04
	IPCC-Greenhouse effect (direct, 20 years)	g eq. CO2	*	2.7E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	2.5E+07
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	3900	6.7E+00
	(a) Halon 1301 (CF3Br)	g eq. CO2	7900	1.0E+02
	(a) Methane (CH4)	g eq. CO2	64	1.4E+06
	(a) Nitrous Oxide (N2O)	g eq. CO2	330	3.5E+04
	IPCC-Greenhouse effect (direct, 500 years)	g eq. CO2	*	2.5E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	2.5E+07
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	8900	1.5E+01
	(a) Halon 1301 (CF3Br)	g eq. CO2	2700	3.6E+01
	(a) Methane (CH4)	g eq. CO2	7.5	1.7E+05
	(a) Nitrous Oxide (N2O)	g eq. CO2	190	2.0E+04
	USES 1.0-Aquatic Ecotoxicity	g eq. 1-4-dichlorobenzene	*	1.1E+05

2.3E+04	CST-Aquatic Eco-toxicity
3.0E+05	CST-Human Toxicity
6.5E+01	CST-Terrestrial Eco-toxicity
7.4E+02	EB(R*Y)-Depletion of non renewa
1.0E+03	ETH-Air Acidification
2.7E+03	CML-Eutrophication
2.6E+07	IPCC-Greenhouse effect (direct, :
2.7E+07	IPCC-Greenhouse effect (direct, :
2.5E+07	IPCC-Greenhouse effect (direct, :
1.1E+05	USES 1.0-Aquatic Ecotoxicity
8.3E+05	USES 1.0-Human Toxicity
3.4E+08	USES 1.0-Terrestrial Ecotoxicity
2.3E-01	WMO-Depletion of the ozone laye
1.3E-01	WMO-Depletion of the ozone laye
7.8E+03	WMO-Photochemical oxidant forr
3.2E+03	WMO-Photochemical oxidant forr

Plastics and PCBs recovered: Processing stage

LIFE CYCLE INVENTORY

	(ar) Krypton (Kr85)	kBq	8.1E+01
	(ar) Lead (Pb210)	kBq	5.4E-01
	(ar) Polonium (Po210)	kBq	9.3E-01
	(ar) Potassium (K40)	kBq	1.4E-01
	(ar) Protactinium (Pa234m)	kBq	7.5E-03
	(ar) Radioactive Substance (unspecified)	kBq	4.1E+04
	(ar) Radium (Ra226)	kBq	6.6E-01
	(ar) Radium (Ra228)	kBq	7.1E-02
	(ar) Radon (Rn220)	kBq	2.2E+00
	(ar) Radon (Rn222)	kBq	6.4E+04
	(ar) Thorium (Th228)	kBq	6.0E-02
	(ar) Thorium (Th230)	kBq	1.1E-01
	(ar) Thorium (Th232)	kBq	3.8E-02
	(ar) Thorium (Th234)	kBq	7.5E-03
	(ar) Tritium (H3)	kBq	1.6E+02
	(ar) Uranium (U234)	kBq	1.9E-01
	(ar) Uranium (U235)	kBq	1.4E-03
	(ar) Uranium (U238)	kBq	3.3E-01
	(ar) Xenon (Xe133)	kBq	1.1E+03
	(s) Aluminium (Al)	g	9.2E+01
	(s) Arsenic (As)	g	3.7E-02
	(s) Cadmium (Cd)	g	1.7E-05
	(s) Calcium (Ca)	g	3.7E+02
	(s) Carbon (C)	g	2.8E+02
	(s) Chromium (Cr III, Cr VI)	g	4.6E-01
	(s) Cobalt (Co)	g	1.7E-05
	(s) Copper (Cu)	g	8.4E-05
	(s) Iron (Fe)	g	1.8E+02
	(s) Lead (Pb)	g	3.9E-04
	(s) Manganese (Mn)	g	3.7E+00
	(s) Mercury (Hg)	g	3.1E-06
	(s) Nickel (Ni)	g	1.3E-04
	(s) Nitrogen (N)	g	1.4E-03
	(s) Oils (unspecified)	g	5.5E-01
	(s) Phosphorus (P)	g	4.6E+00
	(s) Sulphur (S)	g	5.5E+01
	(s) Zinc (Zn)	g	1.4E+00
	(sr) Americium (Am241)	kBq	1.4E+02
	(sr) Americium (Am243)	kBq	3.1E+00
	(sr) Cesium (Cs135)	kBq	6.9E+04
	(sr) Cesium (Cs137)	kBq	1.9E-01
	(sr) Curium (Cm244)	kBq	2.8E+02
	(sr) Curium (Cm245)	kBq	3.2E-02
	(sr) Iodine (I129)	kBq	4.5E-03
	(sr) Neptunium (Np237)	kBq	4.4E+01
	(sr) Palladium (Pd107)	kBq	1.5E-02
	(sr) Plutonium (Pu239)	kBq	5.3E+04
	(sr) Plutonium (Pu240)	kBq	7.6E+04
	(sr) Plutonium (Pu241)	kBq	1.8E+07
	(sr) Plutonium (Pu242)	kBq	2.9E+02
	(sr) Radium (Ra226)	kBq	3.6E+02
	(sr) Samarium (Sm151)	kBq	6.3E+01
	(sr) Selenium (Se79)	kBq	4.9E-02
	(sr) Strontium (Sr90)	kBq	1.0E+04
	(sr) Technetium (Tc99)	kBq	2.1E+00
	(sr) Thorium (Th230)	kBq	3.6E+02
	(sr) Tin (Sn126)	kBq	8.6E-02
	(sr) Uranium (U234)	kBq	2.3E+02
	(sr) Uranium (U235)	kBq	4.1E+00
	(sr) Uranium (U238)	kBq	6.3E+01
	(sr) Zirconium (Zr93)	kBq	2.7E-01
	(w) Acids (H+)	g	9.4E-01
	(w) Alcohol (unspecified)	g	5.6E-02
	(w) Aldehyde (unspecified)	g	3.9E-02
	(w) Alkane (unspecified)	g	1.2E+00
	(w) Alkene (unspecified)	g	1.1E-01
	(w) Aluminium (Al3+)	g	6.9E+01
	(w) Aluminium Hydroxide (Al(OH)3)	g	6.5E-04
	(w) Ammonia (NH4+, NH3, as N)	g	3.0E+01
	(w) AOX (Adsorbable Organic Halogens)	g	1.1E-02
	(w) Aromatic Hydrocarbons (unspecified)	g	9.2E+00
	(w) Arsenic (As3+, As5+)	g	1.3E-01
	(w) Barium (Ba++)	g	1.5E+01
	(w) Barytes	g	1.3E+03
	(w) Benzene (C6H6)	g	1.2E+00
	(w) BOD5 (Biochemical Oxygen Demand)	g	6.6E+00
	(w) Boric Acid (H3BO3)	g	8.3E-01
	(w) Boron (B III)	g	1.6E-01
	(w) Cadmium (Cd++)	g	5.8E+00
	(w) Calcium (Ca++)	g	4.6E+02
	(w) Carbonates (CO3--, HCO3-, CO2, as C)	g	1.0E+00
	(w) Cesium (Cs++)	g	1.7E-03
	(w) Chlorides (Cl-)	g	5.4E+05
	(w) Chlorinated Matter (unspecified, as Cl)	g	2.1E+02
	(w) Chloroform (CHCl3)	g	2.2E-04
	(w) Chromium (Cr III)	g	9.7E-01
	(w) Chromium (Cr III, Cr VI)	g	1.8E-01
	(w) Chromium (Cr VI)	g	1.8E-05
	(w) Cobalt (Co I, Co II, Co III)	g	6.0E-02
	(w) COD (Chemical Oxygen Demand)	g	7.6E+01
	(w) Copper (Cu+, Cu++)	g	7.3E+01
	(w) Cyanides (CN-)	g	9.8E-01
	(w) Dissolved Matter (unspecified)	g	4.6E+02
	(w) Dissolved Organic Carbon (DOC)	g	7.5E+01
	(w) Edetic Acid (C10H16N2O8, EDTA)	g	1.4E-03
	(w) Ethylbenzene (C6H5C2H5)	g	5.6E-02
	(w) Fluorides (F-)	g	1.3E+01
	(w) Formaldehyde (CH2O)	g	2.8E-06
	(w) Hexachloroethane (C2Cl6)	g	3.9E-10
	(w) Hydrazine (N2H4)	g	6.5E-04
	(w) Hydrocarbons (unspecified)	g	2.4E+00
	(w) Hypochlorite (ClO-)	g	6.7E-02
	(w) Hypochlorous Acid (HClO)	g	6.7E-02
	(w) Inorganic Dissolved Matter (unspecified)	g	7.4E-02
	(w) Iodide (I-)	g	1.8E-01
	(w) Iron (Fe++, Fe3+)	g	9.3E+01
	(w) Lead (Pb++, Pb4+)	g	5.8E+01
	(w) Lithium Salts (Lithine)	g	7.3E-05
	(w) Magnesium (Mg++)	g	4.2E+01
	(w) Manganese (Mn II, Mn IV, Mn VII)	g	3.3E+00
	(w) Mercury (Hg+, Hg++)	g	1.3E+01
	(w) Metals (unspecified)	g	1.4E+01
	(w) Methylene Chloride (CH2Cl2)	g	6.4E-01
	(w) Molybdenum (Mo II, Mo III, Mo IV, Mo V, Mo VI)	g	6.3E-02
	(w) Morpholine (C4H9NO)	g	6.9E-03
	(w) Nickel (Ni++, Ni3+)	g	3.6E-01
	(w) Nitrates (NO3-)	g	6.1E+00
	(w) Nitrites (NO2-)	g	1.7E-02
	(w) Nitrogenous Matter (Kjeldahl, as N)	g	3.3E-01
	(w) Nitrogenous Matter (unspecified, as N)	g	4.5E+00
	(w) Oils (unspecified)	g	2.2E+02
	(w) Organic Dissolved Matter (unspecified)	g	2.9E-01
	(w) Oxalic Acid ((COOH)2)	g	2.8E-03
	(w) Phenol (C6H5OH)	g	1.4E+00
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g	8.8E-01
	(w) Phosphorus (P)	g	3.3E-02
	(w) Phosphorus Pentoxide (P2O5)	g	2.1E-02
	(w) Polycyclic Aromatic Hydrocarbons (PAH, unspecified)	g	5.0E-02
	(w) Potassium (K+)	g	3.5E+01
	(w) Rubidium (Rb+)	g	1.7E-02
	(w) Salts (unspecified)	g	1.2E+04
	(w) Saponifiable Oils and Fats	g	8.3E+00
	(w) Selenium (Se II, Se IV, Se VI)	g	5.5E-02
	(w) Silicon Dioxide (SiO2)	g	2.3E-01
	(w) Silver (Ag+)	g	1.0E-03
	(w) Sodium (Na+)	g	1.4E+03
	(w) Strontium (Sr II)	g	1.7E+01
	(w) Sulphates (SO4--)	g	5.8E+03
	(w) Sulphides (S--)	g	8.3E-02
	(w) Sulphites (SO3--)	g	3.2E-03
	(w) Sulphurated Matter (unspecified, as S)	g	2.5E-05
	(w) Suspended Matter (unspecified)	g	4.9E+03
	(w) Tars (unspecified)	g	9.8E-09
	(w) Tetrachloroethylene (C2Cl4)	g	9.6E-07
	(w) Tin (Sn++, Sn4+)	g	1.9E-04
	(w) Titanium (Ti3+, Ti4+)	g	2.4E+00
	(w) TOC (Total Organic Carbon)	g	7.2E+03
	(w) Toluene (C6H5CH3)	g	1.2E+00
	(w) Trichlorethane (1,1,1-CH3CCl3)	g	2.2E-06
	(w) Trichloroethylene (C2HCl3)	g	6.0E-05
	(w) Triethylene Glycol (C6H14O4)	g	7.3E+01
	(w) Vanadium (V3+, V5+)	g	2.1E-01
	(w) VOC (Volatile Organic Compounds)	g	6.0E-01
	(w) Water (unspecified)	litre	6.5E+02

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	5.6	1.3E+00
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.0013	1.1E-01
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	320	7.0E+00
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130	1.0E+02
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	2.6	1.6E-01
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	2.9	7.0E-01
	(a) Ethylene (C2H4)	g eq. 1-4-dichlorobenzene	0.0022	4.9E+00
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	6.1	1.2E+02
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.2	6.8E+00
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	16000	8.7E+04
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	80	7.0E+01
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	39	6.4E-04
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	9.70E-05	3.6E-03
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	11	2.5E+01
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	2.6	2.2E+02
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	3.00E-08	1.1E-09
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	3.90E-06	6.5E-11
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.40E-09	6.4E-10
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	6.80E-08	1.2E-12
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	1.40E-08	1.2E-12
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.80E-09	7.0E-13
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	16000	4.9E-02
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	5.80E-07	7.4E-11
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	3.90E-08	5.4E-08
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	190	2.5E+01
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	1	1.2E+00
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	4500	2.6E+04
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	0.7	1.6E-04
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	84	8.1E+01
	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	84	1.5E+01
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	84	1.5E-03
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	160	4.5E-04
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	0.021	1.3E-02
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	1.1	1.1E-06
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	0.18	3.9E-07
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.16	9.5E-06
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	380	8.1E+01
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.86	1.1E+03
	USES 1.0-Human Toxicity	g eq. 1-4-dichlorobenzene	*	8.3E+05
	(a) Ammonia (NH3)	g eq. 1-4-dichlorobenzene	16	6.0E+02
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	42000	9.9E+03
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	29	2.5E+03
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	3700	8.1E+01
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	23000	1.8E+04
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	7600	4.6E+02
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	350	8.5E+01
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	0.42	8.0E+00
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	67000	3.8E+05
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	29000	1.6E+05
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	9800	8.6E+03
	(a) Nitrogen Oxides (NOx as NO2)	g eq. 1-4-dichlorobenzene	0.26	5.2E+03
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	2.2	3.6E-05
	(a) Sulphur Oxides (SOx as SO2)	g eq. 1-4-dichlorobenzene	0.16	1.8E+03
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.036	1.4E+00
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	4900	1.1E+04
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	0.63	5.3E+01
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	670	2.5E+01
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	20000	3.3E-01
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	1500	2.5E-02
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	30	2.5E-03
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	350	1.4E-01
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	29000	8.9E-02
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	800	1.0E-01
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	12	1.7E+01
	(w) Ammonia (NH4+, NH3, as N)	g eq. 1-4-dichlorobenzene	17	5.0E+02
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	51	6.6E+00
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	22	2.7E+01
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	130	7.5E+02
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	32	7.1E-03
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	9.3	9.0E+00
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	67000	1.2E+00
	(w) Cobalt (Co I, Co II, Co III)	g eq. 1-4-dichlorobenzene	31	1.8E+00
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.1	8.0E+01
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	0.35	9.9E-07
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	0.026	1.5E+00
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	18000	2.3E+05
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	12	7.6E+00
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	63	2.3E+01
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	0.89	1.2E+00
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	37	3.5E-05
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.053	6.6E-02
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	1200	2.6E-03
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.11	6.5E-06
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	19	4.1E+00
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.058	7.7E+01
	USES 1.0-Terrestrial Ecotoxicity	g eq. 1-4-dichlorobenzene	*	3.4E+08
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	72000	1.7E+04
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.063	5.5E+00
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	64000000	1.4E+06
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130000000	1.0E+08
	(a) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	220000	6.8E+04
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	17000	1.0E+03
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	910000	2.2E+05
	(a) Ethylene (C2H4)	g eq. 1-4-dichlorobenzene	17	3.8E+04
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	2600	4.9E+04
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	11000	6.2E+04
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	13000000	7.1E+07
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	190000	1.7E+05
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	11000	1.8E-01
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.035	1.3E+00
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	450000	1.0E+06
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	660000	5.5E+07
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	200000	7.4E+03
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	340000000	5.7E+03
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	600000	2.8E+05
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	45000	7.6E-01
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	2400000	2.0E+02
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	29000	1.1E+01
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	17000000	5.2E+01
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	520000	6.6E+01
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	1800000	2.5E+06
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	9.70E-06	1.3E-06
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.039	4.8E-02
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	0.025	1.4E-01
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	5.2	1.2E-03
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	1.10E-05	1.1E-05
	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.10E-05	2.0E-06
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	1.10E-05	2.0E-10
	(w) Cobalt (Co I, Co II, Co III)	g eq. 1-4-dichlorobenzene	2.00E-07	1.2E-08
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.00E-05	7.3E-04
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	2.5	7.0E-06
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	2.00E-07	1.2E-05
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	8200000	1.1E+08
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	0.078	5.0E-02
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	3.10E-05	1.1E-05
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	34	4.8E+01
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	110	1.1E-04
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.022	2.7E-02
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	2	4.3E-06
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.024	1.4E-06
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	3.40E-05	7.3E-06
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	2.50E-05	3.3E-02
	WMO-Depletion of the ozone layer (high)	g eq. CFC-11	*	2.3E-01
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	17.2	2.3E-01
	WMO-Depletion of the ozone layer (low)	g eq. CFC-11	*	1.3E-01
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	10	1.3E-01
	WMO-Photochemical oxidant formation (high)	g eq. ethylene	*	7.8E+03
	(a) Acetaldehyde (CH3CHO)	g eq. ethylene	1.22	3.4E-01
	(a) Acetone (CH3COCH3)	g eq. ethylene	0.27	3.3E-02
	(a) Acetylene (C2H2)	g eq. ethylene	0.42	2.5E+00
	(a) Aldehyde (unspecified)	g eq. ethylene	1.263	2.9E-01
	(a) Alkane (unspecified)	g eq. ethylene	1.173	6.0E+02
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	1.285	6.5E+00
	(a) Benzaldehyde (C6H5CHO)	g eq. ethylene	-0.12	-2.5E-07
	(a) Benzene (C6H6)	g eq. ethylene	0.45	3.9E+01
	(a) Butane (n-C4H10)	g eq. ethylene	1.15	3.6E+02
	(a) Butene (1-CH3CH2CHCH2)	g eq. ethylene	1.85	1.5E-01
	(a) Ethane (C2H6)	g eq. ethylene	0.3	1.7E+02
	(a) Ethanol (C2H5OH)	g eq. ethylene	0.89	1.8E-01
	(a) Ethylene (C2H4)	g eq. ethylene	1	2.2E+03
	(a) Formaldehyde (CH2O)	g eq. ethylene	0.58	1.1E+01
	(a) Heptane (C7H16)	g eq. ethylene	1.65	8.8E-01
	(a) Hexane (C6H14)	g eq. ethylene	1.51	1.6E+00
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.799	3.3E+03

Plastics and PCBs recovered: Processing stage

LIFE CYCLE INVENTORY

	(w) Water: Chemically Polluted	litre	8.5E+01
	(w) Xylene (C6H4(CH3)2)	g	2.3E+00
	(w) Zinc (Zn++)	g	1.3E+03
	(wr) Antimony (Sb124)	kBq	3.2E-02
	(wr) Cesium (Cs134)	kBq	2.8E-02
	(wr) Cesium (Cs137)	kBq	4.1E-02
	(wr) Cobalt (Co58)	kBq	9.2E-02
	(wr) Cobalt (Co60)	kBq	5.7E-02
	(wr) Iodine (I131)	kBq	3.5E-03
	(wr) Manganese (Mn54)	kBq	4.6E-03
	(wr) Protactinium (Pa234m)	kBq	1.4E-01
	(wr) Radioactive Substance (unspecified)	kBq	3.8E+02
	(wr) Radium (Ra224)	kBq	8.5E-02
	(wr) Radium (Ra226)	kBq	2.7E+02
	(wr) Radium (Ra228)	kBq	1.7E-01
	(wr) Silver (Ag110m)	kBq	1.4E-01
	(wr) Thorium (Th228)	kBq	3.4E-01
	(wr) Thorium (Th230)	kBq	1.3E+01
	(wr) Thorium (Th234)	kBq	1.4E-01
	(wr) Tritium (H3)	kBq	1.7E+03
	(wr) Uranium (U234)	kBq	4.6E+00
	(wr) Uranium (U235)	kBq	2.0E-01
	(wr) Uranium (U238)	kBq	4.3E+00
	Polypropylene (PP)	kg	7.8E+00
	Printers for resale or reuse	kg	7.1E+03
	Recovered Matter (total)	kg	1.7E+00
	Recovered Matter (unspecified)	kg	1.6E+00
	Recovered Matter: Aluminium	kg	4.5E+02
	Recovered Matter: Cardboard	kg	5.1E+02
	Recovered Matter: Copper Cabling	kg	4.4E+02
	Recovered Matter: Iron Scrap	kg	1.6E-02
	Recovered matter: shredded PCB	kg	4.4E+02
	Recovered Matter: Steel Panels	Kg	8.0E+03
	Recovered Matter: Toner Cartridges	kg	7.5E+01
	Waste (hazardous)	kg	9.3E-02
	Waste (incineration)	kg	3.2E-02
	Waste (municipal and industrial)	kg	1.5E-01
	Waste (total)	kg	2.5E+02
	Waste (unspecified)	kg	1.1E+00
	Waste: Highly Radioactive (class C)	kg	4.1E-03
	Waste: Low Radioactive (class A)	kg	1.5E-01
	Waste: Mineral (inert)	kg	2.1E+02
	Waste: Mining	kg	2.1E+02
	Waste: Non Mineral (inert)	kg	8.9E-03
	Waste: Non Toxic Chemicals (unspecified)	kg	6.3E-02
	Waste: Radioactive (unspecified)	kg	1.7E-03
	Waste: Slags and Ash (unspecified)	kg	3.2E+01

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	(a) Hydrocarbons (unspecified)	g eq. ethylene	0.808	1.2E+02
	(a) Methane (CH4)	g eq. ethylene	0.03	6.7E+02
	(a) Methanol (CH3OH)	g eq. ethylene	0.21	6.8E-02
	(a) Propane (C3H8)	g eq. ethylene	1.24	2.2E+02
	(a) Propionaldehyde (CH3CH2CHO)	g eq. ethylene	1.6	9.3E-06
	(a) Propylene (CH2CHCH3)	g eq. ethylene	1.63	1.1E+01
	(a) Toluene (C6H5CH3)	g eq. ethylene	0.83	3.1E+01
	WMO-Photochemical oxidant formation (low)	g eq. ethylene	*	3.2E+03
	(a) Acetaldehyde (CH3CHO)	g eq. ethylene	0.33	9.1E-02
	(a) Acetone (CH3COCH3)	g eq. ethylene	0.1	1.2E-02
	(a) Acetylene (C2H2)	g eq. ethylene	0.1	6.0E-01
	(a) Aldehyde (unspecified)	g eq. ethylene	0.079	1.8E-02
	(a) Alkane (unspecified)	g eq. ethylene	0.114	5.9E+01
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	0.481	2.4E+00
	(a) Benzaldehyde (C6H5CHO)	g eq. ethylene	-0.82	-1.7E-06
	(a) Benzene (C6H6)	g eq. ethylene	0.11	9.5E+00
	(a) Butane (n-C4H10)	g eq. ethylene	0.15	4.7E+01
	(a) Butene (1-CH3CH2CHCH2)	g eq. ethylene	0.57	4.5E-02
	(a) Ethane (C2H6)	g eq. ethylene	0.02	1.1E+01
	(a) Ethanol (C2H5OH)	g eq. ethylene	0.04	8.0E-03
	(a) Ethylene (C2H4)	g eq. ethylene	1	2.2E+03
	(a) Formaldehyde (CH2O)	g eq. ethylene	0.22	4.2E+00
	(a) Heptane (C7H16)	g eq. ethylene	0.13	6.9E-02
	(a) Hexane (C6H14)	g eq. ethylene	0.1	1.1E-01
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.195	8.0E+02
	(a) Hydrocarbons (unspecified)	g eq. ethylene	0.194	2.9E+01
	(a) Methane (CH4)	g eq. ethylene	0	0.0E+00
	(a) Methanol (CH3OH)	g eq. ethylene	0.09	2.9E-02
	(a) Propane (C3H8)	g eq. ethylene	0.16	2.8E+01
	(a) Propionaldehyde (CH3CH2CHO)	g eq. ethylene	0.28	1.6E-06
	(a) Propylene (CH2CHCH3)	g eq. ethylene	0.75	5.0E+00
	(a) Toluene (C6H5CH3)	g eq. ethylene	0.41	1.5E+01

able resources

100 years)
20 years)
500 years)

er (high)
er (low)
mation (high)
mation (low)

Plastics and PCBs recovered: Processing stage: Product dissasembly

LIFE CYCLE INVENTORY

	Flow	Units	Processing of printers
Inputs:	(r) 1-methoxy propan-2-ol	kg	1.2E-01
	(r) Barium Sulphate (BaSO4, in ground)	kg	7.2E+00
	(r) Bauxite (Al2O3, ore)	kg	2.8E-02
	(r) Bentonite (Al2O3.4SiO2.H2O, in ground)	kg	6.8E-01
	(r) Calcium Sulphate (CaSO4, ore)	kg	1.9E-02
	(r) Chromium (Cr, ore)	kg	1.4E-03
	(r) Clay (in ground)	kg	1.7E+00
	(r) Coal (in ground)	kg	6.8E+02
	(r) Commercial butane	g	1.7E+02
	(r) Copper (Cu, ore)	kg	7.0E-03
	(r) Gravel (unspecified)	kg	2.6E+00
	(r) Iron (Fe, ore)	kg	2.2E+01
	(r) Iron Sulphate (FeSO4, ore)	kg	2.1E-02
	(r) Kerosine	kg	1.0E-01
	(r) Lead (Pb, ore)	kg	2.2E-03
	(r) Lignite (in ground)	kg	1.1E+01
	(r) Limestone (CaCO3, in ground)	kg	1.1E+01
	(r) Manganese (Mn, ore)	kg	8.1E-04
	(r) Natural Gas (in ground)	kg	4.4E+03
	(r) Nickel (Ni, ore)	kg	4.7E-04
	(r) Oil (in ground)	kg	4.3E+01
	(r) Propan-2-ol	kg	9.8E-02
	(r) Pyrite (FeS2, ore)	kg	1.2E+01
	(r) Sand (in ground)	kg	2.7E-01
	(r) Silver (Ag, ore)	kg	3.5E-05
	(r) Sodium Chloride (NaCl, in ground or in sea)	kg	6.7E-01
	(r) Uranium (U, ore)	kg	3.1E-02
	(r) Water	kg	2.1E+00
	(r) Zinc (Zn, ore)	kg	5.1E-05
	Explosive (unspecified)	kg	2.5E-01
	Iron Scrap	kg	1.7E-01
	Land Use (II -> III)	m2a	2.8E+00
	Land Use (II -> IV)	m2a	3.8E-01
	Land Use (III -> IV)	m2a	1.3E-01
	Raw Materials (unspecified)	kg	1.0E+00
	Traded-in printers	kg	2.2E+04
	Water Used (total)	litre	5.6E+03
	Water: Unspecified Origin	litre	5.6E+03
	Wood	kg	2.3E-01
	Wood (standing)	m3	4.3E-03
Outputs:	(a) 1-methoxy propan-2-ol	kg	1.2E-01
	(a) Acetaldehyde (CH3CHO)	g	2.8E-01
	(a) Acetic Acid (CH3COOH)	g	2.7E+01
	(a) Acetone (CH3COCH3)	g	1.2E-01
	(a) Acetylene (C2H2)	g	5.9E+00
	(a) Aldehyde (unspecified)	g	2.3E-01
	(a) Alkane (unspecified)	g	5.1E+02
	(a) Alkene (unspecified)	g	7.1E+00
	(a) Alkyne (unspecified)	g	1.2E-02
	(a) Aluminium (Al)	g	1.1E+02
	(a) Ammonia (NH3)	g	2.6E+00
	(a) Antimony (Sb)	g	2.2E-02
	(a) AOX (Adsorbable Organic Halogens)	g	9.5E-11
	(a) Aromatic Hydrocarbons (unspecified)	g	8.8E-02
	(a) Arsenic (As)	g	2.3E-01
	(a) Barium (Ba)	g	1.4E+00
	(a) Benzaldehyde (C6H5CHO)	g	2.1E-06
	(a) Benzene (C6H6)	g	7.9E+01
	(a) Benzo(a)pyrene (C20H12)	g	2.1E-02
	(a) Beryllium (Be)	g	2.2E-02
	(a) Boron (B)	g	1.1E+01
	(a) Bromium (Br)	g	2.2E+00
	(a) Butane (n-C4H10)	g	3.1E+02
	(a) Butene (1-CH3CH2CHCH2)	g	7.9E-02
	(a) Cadmium (Cd)	g	4.1E-02
	(a) Calcium (Ca)	g	1.5E+01
	(a) Carbon Dioxide (CO2, fossil)	g	1.2E+07
	(a) Carbon Monoxide (CO)	g	4.9E+03
	(a) Carbon Tetrafluoride (CF4)	g	1.7E-03
	(a) Chlorine (Cl2)	g	6.2E-06
	(a) Chromium (Cr III, Cr VI)	g	3.0E-01
	(a) Cobalt (Co)	g	6.0E-02
	(a) Copper (Cu)	g	2.4E-01
	(a) Cyanide (CN-)	g	3.6E-02
	(a) Dioxins (unspecified)	g	3.0E-07
	(a) Ethane (C2H6)	g	5.7E+02
	(a) Ethanol (C2H5OH)	g	2.0E-01
	(a) Ethylbenzene (C8H10)	g	7.9E-02
	(a) Ethylene (C2H4)	g	2.2E+03
	(a) Fluorides (F-)	g	6.6E-04
	(a) Fluorine (F2)	g	4.1E-04
	(a) Formaldehyde (CH2O)	g	1.9E+01
	(a) Halogenated Matter (unspecified)	g	1.3E-12
	(a) Halon 1301 (CF3Br)	g	8.3E-03
	(a) Heptane (C7H16)	g	5.3E-01
	(a) Hexane (C6H14)	g	1.1E+00
	(a) Hydrocarbons (except methane)	g	2.6E+03
	(a) Hydrocarbons (unspecified)	g	1.5E+02
	(a) Hydrogen (H2)	g	2.6E-05
	(a) Hydrogen Chloride (HCl)	g	5.5E+02
	(a) Hydrogen Fluoride (HF)	g	2.0E+01
	(a) Hydrogen Sulphide (H2S)	g	8.3E+01
	(a) Iodine (I)	g	5.5E-01
	(a) Iron (Fe)	g	4.7E+01
	(a) Kerosine	kg	1.1E-01
	(a) lanthanum (La)	g	3.6E-02
	(a) Lead (Pb)	g	1.1E+00
	(a) Magnesium (Mg)	g	4.0E+01
	(a) Manganese (Mn)	g	1.2E+00
	(a) Mercury (Hg)	g	6.8E-02
	(a) Metals (unspecified)	g	7.9E-02
	(a) Methane (CH4)	g	1.6E+04
	(a) Methanol (CH3OH)	g	3.2E-01
	(a) Molybdenum (Mo)	g	5.4E-02
	(a) Nickel (Ni)	g	8.1E-01
	(a) Nitrogen Oxides (NOx as NO2)	g	1.3E+04
	(a) Nitrous Oxide (N2O)	g	3.9E+01
	(a) Organic Matter (unspecified)	g	3.1E-01
	(a) Particulates (unspecified)	g	1.0E+03
	(a) Pentane (C5H12)	g	2.2E+02
	(a) Phenol (C6H5OH)	g	1.6E-05
	(a) Phosphorus (P)	g	1.0E+00
	(a) Phosphorus Pentoxide (P2O5)	g	6.8E-04
	(a) Polycyclic Aromatic Hydrocarbons (PAH, unspecified)	g	1.8E+00
	(a) Potassium (K)	g	1.7E+01
	(a) Propan-2-ol	kg	9.8E-02
	(a) Propane (C3H8)	g	1.8E+02
	(a) Propionaldehyde (CH3CH2CHO)	g	5.8E-06
	(a) Propionic Acid (CH3CH2COOH)	g	7.7E-03
	(a) Propylene (CH2CHCH3)	g	6.6E+00
	(a) Scandium (Sc)	g	1.2E-02

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	Classification	Units	Charact-erisation	Environmental impacts
Methods:	CML-Air Acidification	g eq. H+	/	5.8E+02
	(a) Ammonia (NH3)	g eq. H+	17	1.5E-01
	(a) Hydrogen Chloride (HCl)	g eq. H+	36.5	1.5E+01
	(a) Hydrogen Fluoride (HF)	g eq. H+	20	1.0E+00
	(a) Hydrogen Sulphide (H2S)	g eq. H+	17	4.9E+00
	(a) Nitrogen Oxides (NOx as NO2)	g eq. H+	46	2.7E+02
	(a) Sulphur Oxides (SOx as SO2)	g eq. H+	32	2.9E+02
	CML-Eutrophication	g eq. PO4	*	1.7E+03
	(a) Nitrogen Oxides (NOx as NO2)	g eq. PO4	0.13	1.6E+03
	(a) Nitrous Oxide (N2O)	g eq. PO4	0.27	1.0E+01
	(w) Ammonia (NH4+, NH3, as N)	g eq. PO4	0.42	4.5E+00
	(w) COD (Chemical Oxygen Demand)	g eq. PO4	0.022	1.6E+00
	(w) Nitrogenous Matter (Kjeldahl, as N)	g eq. PO4	0.42	1.4E-01
	(w) Nitrogenous Matter (unspecified, as N)	g eq. PO4	0.42	9.9E-01
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g eq. PO4	3.06	1.9E+00
	(w) Phosphorus (P)	g eq. PO4	3.06	1.0E-01
	(w) Phosphorus Pentoxide (P2O5)	g eq. PO4	1.336	2.7E-02
	CST-Aquatic Eco-toxicity	eq. Zn water	*	7.7E+01
	(a) Arsenic (As)	eq. Zn water	0.078	1.8E-02
	(a) Cadmium (Cd)	eq. Zn water	79	3.2E+00
	(a) Chromium (Cr III, Cr VI)	eq. Zn water	0.39	1.2E-01
	(a) Copper (Cu)	eq. Zn water	0.66	1.6E-01
	(a) Lead (Pb)	eq. Zn water	1.28	1.4E+00
	(a) Mercury (Hg)	eq. Zn water	196	1.3E+01
	(a) Nickel (Ni)	eq. Zn water	0.12	9.7E-02
	(a) Zinc (Zn)	eq. Zn water	0.076	9.7E-02
	(s) Arsenic (As)	eq. Zn water	0.24	8.8E-03
	(s) Cadmium (Cd)	eq. Zn water	240	4.0E-03
	(s) Chromium (Cr III, Cr VI)	eq. Zn water	1.2	5.5E-01
	(s) Copper (Cu)	eq. Zn water	2	1.7E-04
	(s) Lead (Pb)	eq. Zn water	3.9	1.5E-03
	(s) Mercury (Hg)	eq. Zn water	600	1.8E-03
	(s) Nickel (Ni)	eq. Zn water	0.36	4.6E-05
	(s) Zinc (Zn)	eq. Zn water	0.23	3.2E-01
	(w) Arsenic (As3+, As5+)	eq. Zn water	0.52	5.3E-02
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Zn water	0.00013	8.2E-04
	(w) Cadmium (Cd++)	eq. Zn water	520	4.5E+00
	(w) Chromium (Cr III, Cr VI)	eq. Zn water	2.6	8.1E-02
	(w) Copper (Cu+, Cu++)	eq. Zn water	5.2	1.1E+00
	(w) Lead (Pb++, Pb4+)	eq. Zn water	5.2	6.1E+00
	(w) Mercury (Hg+, Hg++)	eq. Zn water	1300	1.5E-02
	(w) Nickel (Ni++, Ni3+)	eq. Zn water	0.79	2.3E-01
	(w) Oils (unspecified)	eq. Zn water	0.13	2.4E+01
	(w) Phenol (C6H5OH)	eq. Zn water	15.4	1.9E+01
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Zn water	0.01	6.1E-03
	(w) Zinc (Zn++)	eq. Zn water	1	1.8E+00
	CST-Human Toxicity	eq. Pb air	*	2.9E+04
	(a) Aldehyde (unspecified)	eq. Pb air	0.0087	2.0E-03
	(a) Arsenic (As)	eq. Pb air	9000	2.1E+03
	(a) Benzene (C6H6)	eq. Pb air	0.012	9.5E-01
	(a) Cadmium (Cd)	eq. Pb air	19000	7.8E+02
	(a) Carbon Monoxide (CO)	eq. Pb air	0.00014	6.9E-01
	(a) Chromium (Cr III, Cr VI)	eq. Pb air	3700	1.1E+03
	(a) Cobalt (Co)	eq. Pb air	12900	7.8E+02
	(a) Copper (Cu)	eq. Pb air	145	3.5E+01
	(a) Formaldehyde (CH2O)	eq. Pb air	0.0099	1.9E-01
	(a) Lead (Pb)	eq. Pb air	2300	2.5E+03
	(a) Mercury (Hg)	eq. Pb air	46000	3.1E+03
	(a) Nickel (Ni)	eq. Pb air	370	3.0E+02
	(a) Nitrogen Oxides (NOx as NO2)	eq. Pb air	0.002	2.5E+01
	(a) Particulates (unspecified)	eq. Pb air	0.0075	7.5E+00
	(a) Selenium (Se)	eq. Pb air	64000	1.8E+04
	(a) Sulphur Oxides (SOx as SO2)	eq. Pb air	0.0075	6.9E+01
	(a) Tin (Sn)	eq. Pb air	9	6.5E-02
	(a) Zinc (Zn)	eq. Pb air	27	3.5E+01
	(s) Arsenic (As)	eq. Pb air	0.7	2.6E-02
	(s) Cadmium (Cd)	eq. Pb air	1.46	2.4E-05
	(s) Chromium (Cr III, Cr VI)	eq. Pb air	0.29	1.3E-01
	(s) Cobalt (Co)	eq. Pb air	1	1.7E-05
	(s) Copper (Cu)	eq. Pb air	0.009	7.6E-07
	(s) Lead (Pb)	eq. Pb air	0.6	2.3E-04
	(s) Mercury (Hg)	eq. Pb air	3.6	1.1E-05
	(s) Nickel (Ni)	eq. Pb air	0.029	3.7E-06
	(s) Zinc (Zn)	eq. Pb air	0.0007	9.7E-04
	(w) Arsenic (As3+, As5+)	eq. Pb air	1.5	1.5E-01
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Pb air	0.022	1.4E-01
	(w) Cadmium (Cd++)	eq. Pb air	3.2	2.8E-02
	(w) Chromium (Cr III, Cr VI)	eq. Pb air	0.62	1.9E-02
	(w) Cobalt (Co I, Co II, Co III)	eq. Pb air	2.2	1.3E-01
	(w) Copper (Cu+, Cu++)	eq. Pb air	0.022	4.8E-03
	(w) Fluorides (F-)	eq. Pb air	0.045	5.9E-01
	(w) Lead (Pb++, Pb4+)	eq. Pb air	0.86	1.0E+00
	(w) Mercury (Hg+, Hg++)	eq. Pb air	7.8	9.1E-05
	(w) Nickel (Ni++, Ni3+)	eq. Pb air	0.062	1.8E-02
	(w) Phenol (C6H5OH)	eq. Pb air	0.052	6.5E-02
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Pb air	3.20E-06	2.0E-06
	(w) Selenium (Se II, Se IV, Se VI)	eq. Pb air	10.9	6.0E-01
	(w) Tin (Sn++, Sn4+)	eq. Pb air	0.0015	2.9E-07
	(w) Zinc (Zn++)	eq. Pb air	0.0032	5.7E-03
	CST-Terrestrial Eco-toxicity	eq. Zn air	*	3.2E+00
	(a) Arsenic (As)	eq. Zn air	0.75	1.8E-01
	(a) Cadmium (Cd)	eq. Zn air	3.14	1.3E-01
	(a) Chromium (Cr III, Cr VI)	eq. Zn air	0.08	2.4E-02
	(a) Cobalt (Co)	eq. Zn air	0.08	4.8E-03
	(a) Copper (Cu)	eq. Zn air	0.14	3.4E-02
	(a) Lead (Pb)	eq. Zn air	0.13	1.4E-01
	(a) Mercury (Hg)	eq. Zn air	5.94	4.0E-01
	(a) Nickel (Ni)	eq. Zn air	0.35	2.8E-01
	(a) Zinc (Zn)	eq. Zn air	0.33	4.2E-01
	(s) Arsenic (As)	eq. Zn air	2.3	8.4E-02
	(s) Cadmium (Cd)	eq. Zn air	9.6	1.6E-04
	(s) Chromium (Cr III, Cr VI)	eq. Zn air	0.26	1.2E-01
	(s) Cobalt (Co)	eq. Zn air	0.26	4.4E-06
	(s) Copper (Cu)	eq. Zn air	0.42	3.5E-05
	(s) Lead (Pb)	eq. Zn air	0.41	1.6E-04
	(s) Mercury (Hg)	eq. Zn air	18.3	5.6E-05
	(s) Nickel (Ni)	eq. Zn air	1.1	1.4E-04
	(s) Zinc (Zn)	eq. Zn air	1	1.4E+00
	EB(R*Y)-Depletion of non renewable resources	yr-1	*	7.3E+02
	(r) Barium Sulphate (BaSO4, in ground)	yr-1	26.91	1.9E+02
	(r) Bauxite (Al2O3, ore)	yr-1	0.108	3.0E-03
	(r) Chromium (Cr, ore)	yr-1	0.2133	3.0E-04
	(r) Chromium (Cr, ore)	yr-1	0.319	4.4E-04
	(r) Coal (in ground)	yr-1	0.0005037	3.4E-01
	(r) Copper (Cu, ore)	yr-1	28.16	2.0E-01
	(r) Iron (Fe, ore)	yr-1	0.04	9.0E-01
	(r) Lead (Pb, ore)	yr-1	157	3.5E-01
	(r) Lignite (in ground)	yr-1	0.0005037	5.7E-03
	(r) Manganese (Mn, ore)	yr-1	0.296	2.4E-04
	(r) Natural Gas (in ground)	yr-1	0.117	5.2E+02
	(r) Nickel (Ni, ore)	yr-1	59.7	2.8E-02

Plastics and PCBs recovered: Processing stage: Product dissasembly

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	(a) Selenium (Se)	g	2.9E-01
	(a) Silicon (Si)	g	1.7E+02
	(a) Sodium (Na)	g	7.4E+00
	(a) Strontium (Sr)	g	2.2E+00
	(a) Sulphur Oxides (SOx as SO2)	g	9.1E+03
	(a) Tars (unspecified)	g	6.8E-07
	(a) Thallium (Tl)	g	1.1E-02
	(a) Thorium (Th)	g	2.3E-02
	(a) Tin (Sn)	g	7.2E-03
	(a) Titanium (Ti)	g	4.0E+00
	(a) Toluene (C6H5CH3)	g	3.8E+01
	(a) Uranium (U)	g	2.2E-02
	(a) Vanadium (V)	g	2.2E+00
	(a) Water vapour	kg	2.1E+00
	(a) Xylene (C6H4(CH3)2)	g	1.4E+00
	(a) Zinc (Zn)	g	1.3E+00
	(a) Zirconium (Zr)	g	1.7E-02
	(ar) Aerosols and Halogenes (unspecified)	kBq	4.1E-02
	(ar) Carbon (C14)	kBq	1.4E+01
	(ar) Cesium (Cs134)	kBq	5.3E-04
	(ar) Cesium (Cs137)	kBq	5.3E-04
	(ar) Cobalt (Co58)	kBq	5.3E-04
	(ar) Cobalt (Co60)	kBq	5.3E-04
	(ar) Gas (unspecified)	kBq	1.3E+03
	(ar) Iodine (I131)	kBq	3.1E-03
	(ar) Iodine (I133)	kBq	6.0E-03
	(ar) Krypton (Kr85)	kBq	8.0E+01
	(ar) Lead (Pb210)	kBq	5.3E-01
	(ar) Polonium (Po210)	kBq	9.2E-01
	(ar) Potassium (K40)	kBq	1.4E-01
	(ar) Protactinium (Pa234m)	kBq	7.5E-03
	(ar) Radioactive Substance (unspecified)	kBq	4.1E-03
	(ar) Radium (Ra226)	kBq	6.5E-01
	(ar) Radium (Ra228)	kBq	7.0E-02
	(ar) Radon (Rn220)	kBq	2.2E+00
	(ar) Radon (Rn222)	kBq	6.3E+04
	(ar) Thorium (Th228)	kBq	5.9E-02
	(ar) Thorium (Th230)	kBq	1.1E-01
	(ar) Thorium (Th232)	kBq	3.8E-02
	(ar) Thorium (Th234)	kBq	7.5E-03
	(ar) Tritium (H3)	kBq	1.6E+02
	(ar) Uranium (U234)	kBq	1.9E-01
	(ar) Uranium (U235)	kBq	1.4E-03
	(ar) Uranium (U238)	kBq	3.2E-01
	(ar) Xenon (Xe133)	kBq	1.1E+03
	(s) Aluminium (Al)	g	9.2E+01
	(s) Arsenic (As)	g	3.7E-02
	(s) Cadmium (Cd)	g	1.7E-05
	(s) Calcium (Ca)	g	3.7E+02
	(s) Carbon (C)	g	2.8E+02
	(s) Chromium (Cr III, Cr VI)	g	4.6E-01
	(s) Cobalt (Co)	g	1.7E-05
	(s) Copper (Cu)	g	8.4E-05
	(s) Iron (Fe)	g	1.8E+02
	(s) Lead (Pb)	g	3.9E-04
	(s) Manganese (Mn)	g	3.7E+00
	(s) Mercury (Hg)	g	3.1E-06
	(s) Nickel (Ni)	g	1.3E-04
	(s) Nitrogen (N)	g	1.4E-03
	(s) Oils (unspecified)	g	5.5E-01
	(s) Phosphorus (P)	g	4.6E+00
	(s) Sulphur (S)	g	5.5E+01
	(s) Zinc (Zn)	g	1.4E+00
	(sr) Americium (Am241)	kBq	1.4E+02
	(sr) Americium (Am243)	kBq	3.0E+00
	(sr) Cesium (Cs135)	kBq	6.8E+04
	(sr) Cesium (Cs137)	kBq	1.9E-01
	(sr) Curium (Cm244)	kBq	2.8E+02
	(sr) Curium (Cm245)	kBq	3.1E-02
	(sr) Iodine (I129)	kBq	4.4E-03
	(sr) Neptunium (Np237)	kBq	4.4E+01
	(sr) Palladium (Pd107)	kBq	1.5E-02
	(sr) Plutonium (Pu239)	kBq	5.3E+04
	(sr) Plutonium (Pu240)	kBq	7.5E+04
	(sr) Plutonium (Pu241)	kBq	1.7E+07
	(sr) Plutonium (Pu242)	kBq	2.8E+02
	(sr) Radium (Ra226)	kBq	3.6E+02
	(sr) Samarium (Sm151)	kBq	6.3E+01
	(sr) Selenium (Se79)	kBq	4.9E-02
	(sr) Strontium (Sr90)	kBq	1.0E+04
	(sr) Technetium (Tc99)	kBq	2.1E+00
	(sr) Thorium (Th230)	kBq	3.6E+02
	(sr) Tin (Sn126)	kBq	8.5E-02
	(sr) Uranium (U234)	kBq	2.2E+02
	(sr) Uranium (U235)	kBq	4.0E+00
	(sr) Uranium (U238)	kBq	6.2E+01
	(sr) Zirconium (Zr93)	kBq	2.7E-01
	(w) Acids (H+)	g	9.3E-01
	(w) Alcohol (unspecified)	g	5.5E-02
	(w) Aldehyde (unspecified)	g	3.9E-02
	(w) Alkane (unspecified)	g	1.2E+00
	(w) Alkene (unspecified)	g	1.1E-01
	(w) Aluminium (Al3+)	g	5.6E+01
	(w) Aluminium Hydroxide (Al(OH)3)	g	6.4E-04
	(w) Ammonia (NH4+, NH3, as N)	g	1.1E+01
	(w) AOX (Adsorbable Organic Halogens)	g	6.8E-03
	(w) Aromatic Hydrocarbons (unspecified)	g	8.2E+00
	(w) Arsenic (As3+, As5+)	g	1.0E-01
	(w) Barium (Ba++)	g	1.1E+01
	(w) Barytes	g	1.3E+03
	(w) Benzene (C6H6)	g	1.2E+00
	(w) BOD5 (Biochemical Oxygen Demand)	g	6.3E+00
	(w) Boric Acid (H3BO3)	g	8.2E-01
	(w) Boron (B III)	g	1.6E-01
	(w) Cadmium (Cd++)	g	8.6E-03
	(w) Calcium (Ca++)	g	4.5E+02
	(w) Carbonates (CO3--, HCO3-, CO2, as C)	g	1.0E+00
	(w) Cesium (Cs++)	g	1.7E-03
	(w) Chlorides (Cl-)	g	8.0E+03
	(w) Chlorinated Matter (unspecified, as Cl)	g	2.1E+02
	(w) Chloroform (CHCl3)	g	2.2E-04
	(w) Chromium (Cr III)	g	9.7E-01
	(w) Chromium (Cr III, Cr VI)	g	3.1E-02
	(w) Chromium (Cr VI)	g	1.8E-05
	(w) Cobalt (Co I, Co II, Co III)	g	6.0E-02
	(w) COD (Chemical Oxygen Demand)	g	7.3E+01
	(w) Copper (Cu+, Cu++)	g	2.2E-01
	(w) Cyanides (CN-)	g	9.5E-01
	(w) Dissolved Matter (unspecified)	g	4.6E+02
	(w) Dissolved Organic Carbon (DOC)	g	7.3E+01
	(w) Edetic Acid (C10H16N2O8, EDTA)	g	1.4E-03
	(w) Ethylbenzene (C6H5C2H5)	g	5.5E-02
	(w) Fluorides (F-)	g	1.3E+01

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	(r) Oil (in ground)	yr-1	0.0557	2.4E+00
	(r) Silver (Ag, ore)	yr-1	92837	3.2E+00
	(r) Uranium (U, ore)	yr-1	181	5.6E+00
	(r) Zinc (Zn, ore)	yr-1	40.29	2.1E-03
	ETH-Air Acidification	g eq. H+	/	5.8E+02
	(a) Ammonia (NH3)	g eq. H+	17	1.5E-01
	(a) Hydrogen Chloride (HCl)	g eq. H+	36.5	1.5E+01
	(a) Hydrogen Fluoride (HF)	g eq. H+	20	1.0E+00
	(a) Hydrogen Sulphide (H2S)	g eq. H+	17	4.9E+00
	(a) Nitrogen Oxides (NOx as NO2)	g eq. H+	46	2.7E+02
	(a) Sulphur Oxides (SOx as SO2)	g eq. H+	32	2.9E+02
	IPCC-Greenhouse effect (direct, 100 years)	g eq. CO2	*	1.2E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	1.2E+07
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	5700	9.7E+00
	(a) Halon 1301 (CF3Br)	g eq. CO2	6900	5.7E+01
	(a) Methane (CH4)	g eq. CO2	24	3.7E+05
	(a) Nitrous Oxide (N2O)	g eq. CO2	360	1.4E+04
	IPCC-Greenhouse effect (direct, 20 years)	g eq. CO2	*	1.3E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	1.2E+07
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	3900	6.6E+00
	(a) Halon 1301 (CF3Br)	g eq. CO2	7900	6.6E+01
	(a) Methane (CH4)	g eq. CO2	64	1.0E+06
	(a) Nitrous Oxide (N2O)	g eq. CO2	330	1.3E+04
	IPCC-Greenhouse effect (direct, 500 years)	g eq. CO2	*	1.2E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	1.2E+07
	(a) Carbon Tetrafluoride (CF4)	g eq. CO2	8900	1.5E+01
	(a) Halon 1301 (CF3Br)	g eq. CO2	2700	2.2E+01
	(a) Methane (CH4)	g eq. CO2	7.5	1.2E+05
	(a) Nitrous Oxide (N2O)	g eq. CO2	190	7.4E+03
	USES 1.0-Aquatic Ecotoxicity	g eq. 1-4-dichlorobenzene	*	1.5E+03
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	5.6	1.3E+00
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.0013	1.0E-01
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	320	6.7E+00
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130	5.3E+00
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	2.6	1.6E-01
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	2.9	7.0E-01
	(a) Ethylene (C2H4)	g eq. 1-4-dichlorobenzene	0.0022	4.9E+00
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	6.1	1.2E+02
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.2	1.3E+00
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	16000	1.1E+03
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	80	6.4E+01
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	39	6.3E-04
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	9.70E-05	3.6E-03
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	11	2.4E+01
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	2.6	3.3E+00
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	3.00E-08	1.1E-09
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	3.90E-06	6.5E-11
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.40E-09	6.4E-10
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	6.80E-08	1.2E-12
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	1.40E-08	1.2E-12
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.80E-09	6.9E-13
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	16000	4.9E-02
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	5.80E-07	7.4E-11
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	3.90E-08	5.4E-08
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	190	1.9E+01
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	1	1.2E+00
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	4500	3.9E+01
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	0.7	1.6E-04
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	84	8.1E+01
	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	84	2.6E+00
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	84	1.5E-03
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	160	4.5E-04
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	0.021	1.3E-02
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	1.1	1.1E-06
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	0.18	3.9E-07
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.16	9.5E-06
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	380	8.0E+01
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.86	1.5E+00
	USES 1.0-Human Toxicity	g eq. 1-4-dichlorobenzene	*	1.1E+05
	(a) Ammonia (NH3)	g eq. 1-4-dichlorobenzene	16	4.1E+01
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	42000	9.8E+03
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	29	2.3E+03
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	3700	7.7E+01
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	23000	9.4E+02
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	7600	4.6E+02
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	350	8.4E+01
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	0.42	8.0E+00
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	67000	7.2E+04
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	29000	2.0E+03
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	9800	7.9E+03
	(a) Nitrogen Oxides (NOx as NO2)	g eq. 1-4-dichlorobenzene	0.26	3.3E+03
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	2.2	3.6E-05
	(a) Sulphur Oxides (SOx as SO2)	g eq. 1-4-dichlorobenzene	0.16	1.5E+03
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.036	1.4E+00
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	4900	1.1E+04
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	0.63	8.1E-01
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	670	2.5E+01
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	20000	3.3E-01
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	1500	2.5E-02
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	30	2.5E-03
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	350	1.4E-01
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	29000	8.9E-02
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	800	1.0E-01
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	12	1.7E+01
	(w) Ammonia (NH4+, NH3, as N)	g eq. 1-4-dichlorobenzene	17	1.8E+02
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	51	5.2E+00
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	22	2.7E+01
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	130	1.1E+00
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	32	7.1E-03
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	9.3	9.0E+00
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	67000	1.2E+00
	(w) Cobalt (Co I, Co II, Co III)	g eq. 1-4-dichlorobenzene	31	1.8E+00
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.1	2.4E-01
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	0.35	9.9E-07
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	0.026	3.0E-02
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	18000	2.1E-01
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	12	7.6E+00
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	63	1.8E+01
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	0.89	1.1E+00
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	37	3.5E-05
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.053	5.8E-02
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	1200	2.6E-03
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.11	6.5E-06
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	19	4.0E+00
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.058	1.0E-01
	USES 1.0-Terrestrial Ecotoxicity	g eq. 1-4-dichlorobenzene	*	1.3E+07
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	72000	1.7E+04
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.063	5.0E+00
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	64000000	1.3E+06
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130000000	5.3E+06
	(a) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	220000	6.7E+04
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	17000	1.0E+03
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	910000	2.2E+05

Plastics and PCBs recovered: Processing stage: Product dissasembly

LIFE CYCLE INVENTORY

	(w) Formaldehyde (CH2O)	g	2.8E-06
	(w) Hexachloroethane (C2Cl6)	g	3.9E-10
	(w) Hydrazine (N2H4)	g	6.4E-04
	(w) Hydrocarbons (unspecified)	g	2.4E+00
	(w) Hypochlorite (ClO-)	g	6.7E-02
	(w) Hypochlorous Acid (HClO)	g	6.7E-02
	(w) Inorganic Dissolved Matter (unspecified)	g	7.3E-02
	(w) Iode (I-)	g	1.8E-01
	(w) Iron (Fe++, Fe3+)	g	5.6E+01
	(w) Lead (Pb++, Pb4+)	g	1.2E+00
	(w) Lithium Salts (Lithine)	g	7.2E-05
	(w) Magnesium (Mg++)	g	4.2E+01
	(w) Manganese (Mn II, Mn IV, Mn VII)	g	3.2E+00
	(w) Mercury (Hg+, Hg++)	g	1.2E-05
	(w) Metals (unspecified)	g	2.5E+00
	(w) Methylene Chloride (CH2Cl2)	g	6.4E-01
	(w) Molybdenum (Mo II, Mo III, Mo IV, Mo V, Mo VI)	g	6.3E-02
	(w) Morpholine (C4H9NO)	g	6.8E-03
	(w) Nickel (Ni++, Ni3+)	g	2.9E-01
	(w) Nitrates (NO3-)	g	2.6E+00
	(w) Nitrites (NO2-)	g	1.7E-02
	(w) Nitrogenous Matter (Kjeldahl, as N)	g	3.2E-01
	(w) Nitrogenous Matter (unspecified, as N)	g	2.4E+00
	(w) Oils (unspecified)	g	1.9E+02
	(w) Organic Dissolved Matter (unspecified)	g	2.9E-01
	(w) Oxalic Acid ((COOH)2)	g	2.8E-03
	(w) Phenol (C6H5OH)	g	1.2E+00
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g	6.1E-01
	(w) Phosphorus (P)	g	3.3E-02
	(w) Phosphorus Pentoxide (P2O5)	g	2.0E-02
	(w) Polycyclic Aromatic Hydrocarbons (PAH, unspecified)	g	3.7E-02
	(w) Potassium (K+)	g	3.5E+01
	(w) Rubidium (Rb+)	g	1.7E-02
	(w) Salts (unspecified)	g	3.7E+01
	(w) Saponifiable Oils and Fats	g	8.2E+00
	(w) Selenium (Se II, Se IV, Se VI)	g	5.5E-02
	(w) Silicon Dioxide (SiO2)	g	2.3E-01
	(w) Silver (Ag+)	g	1.0E-03
	(w) Sodium (Na+)	g	1.4E+03
	(w) Strontium (Sr II)	g	1.7E+01
	(w) Sulphates (SO4--)	g	2.5E+03
	(w) Sulphides (S--)	g	5.1E-02
	(w) Sulphites (SO3--)	g	3.2E-03
	(w) Sulphurated Matter (unspecified, as S)	g	2.5E-05
	(w) Suspended Matter (unspecified)	g	4.6E+03
	(w) Tars (unspecified)	g	9.7E-09
	(w) Tetrachloroethylene (C2Cl4)	g	9.6E-07
	(w) Tin (Sn++, Sn4+)	g	1.9E-04
	(w) Titanium (Ti3+, Ti4+)	g	2.4E+00
	(w) TOC (Total Organic Carbon)	g	1.1E+03
	(w) Toluene (C6H5CH3)	g	1.1E+00
	(w) Trichlorethane (1,1,1-CH3CCl3)	g	2.2E-06
	(w) Trichloroethylene (C2HCl3)	g	5.9E-05
	(w) Triethylene Glycol (C6H14O4)	g	7.3E+01
	(w) Vanadium (V3+, V5+)	g	2.1E-01
	(w) VOC (Volatile Organic Compounds)	g	5.9E-01
	(w) Water (unspecified)	litre	6.4E+02
	(w) Water: Chemically Polluted	litre	8.4E+01
	(w) Xylene (C6H4(CH3)2)	g	2.3E+00
	(w) Zinc (Zn++)	g	1.8E+00
	(wr) Antimony (Sb124)	kBq	3.1E-02
	(wr) Cesium (Cs134)	kBq	2.8E-02
	(wr) Cesium (Cs137)	kBq	4.0E-02
	(wr) Cobalt (Co58)	kBq	9.1E-02
	(wr) Cobalt (Co60)	kBq	5.7E-02
	(wr) Iodine (I131)	kBq	3.4E-03
	(wr) Manganese (Mn54)	kBq	4.5E-03
	(wr) Protactinium (Pa234m)	kBq	1.4E-01
	(wr) Radioactive Substance (unspecified)	kBq	3.8E-05
	(wr) Radium (Ra224)	kBq	8.4E-02
	(wr) Radium (Ra226)	kBq	2.6E+02
	(wr) Radium (Ra228)	kBq	1.7E-01
	(wr) Silver (Ag110m)	kBq	1.4E-01
	(wr) Thorium (Th228)	kBq	3.4E-01
	(wr) Thorium (Th230)	kBq	1.3E+01
	(wr) Thorium (Th234)	kBq	1.4E-01
	(wr) Tritium (H3)	kBq	1.6E+03
	(wr) Uranium (U234)	kBq	4.6E+00
	(wr) Uranium (U235)	kBq	2.0E-01
	(wr) Uranium (U238)	kBq	4.3E+00
	Mixed plastics (shredded)	kg	4.6E+03
	Polypropylene (PP)	kg	7.8E+00
	Printers for resale or reuse	kg	7.1E+03
	Recovered Matter (total)	kg	1.6E+00
	Recovered Matter (unspecified)	kg	1.6E+00
	Recovered Matter: Cardboard	kg	5.1E+02
	Recovered Matter: Copper Cabling	kg	4.4E+02
	Recovered Matter: Iron Scrap	kg	1.6E-02
	Recovered Matter: Printer Circuit Boards	kg	9.4E+02
	Recovered Matter: Steel and Aluminium	kg	8.4E+03
	Recovered Matter: Toner Cartridges	kg	7.5E+01
	Waste (hazardous)	kg	9.2E-02
	Waste (incineration)	kg	3.2E-02
	Waste (municipal and industrial)	kg	1.5E-01
	Waste (total)	kg	2.4E+02
	Waste (unspecified)	kg	1.1E+00
	Waste: Highly Radioactive (class C)	kg	4.0E-03
	Waste: Inkjet cartridges	kg	5.0E+01
	Waste: Low Radioactive (class A)	kg	1.5E-01
	Waste: Mineral (inert)	kg	2.1E+02
	Waste: Mining	kg	2.1E+02
	Waste: Non Mineral (inert)	kg	8.8E-03
	Waste: Non Toxic Chemicals (unspecified)	kg	6.3E-02
	Waste: Radioactive (unspecified)	kg	1.6E-03
	Waste: Slags and Ash (unspecified)	kg	3.2E+01

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	(a) Ethylene (C2H4)	g eq. 1-4-dichlorobenzene	17	3.8E+04
	(a) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	2600	4.9E+04
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	11000	1.2E+04
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	13000000	8.8E+05
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	190000	1.5E+05
	(a) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	11000	1.8E-01
	(a) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.035	1.3E+00
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	450000	9.9E+05
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	660000	8.5E+05
	(s) Arsenic (As)	g eq. 1-4-dichlorobenzene	200000	7.3E+03
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	340000000	5.7E+03
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	600000	2.8E+05
	(s) Cobalt (Co)	g eq. 1-4-dichlorobenzene	45000	7.6E-01
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	2400000	2.0E+02
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	29000	1.1E+01
	(s) Mercury (Hg)	g eq. 1-4-dichlorobenzene	17000000	5.2E+01
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	520000	6.6E+01
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	1800000	2.5E+06
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	9.70E-06	9.9E-07
	(w) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.039	4.8E-02
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	0.025	2.2E-04
	(w) Chloroform (CHCl3)	g eq. 1-4-dichlorobenzene	5.2	1.2E-03
	(w) Chromium (Cr III)	g eq. 1-4-dichlorobenzene	1.10E-05	1.1E-05
	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.10E-05	3.4E-07
	(w) Chromium (Cr VI)	g eq. 1-4-dichlorobenzene	1.10E-05	2.0E-10
	(w) Cobalt (Co I, Co II, Co III)	g eq. 1-4-dichlorobenzene	2.00E-07	1.2E-08
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.00E-05	2.2E-06
	(w) Formaldehyde (CH2O)	g eq. 1-4-dichlorobenzene	2.5	7.0E-06
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	2.00E-07	2.3E-07
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	8200000	9.6E+01
	(w) Methylene Chloride (CH2Cl2)	g eq. 1-4-dichlorobenzene	0.078	5.0E-02
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	3.10E-05	8.9E-06
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	34	4.2E+01
	(w) Tetrachloroethylene (C2Cl4)	g eq. 1-4-dichlorobenzene	110	1.1E-04
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.022	2.4E-02
	(w) Trichlorethane (1,1,1-CH3CCl3)	g eq. 1-4-dichlorobenzene	2	4.3E-06
	(w) Trichloroethylene (C2HCl3)	g eq. 1-4-dichlorobenzene	0.024	1.4E-06
	(w) Vanadium (V3+, V5+)	g eq. 1-4-dichlorobenzene	3.40E-05	7.2E-06
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	2.50E-05	4.4E-05
	WMO-Depletion of the ozone layer (high)	g eq. CFC-11	*	1.4E-01
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	17.2	1.4E-01
	WMO-Depletion of the ozone layer (low)	g eq. CFC-11	*	8.3E-02
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	10	8.3E-02
	WMO-Photochemical oxidant formation (high)	g eq. ethylene	*	6.3E+03
	(a) Acetaldehyde (CH3CHO)	g eq. ethylene	1.22	3.4E-01
	(a) Acetone (CH3COCH3)	g eq. ethylene	0.27	3.2E-02
	(a) Acetylene (C2H2)	g eq. ethylene	0.42	2.5E+00
	(a) Aldehyde (unspecified)	g eq. ethylene	1.263	2.9E-01
	(a) Alkane (unspecified)	g eq. ethylene	1.173	6.0E+02
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	1.285	1.1E-01
	(a) Benzaldehyde (C6H5CHO)	g eq. ethylene	-0.12	-2.5E-07
	(a) Benzene (C6H6)	g eq. ethylene	0.45	3.6E+01
	(a) Butane (n-C4H10)	g eq. ethylene	1.15	3.6E+02
	(a) Butene (1-CH3CH2CHCH2)	g eq. ethylene	1.85	1.5E-01
	(a) Ethane (C2H6)	g eq. ethylene	0.3	1.7E+02
	(a) Ethanol (C2H5OH)	g eq. ethylene	0.89	1.8E-01
	(a) Ethylene (C2H4)	g eq. ethylene	1	2.2E+03
	(a) Formaldehyde (CH2O)	g eq. ethylene	0.58	1.1E+01
	(a) Heptane (C7H16)	g eq. ethylene	1.65	8.8E-01
	(a) Hexane (C6H14)	g eq. ethylene	1.51	1.6E+00
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.799	2.1E+03
	(a) Hydrocarbons (unspecified)	g eq. ethylene	0.808	1.2E+02
	(a) Methane (CH4)	g eq. ethylene	0.03	4.7E+02
	(a) Methanol (CH3OH)	g eq. ethylene	0.21	6.8E-02
	(a) Propane (C3H8)	g eq. ethylene	1.24	2.2E+02
	(a) Propionaldehyde (CH3CH2CHO)	g eq. ethylene	1.6	9.3E-06
	(a) Propylene (CH2CHCH3)	g eq. ethylene	1.63	1.1E+01
	(a) Toluene (C6H5CH3)	g eq. ethylene	0.83	3.1E+01
	WMO-Photochemical oxidant formation (low)	g eq. ethylene	*	2.9E+03
	(a) Acetaldehyde (CH3CHO)	g eq. ethylene	0.33	9.1E-02
	(a) Acetone (CH3COCH3)	g eq. ethylene	0.1	1.2E-02
	(a) Acetylene (C2H2)	g eq. ethylene	0.1	5.9E-01
	(a) Aldehyde (unspecified)	g eq. ethylene	0.079	1.8E-02
	(a) Alkane (unspecified)	g eq. ethylene	0.114	5.8E+01
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	0.481	4.2E-02
	(a) Benzaldehyde (C6H5CHO)	g eq. ethylene	-0.82	-1.7E-06
	(a) Benzene (C6H6)	g eq. ethylene	0.11	8.7E+00
	(a) Butane (n-C4H10)	g eq. ethylene	0.15	4.7E+01
	(a) Butene (1-CH3CH2CHCH2)	g eq. ethylene	0.57	4.5E-02
	(a) Ethane (C2H6)	g eq. ethylene	0.02	1.1E+01
	(a) Ethanol (C2H5OH)	g eq. ethylene	0.04	7.9E-03
	(a) Ethylene (C2H4)	g eq. ethylene	1	2.2E+03
	(a) Formaldehyde (CH2O)	g eq. ethylene	0.22	4.2E+00
	(a) Heptane (C7H16)	g eq. ethylene	0.13	6.9E-02
	(a) Hexane (C6H14)	g eq. ethylene	0.1	1.1E-01
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.195	5.1E+02
	(a) Hydrocarbons (unspecified)	g eq. ethylene	0.194	2.9E+01
	(a) Methane (CH4)	g eq. ethylene	0	0.0E+00
	(a) Methanol (CH3OH)	g eq. ethylene	0.09	2.9E-02
	(a) Propane (C3H8)	g eq. ethylene	0.16	2.8E+01
	(a) Propionaldehyde (CH3CH2CHO)	g eq. ethylene	0.28	1.6E-06
	(a) Propylene (CH2CHCH3)	g eq. ethylene	0.75	4.9E+00
	(a) Toluene (C6H5CH3)	g eq. ethylene	0.41	1.5E+01

Plastics and PCBs recovered: Processing stage: Plastics incineration (recovered plastics)

LIFE CYCLE INVENTORY

	Flow	Units	Plastics processing
Inputs:	(r) Coal (in ground)	kg	2.0E+01
	(r) Iron (Fe, ore)	kg	2.3E-02
	(r) Lignite (in ground)	kg	1.3E+01
	(r) Limestone (CaCO3, in ground)	kg	1.2E+03
	(r) Natural Gas (in ground)	kg	8.7E+01
	(r) Oil (in ground)	kg	2.4E+01
	(r) Sand (in ground)	kg	1.2E-02
	(r) Sodium Chloride (NaCl, in ground or in sea)	kg	3.0E+01
	(r) Sulphur (S, in ground)	kg	4.9E-02
	(r) Uranium (U, ore)	kg	1.1E-03
	Diesel Oil	kg	4.0E+01
	Mixed plastics (shredded)	kg	4.6E+03
	Water Used (total)	litre	4.6E+03
	Water: Unspecified Origin	litre	4.6E+03
	Wood	kg	8.1E-02
Outputs:	(a) Ammonia (NH3)	g	3.5E+01
	(a) Aromatic Hydrocarbons (unspecified)	g	5.0E+00
	(a) Benzene (C6H6)	g	3.5E+00
	(a) Benzo(a)pyrene (C20H12)	g	2.0E-04
	(a) Cadmium (Cd)	g	7.3E-01
	(a) Carbon Dioxide (CO2, fossil)	g	1.3E+07
	(a) Carbon Monoxide (CO)	g	1.6E+03
	(a) Dioxins (unspecified)	g	5.3E-05
	(a) Halogenated Matter (unspecified)	g	9.5E-03
	(a) Halon 1301 (CF3Br)	g	4.9E-03
	(a) Hydrocarbons (except methane)	g	1.1E+03
	(a) Hydrogen Chloride (HCl)	g	6.9E+03
	(a) Hydrogen Fluoride (HF)	g	1.1E+01
	(a) Lead (Pb)	g	4.2E+00
	(a) Manganese (Mn)	g	3.0E-03
	(a) Mercury (Hg)	g	5.4E+00
	(a) Metals (unspecified)	g	1.3E+01
	(a) Methane (CH4)	g	7.8E+02
	(a) Nickel (Ni)	g	6.8E-02
	(a) Nitrogen Oxides (NOx as NO2)	g	5.2E+03
	(a) Nitrous Oxide (N2O)	g	4.1E+01
	(a) Particulates (unspecified)	g	9.5E+03
	(a) Polycyclic Aromatic Hydrocarbons (PAH, unspecified)	g	3.3E-02
	(a) Sulphur Oxides (SOx as SO2)	g	1.7E+03
	(a) Zinc (Zn)	g	7.8E+01
	(ar) Radioactive Substance (unspecified)	kBq	4.1E+04
	(w) Aluminium (Al3+)	g	1.3E+01
	(w) Ammonia (NH4+, NH3, as N)	g	1.9E+01
	(w) AOX (Adsorbable Organic Halogens)	g	4.0E-03
	(w) Aromatic Hydrocarbons (unspecified)	g	1.1E+00
	(w) Arsenic (As3+, As5+)	g	2.7E-02
	(w) Barium (Ba++)	g	3.6E+00
	(w) BOD5 (Biochemical Oxygen Demand)	g	2.5E-01
	(w) Cadmium (Cd++)	g	5.8E+00
	(w) Chlorides (Cl-)	g	5.3E+05
	(w) Chlorinated Matter (unspecified, as Cl)	g	2.4E-03
	(w) Chromium (Cr III, Cr VI)	g	1.5E-01
	(w) COD (Chemical Oxygen Demand)	g	3.6E+00
	(w) Copper (Cu+, Cu++)	g	7.3E+01
	(w) Cyanides (CN-)	g	4.3E-03
	(w) Dissolved Organic Carbon (DOC)	g	1.5E+00
	(w) Iron (Fe++, Fe3+)	g	3.6E+01
	(w) Lead (Pb++, Pb4+)	g	5.6E+01
	(w) Mercury (Hg+, Hg++)	g	1.3E+01
	(w) Metals (unspecified)	g	1.1E+01
	(w) Nickel (Ni++, Ni3+)	g	7.0E-02
	(w) Nitrates (NO3-)	g	3.5E+00
	(w) Nitrogenous Matter (unspecified, as N)	g	2.1E+00
	(w) Oils (unspecified)	g	3.1E+01
	(w) Phenol (C6H5OH)	g	1.5E-01
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g	2.6E-01
	(w) Polycyclic Aromatic Hydrocarbons (PAH, unspecified)	g	1.3E-02
	(w) Salts (unspecified)	g	1.2E+04
	(w) Sulphates (SO4--)	g	3.3E+03
	(w) Sulphides (S--)	g	3.2E-02
	(w) Suspended Matter (unspecified)	g	2.2E+02
	(w) TOC (Total Organic Carbon)	g	6.1E+03
	(w) Toluene (C6H5CH3)	g	1.4E-01
	(w) Water: Chemically Polluted	litre	1.5E-01
	(w) Zinc (Zn++)	g	1.3E+03
	(wr) Radioactive Substance (unspecified)	kBq	3.8E+02

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	Classification	Units	Charact-erisation	Environmental impacts
Methods:	CML-Air Acidification	g eq. H+	/	3.6E+02
	(a) Ammonia (NH3)	g eq. H+	17	2.0E+00
	(a) Hydrogen Chloride (HCl)	g eq. H+	36.5	1.9E+02
	(a) Hydrogen Fluoride (HF)	g eq. H+	20	5.6E-01
	(a) Nitrogen Oxides (NOx as NO2)	g eq. H+	46	1.1E+02
	(a) Sulphur Oxides (SOx as SO2)	g eq. H+	32	5.3E+01
	CML-Eutrophication	g eq. PO4	*	7.0E+02
	(a) Nitrogen Oxides (NOx as NO2)	g eq. PO4	0.13	6.8E+02
	(a) Nitrous Oxide (N2O)	g eq. PO4	0.27	1.1E+01
	(w) Ammonia (NH4+, NH3, as N)	g eq. PO4	0.42	7.9E+00
	(w) COD (Chemical Oxygen Demand)	g eq. PO4	0.022	7.9E-02
	(w) Nitrogenous Matter (unspecified, as N)	g eq. PO4	0.42	8.8E-01
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g eq. PO4	3.06	8.0E-01
	CST-Aquatic Eco-toxicity	eq. Zn water	*	2.3E+04
	(a) Cadmium (Cd)	eq. Zn water	79	5.8E+01
	(a) Lead (Pb)	eq. Zn water	1.28	5.4E+00
	(a) Mercury (Hg)	eq. Zn water	196	1.1E+03
	(a) Nickel (Ni)	eq. Zn water	0.12	8.1E-03
	(a) Zinc (Zn)	eq. Zn water	0.076	5.9E+00
	(w) Arsenic (As3+, As5+)	eq. Zn water	0.52	1.4E-02
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Zn water	0.00013	3.2E-05
	(w) Cadmium (Cd++)	eq. Zn water	520	3.0E+03
	(w) Chromium (Cr III, Cr VI)	eq. Zn water	2.6	3.9E-01
	(w) Copper (Cu+, Cu++)	eq. Zn water	5.2	3.8E+02
	(w) Lead (Pb++, Pb4+)	eq. Zn water	5.2	2.9E+02
	(w) Mercury (Hg+, Hg++)	eq. Zn water	1300	1.7E+04
	(w) Nickel (Ni++, Ni3+)	eq. Zn water	0.79	5.5E-02
	(w) Oils (unspecified)	eq. Zn water	0.13	4.0E+00
	(w) Phenol (C6H5OH)	eq. Zn water	15.4	2.3E+00
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Zn water	0.01	2.6E-03
	(w) Zinc (Zn++)	eq. Zn water	1	1.3E+03
	CST-Human Toxicity	eq. Pb air	*	2.7E+05
	(a) Benzene (C6H6)	eq. Pb air	0.012	4.2E-02
	(a) Cadmium (Cd)	eq. Pb air	19000	1.4E+04
	(a) Carbon Monoxide (CO)	eq. Pb air	0.00014	2.3E-01
	(a) Lead (Pb)	eq. Pb air	2300	9.7E+03
	(a) Mercury (Hg)	eq. Pb air	46000	2.5E+05
	(a) Nickel (Ni)	eq. Pb air	370	2.5E+01
	(a) Nitrogen Oxides (NOx as NO2)	eq. Pb air	0.002	1.0E+01
	(a) Particulates (unspecified)	eq. Pb air	0.0075	7.1E+01
	(a) Sulphur Oxides (SOx as SO2)	eq. Pb air	0.0075	1.3E+01
	(a) Zinc (Zn)	eq. Pb air	27	2.1E+03
	(w) Arsenic (As3+, As5+)	eq. Pb air	1.5	4.1E-02
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Pb air	0.022	5.4E-03
	(w) Cadmium (Cd++)	eq. Pb air	3.2	1.8E+01
	(w) Chromium (Cr III, Cr VI)	eq. Pb air	0.62	9.4E-02
	(w) Copper (Cu+, Cu++)	eq. Pb air	0.022	1.6E+00
	(w) Lead (Pb++, Pb4+)	eq. Pb air	0.86	4.9E+01
	(w) Mercury (Hg+, Hg++)	eq. Pb air	7.8	1.0E+02
	(w) Nickel (Ni++, Ni3+)	eq. Pb air	0.062	4.3E-03
	(w) Phenol (C6H5OH)	eq. Pb air	0.052	7.9E-03
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Pb air	3.20E-06	8.4E-07
	(w) Zinc (Zn++)	eq. Pb air	0.0032	4.2E+00
	CST-Terrestrial Eco-toxicity	eq. Zn air	*	6.0E+01
	(a) Cadmium (Cd)	eq. Zn air	3.14	2.3E+00
	(a) Lead (Pb)	eq. Zn air	0.13	5.5E-01
	(a) Mercury (Hg)	eq. Zn air	5.94	3.2E+01
	(a) Nickel (Ni)	eq. Zn air	0.35	2.4E-02
	(a) Zinc (Zn)	eq. Zn air	0.33	2.6E+01
	EB(R*Y)-Depletion of non renewable resources	yr-1	*	1.2E+01
	(r) Coal (in ground)	yr-1	0.0005037	1.0E-02
	(r) Iron (Fe, ore)	yr-1	0.04	9.2E-04
	(r) Lignite (in ground)	yr-1	0.0005037	6.7E-03
	(r) Natural Gas (in ground)	yr-1	0.117	1.0E+01
	(r) Oil (in ground)	yr-1	0.0557	1.4E+00
	(r) Sulphur (S, in ground)	yr-1	4.408	2.2E-01
	(r) Uranium (U, ore)	yr-1	181	2.0E-01
	ETH-Air Acidification	g eq. H+	/	3.6E+02
	(a) Ammonia (NH3)	g eq. H+	17	2.0E+00
	(a) Hydrogen Chloride (HCl)	g eq. H+	36.5	1.9E+02
	(a) Hydrogen Fluoride (HF)	g eq. H+	20	5.6E-01
	(a) Nitrogen Oxides (NOx as NO2)	g eq. H+	46	1.1E+02
	(a) Sulphur Oxides (SOx as SO2)	g eq. H+	32	5.3E+01
	IPCC-Greenhouse effect (direct, 100 years)	g eq. CO2	*	1.3E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	1.3E+07
	(a) Halon 1301 (CF3Br)	g eq. CO2	6900	3.4E+01
	(a) Methane (CH4)	g eq. CO2	24	1.9E+04
	(a) Nitrous Oxide (N2O)	g eq. CO2	360	1.5E+04
	IPCC-Greenhouse effect (direct, 20 years)	g eq. CO2	*	1.3E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	1.3E+07
	(a) Halon 1301 (CF3Br)	g eq. CO2	7900	3.9E+01
	(a) Methane (CH4)	g eq. CO2	64	5.0E+04
	(a) Nitrous Oxide (N2O)	g eq. CO2	330	1.4E+04
	IPCC-Greenhouse effect (direct, 500 years)	g eq. CO2	*	1.3E+07
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	1.3E+07
	(a) Halon 1301 (CF3Br)	g eq. CO2	2700	1.3E+01
	(a) Methane (CH4)	g eq. CO2	7.5	5.8E+03
	(a) Nitrous Oxide (N2O)	g eq. CO2	190	7.9E+03
	USES 1.0-Aquatic Ecotoxicity	g eq. 1-4-dichlorobenzene	*	1.1E+05
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.0013	4.5E-03
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	320	6.4E-02
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130	9.5E+01
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.2	5.0E+00
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	16000	8.6E+04
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	80	5.4E+00
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	2.6	2.0E+02
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	190	5.2E+00
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	4500	2.6E+04
	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	84	1.3E+01
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.86	1.1E+03
	USES 1.0-Human Toxicity	g eq. 1-4-dichlorobenzene	*	6.9E+05
	(a) Ammonia (NH3)	g eq. 1-4-dichlorobenzene	16	5.5E+02
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	29	1.0E+02
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	3700	7.3E-01
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	23000	1.7E+04
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	67000	2.8E+05
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	29000	1.6E+05
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	9800	6.6E+02
	(a) Nitrogen Oxides (NOx as NO2)	g eq. 1-4-dichlorobenzene	0.26	1.4E+03
	(a) Sulphur Oxides (SOx as SO2)	g eq. 1-4-dichlorobenzene	0.16	2.7E+02
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	0.63	4.9E+01
	(w) Ammonia (NH4+, NH3, as N)	g eq. 1-4-dichlorobenzene	17	3.2E+02
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	51	1.4E+00
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	130	7.5E+02
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.1	8.0E+01
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	0.026	1.5E+00
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	18000	2.3E+05
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	63	4.4E+00
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	0.89	1.4E-01
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.053	7.3E-03
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.058	7.7E+01

Plastics and PCBs recovered: Processing stage: Plastics incineration (recovered plastics)

LIFE CYCLE INVENTORY

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	USES 1.0-Terrestrial Ecotoxicity	g eq. 1-4-dichlorobenzene	*	3.2E+08
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.063	2.2E-01
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	64000000	1.3E+04
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130000000	9.5E+07
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	11000	4.6E+04
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	13000000	7.0E+07
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	190000	1.3E+04
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	660000	5.2E+07
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	9.70E-06	2.7E-07
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	0.025	1.4E-01
	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.10E-05	1.7E-06
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.00E-05	7.3E-04
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	2.00E-07	1.1E-05
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	8200000	1.1E+08
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	3.10E-05	2.2E-06
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	34	5.2E+00
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.022	3.0E-03
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	2.50E-05	3.3E-02
	WMO-Depletion of the ozone layer (high)	g eq. CFC-11	*	8.4E-02
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	17.2	8.4E-02
	WMO-Depletion of the ozone layer (low)	g eq. CFC-11	*	4.9E-02
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	10	4.9E-02
	WMO-Photochemical oxidant formation (high)	g eq. ethylene	*	9.5E+02
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	1.285	6.4E+00
	(a) Benzene (C6H6)	g eq. ethylene	0.45	1.6E+00
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.799	9.2E+02
	(a) Methane (CH4)	g eq. ethylene	0.03	2.3E+01
	WMO-Photochemical oxidant formation (low)	g eq. ethylene	*	2.3E+02
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	0.481	2.4E+00
	(a) Benzene (C6H6)	g eq. ethylene	0.11	3.8E-01
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.195	2.2E+02
	(a) Methane (CH4)	g eq. ethylene	0	0.0E+00

Plastics and PCBs recovered: Processing stage: product resale

LIFE CYCLE INVENTORY

	Flow	Units	Resale in the UK
Inputs:	(r) Coal (in ground)	kg	5.1E-02
	(r) Lignite (in ground)	kg	6.6E-02
	(r) Natural Gas (in ground)	kg	2.4E-01
	(r) Oil (in ground)	kg	6.0E+00
	(r) Uranium (U, ore)	kg	6.3E-06
	Diesel Oil	kg	1.7E+02
	Printers for resale or reuse	kg	7.1E+03
	Wood	kg	5.0E-04
Outputs:	(a) Benzene (C6H6)	g	1.7E-01
	(a) Benzo(a)pyrene (C20H12)	g	8.6E-04
	(a) Cadmium (Cd)	g	4.5E-03
	(a) Carbon Dioxide (CO2, fossil)	g	5.4E+05
	(a) Carbon Monoxide (CO)	g	1.8E+03
	(a) Hydrocarbons (except methane)	g	9.5E+02
	(a) Lead (Pb)	g	1.9E-02
	(a) Methane (CH4)	g	1.2E+04
	(a) Nitrogen Oxides (NOx as NO2)	g	6.7E+03
	(a) Nitrous Oxide (N2O)	g	7.6E+01
	(a) Particulates (unspecified)	g	4.3E+02
	(a) Sulphur Oxides (SOx as SO2)	g	4.5E+02
	(a) Zinc (Zn)	g	1.2E+01
	(s) Cadmium (Cd)	g	2.2E-01
	(s) Carbon (C)	g	7.0E+00
	(s) Chromium (Cr III, Cr VI)	g	1.3E+02
	(s) Copper (Cu)	g	4.0E+01
	(s) Iron (Fe)	g	5.0E+02
	(s) Lead (Pb)	g	2.2E-01
	(s) Nickel (Ni)	g	2.2E+01
	(s) Zinc (Zn)	g	2.5E+00
	(w) Calcium (Ca++)	g	9.5E-01
	(w) Nitrates (NO3-)	g	1.5E+00
	(w) VOC (Volatile Organic Compounds)	g	1.5E+01
	(w) Water: Chemically Polluted	litre	3.9E-02
	Printers for resale	kg	4.9E+03
	Printers for reuse in maintenance	kg	7.2E+02
	Waste: Active	kg	1.6E+01

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	Classification	Units	Charact-erisation	Environmental impact
Methods:	CML-Air Acidification	g eq. H+	/	1.6E+02
	(a) Nitrogen Oxides (NOx as NO2)	g eq. H+	46	1.5E+02
	(a) Sulphur Oxides (SOx as SO2)	g eq. H+	32	1.4E+01
	CML-Eutrophication	g eq. PO4	*	9.0E+02
	(a) Nitrogen Oxides (NOx as NO2)	g eq. PO4	0.13	8.8E+02
	(a) Nitrous Oxide (N2O)	g eq. PO4	0.27	2.1E+01
	CST-Aquatic Eco-toxicity	eq. Zn water	*	2.9E+02
	(a) Cadmium (Cd)	eq. Zn water	79	3.6E-01
	(a) Lead (Pb)	eq. Zn water	1.28	2.5E-02
	(a) Zinc (Zn)	eq. Zn water	0.076	9.0E-01
	(s) Cadmium (Cd)	eq. Zn water	240	5.4E+01
	(s) Chromium (Cr III, Cr VI)	eq. Zn water	1.2	1.5E+02
	(s) Copper (Cu)	eq. Zn water	2	7.9E+01
	(s) Lead (Pb)	eq. Zn water	3.9	8.7E-01
	(s) Nickel (Ni)	eq. Zn water	0.36	7.9E+00
	(s) Zinc (Zn)	eq. Zn water	0.23	5.7E-01
	CST-Human Toxicity	eq. Pb air	*	5.1E+02
	(a) Benzene (C6H6)	eq. Pb air	0.012	2.1E-03
	(a) Cadmium (Cd)	eq. Pb air	19000	8.6E+01
	(a) Carbon Monoxide (CO)	eq. Pb air	0.00014	2.5E-01
	(a) Lead (Pb)	eq. Pb air	2300	4.4E+01
	(a) Nitrogen Oxides (NOx as NO2)	eq. Pb air	0.002	1.3E+01
	(a) Particulates (unspecified)	eq. Pb air	0.0075	3.2E+00
	(a) Sulphur Oxides (SOx as SO2)	eq. Pb air	0.0075	3.4E+00
	(a) Zinc (Zn)	eq. Pb air	27	3.2E+02
	(s) Cadmium (Cd)	eq. Pb air	1.46	3.3E-01
	(s) Chromium (Cr III, Cr VI)	eq. Pb air	0.29	3.6E+01
	(s) Copper (Cu)	eq. Pb air	0.009	3.6E-01
	(s) Lead (Pb)	eq. Pb air	0.6	1.3E-01
	(s) Nickel (Ni)	eq. Pb air	0.029	6.3E-01
	(s) Zinc (Zn)	eq. Pb air	0.0007	1.7E-03
	CST-Terrestrial Eco-toxicity	eq. Zn air	*	8.2E+01
	(a) Cadmium (Cd)	eq. Zn air	3.14	1.4E-02
	(a) Lead (Pb)	eq. Zn air	0.13	2.5E-03
	(a) Zinc (Zn)	eq. Zn air	0.33	3.9E+00
	(s) Cadmium (Cd)	eq. Zn air	9.6	2.1E+00
	(s) Chromium (Cr III, Cr VI)	eq. Zn air	0.26	3.3E+01
	(s) Copper (Cu)	eq. Zn air	0.42	1.7E+01
	(s) Lead (Pb)	eq. Zn air	0.41	9.2E-02
	(s) Nickel (Ni)	eq. Zn air	1.1	2.4E+01
	(s) Zinc (Zn)	eq. Zn air	1	2.5E+00
	EB(R*Y)-Depletion of non renewable resources	yr-1	*	3.6E-01
	(r) Coal (in ground)	yr-1	0.0005037	2.6E-05
	(r) Lignite (in ground)	yr-1	0.0005037	3.3E-05
	(r) Natural Gas (in ground)	yr-1	0.117	2.9E-02
	(r) Oil (in ground)	yr-1	0.0557	3.3E-01
	(r) Uranium (U, ore)	yr-1	181	1.1E-03
	ETH-Air Acidification	g eq. H+	/	1.6E+02
	(a) Nitrogen Oxides (NOx as NO2)	g eq. H+	46	1.5E+02
	(a) Sulphur Oxides (SOx as SO2)	g eq. H+	32	1.4E+01
	IPCC-Greenhouse effect (direct, 100 years)	g eq. CO2	*	8.6E+05
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	5.4E+05
	(a) Methane (CH4)	g eq. CO2	24	2.9E+05
	(a) Nitrous Oxide (N2O)	g eq. CO2	360	2.7E+04
	IPCC-Greenhouse effect (direct, 20 years)	g eq. CO2	*	1.3E+06
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	5.4E+05
	(a) Methane (CH4)	g eq. CO2	64	7.6E+05
	(a) Nitrous Oxide (N2O)	g eq. CO2	330	2.5E+04
	IPCC-Greenhouse effect (direct, 500 years)	g eq. CO2	*	6.5E+05
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	5.4E+05
	(a) Methane (CH4)	g eq. CO2	7.5	9.0E+04
	(a) Nitrous Oxide (N2O)	g eq. CO2	190	1.4E+04
	USES 1.0-Aquatic Ecotoxicity	g eq. 1-4-dichlorobenzene	*	3.2E+01
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.0013	2.2E-04
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	320	2.8E-01
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130	5.9E-01
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.2	2.3E-02
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	2.6	3.1E+01
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	3.90E-06	8.7E-07
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.40E-09	1.8E-07
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	1.40E-08	5.5E-07
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.80E-09	4.0E-10
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	5.80E-07	1.3E-05
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	3.90E-08	9.7E-08
	USES 1.0-Human Toxicity	g eq. 1-4-dichlorobenzene	*	2.7E+04
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	29	5.0E+00
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	3700	3.2E+00
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	23000	1.0E+02
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	67000	1.3E+03
	(a) Nitrogen Oxides (NOx as NO2)	g eq. 1-4-dichlorobenzene	0.26	1.8E+03
	(a) Sulphur Oxides (SOx as SO2)	g eq. 1-4-dichlorobenzene	0.16	7.2E+01
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	0.63	7.5E+00
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	20000	4.5E+03
	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	30	1.2E+03
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	350	7.8E+01
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	800	1.8E+04
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	12	3.0E+01
	USES 1.0-Terrestrial Ecotoxicity	g eq. 1-4-dichlorobenzene	*	2.7E+08
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.063	1.1E-02
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	64000000	5.5E+04
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130000000	5.9E+05
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	11000	2.1E+02
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	660000	7.8E+06
	(s) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	340000000	7.6E+07
	(s) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	600000	7.5E+07

Plastics and PCBs recovered: Processing stage: product resale

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	(s) Copper (Cu)	g eq. 1-4-dichlorobenzene	2400000	9.5E+07
	(s) Lead (Pb)	g eq. 1-4-dichlorobenzene	29000	6.5E+03
	(s) Nickel (Ni)	g eq. 1-4-dichlorobenzene	520000	1.1E+07
	(s) Zinc (Zn)	g eq. 1-4-dichlorobenzene	1800000	4.5E+06
	WMO-Depletion of the ozone layer (high)	g eq. CFC-11	*	0.0E+00
	WMO-Depletion of the ozone layer (low)	g eq. CFC-11	*	0.0E+00
	WMO-Photochemical oxidant formation (high)	g eq. ethylene	*	1.1E+03
	(a) Benzene (C6H6)	g eq. ethylene	0.45	7.8E-02
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.799	7.6E+02
	(a) Methane (CH4)	g eq. ethylene	0.03	3.6E+02
	WMO-Photochemical oxidant formation (low)	g eq. ethylene	*	1.9E+02
	(a) Benzene (C6H6)	g eq. ethylene	0.11	1.9E-02
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.195	1.9E+02
	(a) Methane (CH4)	g eq. ethylene	0	0.0E+00

Plastics and PCBs recovered: Materials production stage: Recovered aluminium smelting

LIFE CYCLE INVENTORY

	Flow	Units	Aluminium smelting (Africa)
Inputs:	(r) Coal (in ground)	kg	1.4E+01
	(r) Lignite (in ground)	kg	1.4E+01
	(r) Natural Gas (in ground)	kg	3.4E+01
	(r) Oil (in ground)	kg	1.3E+01
	(r) Uranium (U, ore)	kg	1.4E-03
	Argon (Ar)	kg	3.3E-01
	Chlorine (Cl2)	kg	1.9E-01
	Diesel Oil	kg	5.4E+00
	Heavy Fuel Oil	kg	9.9E+00
	Raw Materials (unspecified)	kg	1.0E+01
	Recovered Matter: Aluminium	kg	4.5E+02
	Water Used (total)	litre	3.5E+02
	Water: Unspecified Origin	litre	3.5E+02
	Wood	kg	1.4E-01
Outputs:	(a) Aldehyde (unspecified)	g	1.2E-02
	(a) Aluminium (Al)	g	6.8E-02
	(a) Ammonia (NH3)	g	1.5E-01
	(a) Aromatic Hydrocarbons (unspecified)	g	2.2E+01
	(a) Arsenic (As)	g	6.8E-03
	(a) Benzene (C6H6)	g	2.0E-01
	(a) Benzo(a)pyrene (C20H12)	g	2.7E-05
	(a) Cadmium (Cd)	g	1.8E-03
	(a) Calcium (Ca)	g	5.9E-02
	(a) Carbon Dioxide (CO2, fossil)	g	2.2E+05
	(a) Carbon Monoxide (CO)	g	1.5E+02
	(a) Chromium (Cr III, Cr VI)	g	3.4E-03
	(a) Cobalt (Co)	g	4.3E-03
	(a) Copper (Cu)	g	4.0E-03
	(a) Halogenated Matter (unspecified)	g	3.7E-05
	(a) Halon 1301 (CF3Br)	g	3.2E-03
	(a) Hydrocarbons (except methane)	g	1.6E+02
	(a) Hydrogen Chloride (HCl)	g	8.6E+00
	(a) Hydrogen Fluoride (HF)	g	5.1E+00
	(a) Iron (Fe)	g	1.3E-01
	(a) Lead (Pb)	g	1.5E-02
	(a) Manganese (Mn)	g	4.7E-03
	(a) Mercury (Hg)	g	3.7E-03
	(a) Metals (unspecified)	g	2.7E+00
	(a) Methane (CH4)	g	3.5E+02
	(a) Molybdenum (Mo)	g	5.4E-03
	(a) Nickel (Ni)	g	4.2E-01
	(a) Nitrogen Oxides (NOx as NO2)	g	1.0E+03
	(a) Nitrous Oxide (N2O)	g	3.2E+00
	(a) Particulates (unspecified)	g	1.3E+02
	(a) Phosphorus (P)	g	4.0E-02
	(a) Polycyclic Aromatic Hydrocarbons (PAH, except naphthalene)	g	2.3E-03
	(a) Selenium (Se)	g	2.0E-03
	(a) Silicon (Si)	g	5.9E-02
	(a) Sodium (Na)	g	3.5E-01
	(a) Sulphur Oxides (SOx as SO2)	g	1.4E+03
	(a) Vanadium (V)	g	9.0E-01
	(a) Zinc (Zn)	g	8.3E-01
	(ar) Radioactive Substance (unspecified)	kBq	1.2E+05
	(w) Aluminium (Al3+)	g	2.3E+01
	(w) Ammonia (NH4+, NH3, as N)	g	7.1E-01
	(w) AOX (Adsorbable Organic Halogens)	g	2.3E-03
	(w) Aromatic Hydrocarbons (unspecified)	g	6.5E-01
	(w) Arsenic (As3+, As5+)	g	4.5E-02
	(w) Barium (Ba++)	g	3.5E+00
	(w) BOD5 (Biochemical Oxygen Demand)	g	3.8E-02
	(w) Cadmium (Cd++)	g	2.0E-03
	(w) Chlorides (Cl-)	g	5.0E+02
	(w) Chlorinated Matter (unspecified, as Cl)	g	1.2E-03
	(w) Chromium (Cr III, Cr VI)	g	2.3E-01
	(w) COD (Chemical Oxygen Demand)	g	7.0E-01
	(w) Copper (Cu+, Cu++)	g	1.1E-01
	(w) Cyanides (CN-)	g	3.6E-03
	(w) Dissolved Organic Carbon (DOC)	g	6.2E-01
	(w) Inorganic Dissolved Matter (unspecified)	g	4.0E+02
	(w) Iron (Fe++, Fe3+)	g	3.0E+01
	(w) Lead (Pb++, Pb4+)	g	1.4E-01
	(w) Mercury (Hg+, Hg++)	g	1.7E-04
	(w) Metals (unspecified)	g	6.5E+00
	(w) Nickel (Ni++, Ni3+)	g	1.1E-01
	(w) Nitrates (NO3-)	g	9.5E-01
	(w) Nitrogenous Matter (unspecified, as N)	g	6.7E-01
	(w) Oils (unspecified)	g	1.9E+01
	(w) Phenol (C6H5OH)	g	1.0E-01
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g	4.4E-01
	(w) Polycyclic Aromatic Hydrocarbons (PAH, unspecified)	g	8.8E-03
	(w) Sulphates (SO4--)	g	2.5E+02
	(w) Sulphides (S--)	g	2.2E-02
	(w) Suspended Matter (unspecified)	g	8.3E+01
	(w) TOC (Total Organic Carbon)	g	4.7E+01
	(w) Toluene (C6H5CH3)	g	8.6E-02
	(w) Zinc (Zn++)	g	2.3E-01
	(wr) Radioactive Substance (unspecified)	kBq	1.1E+03
	Aluminium (Al)	kg	4.2E+02
	Recovered Matter (total)	kg	4.6E+01
	Recovered Matter (unspecified)	kg	2.1E+01
	Recovered Matter: Aluminium Scrap	kg	2.5E+01
	Waste (incineration)	kg	4.5E-02
	Waste (total)	kg	3.9E+00
	Waste: Mineral (inert)	kg	3.9E+00

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	Classification	Units	Charact-erisation	Environmental impact
Methods:	CML-Air Acidification	g eq. H+	/	6.6E+01
	(a) Ammonia (NH3)	g eq. H+	17	9.0E-03
	(a) Hydrogen Chloride (HCl)	g eq. H+	36.5	2.4E-01
	(a) Hydrogen Fluoride (HF)	g eq. H+	20	2.5E-01
	(a) Nitrogen Oxides (NOx as NO2)	g eq. H+	46	2.2E+01
	(a) Sulphur Oxides (SOx as SO2)	g eq. H+	32	4.3E+01
	CML-Eutrophication	g eq. PO4	*	1.4E+02
	(a) Nitrogen Oxides (NOx as NO2)	g eq. PO4	0.13	1.3E+02
	(a) Nitrous Oxide (N2O)	g eq. PO4	0.27	8.5E-01
	(w) Ammonia (NH4+, NH3, as N)	g eq. PO4	0.42	3.0E-01
	(w) COD (Chemical Oxygen Demand)	g eq. PO4	0.022	1.5E-02
	(w) Nitrogenous Matter (unspecified, as N)	g eq. PO4	0.42	2.8E-01
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g eq. PO4	3.06	1.3E+00
	CST-Aquatic Eco-toxicity	eq. Zn water	*	8.6E+00
	(a) Arsenic (As)	eq. Zn water	0.078	5.3E-04
	(a) Cadmium (Cd)	eq. Zn water	79	1.5E-01
	(a) Chromium (Cr III, Cr VI)	eq. Zn water	0.39	1.3E-03
	(a) Copper (Cu)	eq. Zn water	0.66	2.6E-03
	(a) Lead (Pb)	eq. Zn water	1.28	1.9E-02
	(a) Mercury (Hg)	eq. Zn water	196	7.3E-01
	(a) Nickel (Ni)	eq. Zn water	0.12	5.1E-02
	(a) Zinc (Zn)	eq. Zn water	0.076	6.3E-02
	(w) Arsenic (As3+, As5+)	eq. Zn water	0.52	2.4E-02
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Zn water	0.00013	4.9E-06
	(w) Cadmium (Cd++)	eq. Zn water	520	1.0E+00
	(w) Chromium (Cr III, Cr VI)	eq. Zn water	2.6	6.0E-01
	(w) Copper (Cu+, Cu++)	eq. Zn water	5.2	5.8E-01
	(w) Lead (Pb++, Pb4+)	eq. Zn water	5.2	7.1E-01
	(w) Mercury (Hg+, Hg++)	eq. Zn water	1300	2.2E-01
	(w) Nickel (Ni++, Ni3+)	eq. Zn water	0.79	9.0E-02
	(w) Oils (unspecified)	eq. Zn water	0.13	2.5E+00
	(w) Phenol (C6H5OH)	eq. Zn water	15.4	1.6E+00
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Zn water	0.01	4.4E-03
	(w) Zinc (Zn++)	eq. Zn water	1	2.3E-01
	CST-Human Toxicity	eq. Pb air	*	6.9E+02
	(a) Aldehyde (unspecified)	eq. Pb air	0.0087	1.0E-04
	(a) Arsenic (As)	eq. Pb air	9000	6.1E+01
	(a) Benzene (C6H6)	eq. Pb air	0.012	2.4E-03
	(a) Cadmium (Cd)	eq. Pb air	19000	3.5E+01
	(a) Carbon Monoxide (CO)	eq. Pb air	0.00014	2.0E-02
	(a) Chromium (Cr III, Cr VI)	eq. Pb air	3700	1.2E+01
	(a) Cobalt (Co)	eq. Pb air	12900	5.5E+01
	(a) Copper (Cu)	eq. Pb air	145	5.7E-01
	(a) Lead (Pb)	eq. Pb air	2300	3.4E+01
	(a) Mercury (Hg)	eq. Pb air	46000	1.7E+02
	(a) Nickel (Ni)	eq. Pb air	370	1.6E+02
	(a) Nitrogen Oxides (NOx as NO2)	eq. Pb air	0.002	2.0E+00
	(a) Particulates (unspecified)	eq. Pb air	0.0075	1.0E+00
	(a) Selenium (Se)	eq. Pb air	64000	1.3E+02
	(a) Sulphur Oxides (SOx as SO2)	eq. Pb air	0.0075	1.0E+01
	(a) Zinc (Zn)	eq. Pb air	27	2.2E+01
	(w) Arsenic (As3+, As5+)	eq. Pb air	1.5	6.8E-02
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Pb air	0.022	8.3E-04
	(w) Cadmium (Cd++)	eq. Pb air	3.2	6.3E-03
	(w) Chromium (Cr III, Cr VI)	eq. Pb air	0.62	1.4E-01
	(w) Copper (Cu+, Cu++)	eq. Pb air	0.022	2.5E-03
	(w) Lead (Pb++, Pb4+)	eq. Pb air	0.86	1.2E-01
	(w) Mercury (Hg+, Hg++)	eq. Pb air	7.8	1.3E-03
	(w) Nickel (Ni++, Ni3+)	eq. Pb air	0.062	7.1E-03
	(w) Phenol (C6H5OH)	eq. Pb air	0.052	5.4E-03
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Pb air	3.20E-06	1.4E-06
	(w) Zinc (Zn++)	eq. Pb air	0.0032	7.4E-04
	CST-Terrestrial Eco-toxicity	eq. Zn air	*	4.6E-01
	(a) Arsenic (As)	eq. Zn air	0.75	5.1E-03
	(a) Cadmium (Cd)	eq. Zn air	3.14	5.8E-03
	(a) Chromium (Cr III, Cr VI)	eq. Zn air	0.08	2.7E-04
	(a) Cobalt (Co)	eq. Zn air	0.08	3.4E-04
	(a) Copper (Cu)	eq. Zn air	0.14	5.5E-04
	(a) Lead (Pb)	eq. Zn air	0.13	1.9E-03
	(a) Mercury (Hg)	eq. Zn air	5.94	2.2E-02
	(a) Nickel (Ni)	eq. Zn air	0.35	1.5E-01
	(a) Zinc (Zn)	eq. Zn air	0.33	2.7E-01
	EB(R*Y)-Depletion of non renewable resources	yr-1	*	5.0E+00
	(r) Coal (in ground)	yr-1	0.0005037	7.0E-03
	(r) Lignite (in ground)	yr-1	0.0005037	7.1E-03
	(r) Natural Gas (in ground)	yr-1	0.117	4.0E+00
	(r) Oil (in ground)	yr-1	0.0557	7.5E-01
	(r) Uranium (U, ore)	yr-1	181	2.5E-01
	ETH-Air Acidification	g eq. H+	/	6.6E+01
	(a) Ammonia (NH3)	g eq. H+	17	9.0E-03
	(a) Hydrogen Chloride (HCl)	g eq. H+	36.5	2.4E-01
	(a) Hydrogen Fluoride (HF)	g eq. H+	20	2.5E-01
	(a) Nitrogen Oxides (NOx as NO2)	g eq. H+	46	2.2E+01
	(a) Sulphur Oxides (SOx as SO2)	g eq. H+	32	4.3E+01
	IPCC-Greenhouse effect (direct, 100 years)	g eq. CO2	*	2.2E+05
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	2.2E+05
	(a) Halon 1301 (CF3Br)	g eq. CO2	6900	2.2E+01
	(a) Methane (CH4)	g eq. CO2	24	8.5E+03
	(a) Nitrous Oxide (N2O)	g eq. CO2	360	1.1E+03
	IPCC-Greenhouse effect (direct, 20 years)	g eq. CO2	*	2.4E+05
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	2.2E+05
	(a) Halon 1301 (CF3Br)	g eq. CO2	7900	2.5E+01
	(a) Methane (CH4)	g eq. CO2	64	2.3E+04
	(a) Nitrous Oxide (N2O)	g eq. CO2	330	1.0E+03
	IPCC-Greenhouse effect (direct, 500 years)	g eq. CO2	*	2.2E+05
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	2.2E+05
	(a) Halon 1301 (CF3Br)	g eq. CO2	2700	8.7E+00
	(a) Methane (CH4)	g eq. CO2	7.5	2.7E+03
	(a) Nitrous Oxide (N2O)	g eq. CO2	190	6.0E+02
	USES 1.0-Aquatic Ecotoxicity	g eq. 1-4-dichlorobenzene	*	1.4E+02
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	5.6	3.8E-02
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.0013	2.6E-04
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	320	8.6E-03
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130	2.4E-01
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	2.6	1.1E-02
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	2.9	1.1E-02
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.2	1.7E-02
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	16000	5.9E+01
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	80	3.4E+01
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	11	9.9E+00
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	2.6	2.2E+00
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	190	8.6E+00
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	4500	8.9E+00
	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	84	1.9E+01
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.86	2.0E-01
	USES 1.0-Human Toxicity	g eq. 1-4-dichlorobenzene	*	1.1E+04
	(a) Ammonia (NH3)	g eq. 1-4-dichlorobenzene	16	2.4E+00
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	42000	2.8E+02
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	29	5.8E+00
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	3700	9.9E-02

Plastics and PCBs recovered: Materials production stage: Recovered aluminium smelting

LIFE CYCLE INVENTORY

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	23000	4.2E+01
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	7600	3.2E+01
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	350	1.4E+00
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	67000	9.8E+02
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	29000	1.1E+02
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	9800	4.1E+03
	(a) Nitrogen Oxides (NOx as NO2)	g eq. 1-4-dichlorobenzene	0.26	2.6E+02
	(a) Sulphur Oxides (SOx as SO2)	g eq. 1-4-dichlorobenzene	0.16	2.2E+02
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	4900	4.4E+03
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	0.63	5.2E-01
	(w) Ammonia (NH4+, NH3, as N)	g eq. 1-4-dichlorobenzene	17	1.2E+01
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	51	2.3E+00
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	130	2.6E-01
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.1	1.2E-01
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	0.026	3.5E-03
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	18000	3.1E+00
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	63	7.2E+00
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	0.89	9.2E-02
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.053	4.6E-03
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.058	1.3E-02
	USES 1.0-Terrestrial Ecotoxicity	g eq. 1-4-dichlorobenzene	*	1.3E+06
	(a) Arsenic (As)	g eq. 1-4-dichlorobenzene	72000	4.9E+02
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.063	1.3E-02
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	64000000	1.7E+03
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130000000	2.4E+05
	(a) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	220000	7.4E+02
	(a) Cobalt (Co)	g eq. 1-4-dichlorobenzene	17000	7.3E+01
	(a) Copper (Cu)	g eq. 1-4-dichlorobenzene	910000	3.6E+03
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	11000	1.6E+02
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	13000000	4.8E+04
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	190000	8.0E+04
	(a) Vanadium (V)	g eq. 1-4-dichlorobenzene	450000	4.1E+05
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	660000	5.5E+05
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	9.70E-06	4.4E-07
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	0.025	4.9E-05
	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.10E-05	2.6E-06
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.00E-05	1.1E-06
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	2.00E-07	2.7E-08
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	8200000	1.4E+03
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	3.10E-05	3.5E-06
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	34	3.5E+00
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.022	1.9E-03
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	2.50E-05	5.8E-06
	WMO-Depletion of the ozone layer (high)	g eq. CFC-11	*	5.5E-02
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	17.2	5.5E-02
	WMO-Depletion of the ozone layer (low)	g eq. CFC-11	*	3.2E-02
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	10	3.2E-02
	WMO-Photochemical oxidant formation (high)	g eq. ethylene	*	1.7E+02
	(a) Aldehyde (unspecified)	g eq. ethylene	1.263	1.5E-02
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	1.285	2.9E+01
	(a) Benzene (C6H6)	g eq. ethylene	0.45	9.1E-02
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.799	1.3E+02
	(a) Methane (CH4)	g eq. ethylene	0.03	1.1E+01
	WMO-Photochemical oxidant formation (low)	g eq. ethylene	*	4.2E+01
	(a) Aldehyde (unspecified)	g eq. ethylene	0.079	9.2E-04
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	0.481	1.1E+01
	(a) Benzene (C6H6)	g eq. ethylene	0.11	2.2E-02
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.195	3.1E+01
	(a) Methane (CH4)	g eq. ethylene	0	0.0E+00

Plastics and PCBs recovered: Materials production stage: Cardboard production

LIFE CYCLE INVENTORY

	Flow	Units	Cardboard recycling (UK)
Inputs:	(r) Coal (in ground)	kg	9.1268
	(r) Iron (Fe, ore)	kg	9.17E-05
	(r) Lignite (in ground)	kg	8.2554
	(r) Limestone (CaCO3, in ground)	kg	0.26509
	(r) Natural Gas (in ground)	kg	63.4748
	(r) Oil (in ground)	kg	20.2028
	(r) Sand (in ground)	kg	4.59E-05
	(r) Sodium Chloride (NaCl, in ground or in sea)	kg	0.119245
	(r) Uranium (U, ore)	kg	0.00600809
	Borax (B4Na2O7)	kg	0.155935
	Diesel Oil	kg	3.672
	Maize	kg	34.0764
	Potatoes	kg	9.17266
	Raw Materials (unspecified)	kg	50.1152
	Recovered Matter: Cardboard	kg	510
	Water Used (total)	litre	2829.77
	Water: Unspecified Origin	litre	3077.43
	Wood	kg	0.0889748
Outputs:	(a) Ammonia (NH3)	g	105.027
	(a) Aromatic Hydrocarbons (unspecified)	g	1.27041
	(a) Benzene (C6H6)	g	1.2695
	(a) Benzo(a)pyrene (C20H12)	g	1.84E-05
	(a) Cadmium (Cd)	g	0.0106099
	(a) Carbon Dioxide (CO2, biomass)	g	130.496
	(a) Carbon Dioxide (CO2, fossil)	g	250973
	(a) Carbon Monoxide (CO)	g	208.854
	(a) Halogenated Matter (unspecified)	g	0.00018763
	(a) Halon 1301 (CF3Br)	g	0.00440288
	(a) Hydrocarbons (except methane)	g	279.961
	(a) Hydrogen Chloride (HCl)	g	6.00809
	(a) Hydrogen Fluoride (HF)	g	0.651259
	(a) Hydrogen Sulphide (H2S)	g	0.0191709
	(a) Lead (Pb)	g	0.0256077
	(a) Manganese (Mn)	g	0.00302698
	(a) Mercury (Hg)	g	0.00596223
	(a) Metals (unspecified)	g	2.96277
	(a) Methane (CH4)	g	578.318
	(a) Nickel (Ni)	g	0.249955
	(a) Nitrogen Oxides (NOx as NO2)	g	778.879
	(a) Nitrous Oxide (N2O)	g	19.8295
	(a) Particulates (unspecified)	g	78.7993
	(a) Polycyclic Aromatic Hydrocarbons (PAH, unspecified)	g	0.0270135
	(a) Sulphur Oxides (SOx as SO2)	g	665.393
	(a) Zinc (Zn)	g	0.674172
	(ar) Radioactive Substance (unspecified)	kBq	527428
	(w) Aluminium (Al3+)	g	16.4191
	(w) Ammonia (NH4+, NH3, as N)	g	1.7372
	(w) AOX (Adsorbable Organic Halogens)	g	0.00697122
	(w) Aromatic Hydrocarbons (unspecified)	g	0.926439
	(w) Arsenic (As3+, As5+)	g	0.0312329
	(w) Barium (Ba++)	g	3.47644
	(w) BOD5 (Biochemical Oxygen Demand)	g	119.703
	(w) Cadmium (Cd++)	g	0.00220144
	(w) Chlorides (Cl-)	g	729.227
	(w) Chlorinated Matter (unspecified, as Cl)	g	0.00201799
	(w) Chromium (Cr III, Cr VI)	g	0.166025
	(w) COD (Chemical Oxygen Demand)	g	683.363
	(w) Copper (Cu+, Cu++)	g	0.0756745
	(w) Cyanides (CN-)	g	0.00380665
	(w) Dissolved Organic Carbon (DOC)	g	1.20162
	(w) Iron (Fe++, Fe3+)	g	18.5288
	(w) Lead (Pb++, Pb4+)	g	0.176574
	(w) Mercury (Hg+, Hg++)	g	0.000297653
	(w) Metals (unspecified)	g	7.61331
	(w) Molybdenum (Mo II, Mo III, Mo IV, Mo V, Mo VI)	g	0.115576
	(w) Nickel (Ni++, Ni3+)	g	0.0779676
	(w) Nitrates (NO3-)	g	1059.44
	(w) Nitrogenous Matter (unspecified, as N)	g	4.41205
	(w) Oils (unspecified)	g	27.6097
	(w) Phenol (C6H5OH)	g	0.140342
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g	0.294829
	(w) Phosphorous Matter (unspecified, as P)	g	1.29335
	(w) Polycyclic Aromatic Hydrocarbons (PAH, unspecified)	g	0.0120621
	(w) Salts (unspecified)	g	720.054
	(w) Sulphates (SO4--)	g	765.917
	(w) Sulphides (S--)	g	0.0279308
	(w) Suspended Matter (unspecified)	g	280.683
	(w) TOC (Total Organic Carbon)	g	95.3957
	(w) Toluene (C6H5CH3)	g	0.122455
	(w) Water: Chemically Polluted	litre	3077.43
	(w) Zinc (Zn++)	g	0.163732
	(wr) Radioactive Substance (unspecified)	kBq	4815.65
	Cardboard	kg	458.633
	Recovered Matter (total)	kg	29.3984
	Recovered Matter: Cardboard	kg	29.3984
	Waste (municipal and industrial)	kg	44.8543
	Waste (total)	kg	44.8915
	Waste: Mineral (inert)	kg	0.0371493

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	Classification	Units	Charact-erisation	Environmental impact
Methods	CML-Air Acidification	g eq. H+	/	4.4E+01
	(a) Ammonia (NH3)	g eq. H+	17	6.2E+00
	(a) Hydrogen Chloride (HCl)	g eq. H+	36.5	1.6E-01
	(a) Hydrogen Fluoride (HF)	g eq. H+	20	3.3E-02
	(a) Hydrogen Sulphide (H2S)	g eq. H+	17	1.1E-03
	(a) Nitrogen Oxides (NOx as NO2)	g eq. H+	46	1.7E+01
	(a) Sulphur Oxides (SOx as SO2)	g eq. H+	32	2.1E+01
	CML-Eutrophication	g eq. PO4	*	1.3E+02
	(a) Nitrogen Oxides (NOx as NO2)	g eq. PO4	0.13	1.0E+02
	(a) Nitrous Oxide (N2O)	g eq. PO4	0.27	5.4E+00
	(w) Ammonia (NH4+, NH3, as N)	g eq. PO4	0.42	7.3E-01
	(w) COD (Chemical Oxygen Demand)	g eq. PO4	0.022	1.5E+01
	(w) Nitrogenous Matter (unspecified, as N)	g eq. PO4	0.42	1.9E+00
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	g eq. PO4	3.06	9.0E-01
	(w) Phosphorous Matter (unspecified, as P)	g eq. PO4	3.06	4.0E+00
	CST-Aquatic Eco-toxicity	eq. Zn water	*	1.1E+01
	(a) Cadmium (Cd)	eq. Zn water	79	8.4E-01
	(a) Lead (Pb)	eq. Zn water	1.28	3.3E-02
	(a) Mercury (Hg)	eq. Zn water	196	1.2E+00
	(a) Nickel (Ni)	eq. Zn water	0.12	3.0E-02
	(a) Zinc (Zn)	eq. Zn water	0.076	5.1E-02
	(w) Arsenic (As3+, As5+)	eq. Zn water	0.52	1.6E-02
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Zn water	0.00013	1.6E-02
	(w) Cadmium (Cd++)	eq. Zn water	520	1.1E+00
	(w) Chromium (Cr III, Cr VI)	eq. Zn water	2.6	4.3E-01
	(w) Copper (Cu+, Cu++)	eq. Zn water	5.2	3.9E-01
	(w) Lead (Pb++, Pb4+)	eq. Zn water	5.2	9.2E-01
	(w) Mercury (Hg+, Hg++)	eq. Zn water	1300	3.9E-01
	(w) Nickel (Ni++, Ni3+)	eq. Zn water	0.79	6.2E-02
	(w) Oils (unspecified)	eq. Zn water	0.13	3.6E+00
	(w) Phenol (C6H5OH)	eq. Zn water	15.4	2.2E+00
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Zn water	0.01	2.9E-03
	(w) Zinc (Zn++)	eq. Zn water	1	1.6E-01
	CST-Human Toxicity	eq. Pb air	*	6.6E+02
	(a) Benzene (C6H6)	eq. Pb air	0.012	1.5E-02
	(a) Cadmium (Cd)	eq. Pb air	19000	2.0E+02
	(a) Carbon Monoxide (CO)	eq. Pb air	0.00014	2.9E-02
	(a) Lead (Pb)	eq. Pb air	2300	5.9E+01
	(a) Mercury (Hg)	eq. Pb air	46000	2.7E+02
	(a) Nickel (Ni)	eq. Pb air	370	9.2E+01
	(a) Nitrogen Oxides (NOx as NO2)	eq. Pb air	0.002	1.6E+00
	(a) Particulates (unspecified)	eq. Pb air	0.0075	5.9E-01
	(a) Sulphur Oxides (SOx as SO2)	eq. Pb air	0.0075	5.0E+00
	(a) Zinc (Zn)	eq. Pb air	27	1.8E+01
	(w) Arsenic (As3+, As5+)	eq. Pb air	1.5	4.7E-02
	(w) BOD5 (Biochemical Oxygen Demand)	eq. Pb air	0.022	2.6E+00
	(w) Cadmium (Cd++)	eq. Pb air	3.2	7.0E-03
	(w) Chromium (Cr III, Cr VI)	eq. Pb air	0.62	1.0E-01
	(w) Copper (Cu+, Cu++)	eq. Pb air	0.022	1.7E-03
	(w) Lead (Pb++, Pb4+)	eq. Pb air	0.86	1.5E-01
	(w) Mercury (Hg+, Hg++)	eq. Pb air	7.8	2.3E-03
	(w) Nickel (Ni++, Ni3+)	eq. Pb air	0.062	4.8E-03
	(w) Phenol (C6H5OH)	eq. Pb air	0.052	7.3E-03
	(w) Phosphates (PO4 3-, HPO4--, H2PO4-, H3PO4, as P)	eq. Pb air	3.20E-06	9.4E-07
	(w) Zinc (Zn++)	eq. Pb air	0.0032	5.2E-04
	CST-Terrestrial Eco-toxicity	eq. Zn air	*	3.8E-01
	(a) Cadmium (Cd)	eq. Zn air	3.14	3.3E-02
	(a) Lead (Pb)	eq. Zn air	0.13	3.3E-03
	(a) Mercury (Hg)	eq. Zn air	5.94	3.5E-02
	(a) Nickel (Ni)	eq. Zn air	0.35	8.7E-02
	(a) Zinc (Zn)	eq. Zn air	0.33	2.2E-01
	EB(R*Y)-Depletion of non renewable resources	yr-1	*	9.6E+00
	(r) Coal (in ground)	yr-1	0.0005037	4.6E-03
	(r) Iron (Fe, ore)	yr-1	0.04	3.7E-06
	(r) Lignite (in ground)	yr-1	0.0005037	4.2E-03
	(r) Natural Gas (in ground)	yr-1	0.117	7.4E+00
	(r) Oil (in ground)	yr-1	0.0557	1.1E+00
	(r) Uranium (U, ore)	yr-1	181	1.1E+00
	ETH-Air Acidification	g eq. H+	/	4.4E+01
	(a) Ammonia (NH3)	g eq. H+	17	6.2E+00
	(a) Hydrogen Chloride (HCl)	g eq. H+	36.5	1.6E-01
	(a) Hydrogen Fluoride (HF)	g eq. H+	20	3.3E-02
	(a) Hydrogen Sulphide (H2S)	g eq. H+	17	1.1E-03
	(a) Nitrogen Oxides (NOx as NO2)	g eq. H+	46	1.7E+01
	(a) Sulphur Oxides (SOx as SO2)	g eq. H+	32	2.1E+01
	IPCC-Greenhouse effect (direct, 100 years)	g eq. CO2	*	2.7E+05
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	2.5E+05
	(a) Halon 1301 (CF3Br)	g eq. CO2	6900	3.0E+01
	(a) Methane (CH4)	g eq. CO2	24	1.4E+04
	(a) Nitrous Oxide (N2O)	g eq. CO2	360	7.1E+03
	IPCC-Greenhouse effect (direct, 20 years)	g eq. CO2	*	2.9E+05
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	2.5E+05
	(a) Halon 1301 (CF3Br)	g eq. CO2	7900	3.5E+01
	(a) Methane (CH4)	g eq. CO2	64	3.7E+04
	(a) Nitrous Oxide (N2O)	g eq. CO2	330	6.5E+03
	IPCC-Greenhouse effect (direct, 500 years)	g eq. CO2	*	2.6E+05
	(a) Carbon Dioxide (CO2, fossil)	g eq. CO2	1	2.5E+05
	(a) Halon 1301 (CF3Br)	g eq. CO2	2700	1.2E+01
	(a) Methane (CH4)	g eq. CO2	7.5	4.3E+03
	(a) Nitrous Oxide (N2O)	g eq. CO2	190	3.8E+03
	USES 1.0-Aquatic Ecotoxicity	g eq. 1-4-dichlorobenzene	*	1.5E+02
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.0013	1.7E-03
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	320	5.9E-03
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130	1.4E+00
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	1.2	3.1E-02
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	16000	9.5E+01
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	80	2.0E+01
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	2.6	1.8E+00
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	190	5.9E+00
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	4500	9.9E+00
	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	84	1.4E+01
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.86	1.4E-01
	USES 1.0-Human Toxicity	g eq. 1-4-dichlorobenzene	*	6.7E+03
	(a) Ammonia (NH3)	g eq. 1-4-dichlorobenzene	16	1.7E+03
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	29	3.7E+01
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	3700	6.8E-02
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	23000	2.4E+02
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	67000	1.7E+03
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	29000	1.7E+02
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	9800	2.4E+03
	(a) Nitrogen Oxides (NOx as NO2)	g eq. 1-4-dichlorobenzene	0.26	2.0E+02
	(a) Sulphur Oxides (SOx as SO2)	g eq. 1-4-dichlorobenzene	0.16	1.1E+02
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	0.63	4.2E-01
	(w) Ammonia (NH4+, NH3, as N)	g eq. 1-4-dichlorobenzene	17	3.0E+01
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	51	1.6E+00
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	130	2.9E-01
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.1	8.3E-02
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	0.026	4.6E-03
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	18000	5.4E+00
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	63	4.9E+00

Plastics and PCBs recovered: Materials production stage: Cardboard production

LIFE CYCLE INVENTORY

LIFE CYCLE ENVIRONMENTAL IMPACT ASSESSMENT

	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	0.89	1.2E-01
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.053	6.5E-03
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	0.058	9.5E-03
	USES 1.0-Terrestrial Ecotoxicity	g eq. 1-4-dichlorobenzene	*	2.0E+06
	(a) Benzene (C6H6)	g eq. 1-4-dichlorobenzene	0.063	8.0E-02
	(a) Benzo(a)pyrene (C20H12)	g eq. 1-4-dichlorobenzene	64000000	1.2E+03
	(a) Cadmium (Cd)	g eq. 1-4-dichlorobenzene	130000000	1.4E+06
	(a) Lead (Pb)	g eq. 1-4-dichlorobenzene	11000	2.8E+02
	(a) Mercury (Hg)	g eq. 1-4-dichlorobenzene	13000000	7.8E+04
	(a) Nickel (Ni)	g eq. 1-4-dichlorobenzene	190000	4.7E+04
	(a) Zinc (Zn)	g eq. 1-4-dichlorobenzene	660000	4.4E+05
	(w) Arsenic (As3+, As5+)	g eq. 1-4-dichlorobenzene	9.70E-06	3.0E-07
	(w) Cadmium (Cd++)	g eq. 1-4-dichlorobenzene	0.025	5.5E-05
	(w) Chromium (Cr III, Cr VI)	g eq. 1-4-dichlorobenzene	1.10E-05	1.8E-06
	(w) Copper (Cu+, Cu++)	g eq. 1-4-dichlorobenzene	1.00E-05	7.6E-07
	(w) Lead (Pb++, Pb4+)	g eq. 1-4-dichlorobenzene	2.00E-07	3.5E-08
	(w) Mercury (Hg+, Hg++)	g eq. 1-4-dichlorobenzene	8200000	2.4E+03
	(w) Nickel (Ni++, Ni3+)	g eq. 1-4-dichlorobenzene	3.10E-05	2.4E-06
	(w) Phenol (C6H5OH)	g eq. 1-4-dichlorobenzene	34	4.8E+00
	(w) Toluene (C6H5CH3)	g eq. 1-4-dichlorobenzene	0.022	2.7E-03
	(w) Zinc (Zn++)	g eq. 1-4-dichlorobenzene	2.50E-05	4.1E-06
	WMO-Depletion of the ozone layer (high)	g eq. CFC-11	*	7.6E-02
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	17.2	7.6E-02
	WMO-Depletion of the ozone layer (low)	g eq. CFC-11	*	4.4E-02
	(a) Halon 1301 (CF3Br)	g eq. CFC-11	10	4.4E-02
	WMO-Photochemical oxidant formation (high)	g eq. ethylene	*	2.4E+02
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	1.285	1.6E+00
	(a) Benzene (C6H6)	g eq. ethylene	0.45	5.7E-01
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.799	2.2E+02
	(a) Methane (CH4)	g eq. ethylene	0.03	1.7E+01
	WMO-Photochemical oxidant formation (low)	g eq. ethylene	*	5.5E+01
	(a) Aromatic Hydrocarbons (unspecified)	g eq. ethylene	0.481	6.1E-01
	(a) Benzene (C6H6)	g eq. ethylene	0.11	1.4E-01
	(a) Hydrocarbons (except methane)	g eq. ethylene	0.195	5.5E+01
	(a) Methane (CH4)	g eq. ethylene	0	0.0E+00

Appendix 4: Results of the sensitivity analysis

	Sensitivity analysis	Original	1	2	3	4	5	6	7
		For assumptions, see Appendix 1.	Pallets occupy 50% more floor space than estimated	consumption in collection centres (originally 50% below best practice)	Collection centres use oil-based heating system (originally natural gas)	Only 40% non-mettallic materials removed from PCBs in shredding (80% originally)	Only 45% of copper cabling assumed to be copper (90% originally)	One half of printers resold in maintenance enter reuse (one third originally)	50% underestimation of unknown transport distances
Environmental impact	**Units**	**Recovery**							
CST-Aquatic Eco-toxicity	eq. Zn water	2.43E+04	2.43E+04	2.43E+04	2.44E+04	2.43E+04	2.52E+04	2.43E+04	2.43E+04
CST-Human Toxicity	eq. Pb air	5.02E+05	5.03E+05	5.02E+05	5.11E+05	5.06E+05	5.05E+05	5.02E+05	5.04E+05
CST-Terrestrial Eco-toxicity	eq. Zn air	2.00E+02	2.00E+02	2.00E+02	2.01E+02	2.01E+02	1.83E+02	1.80E+02	2.10E+02
EB(R*Y)-Depletion of non renewable resources	yr-1	9.56E+02	9.63E+02	9.51E+02	9.49E+02	9.55E+02	9.15E+02	9.55E+02	9.56E+02
ETH-Air Acidification	g eq. H+	4.61E+03	4.62E+03	4.61E+03	4.76E+03	4.64E+03	3.75E+03	4.61E+03	4.90E+03
CML-Eutrophication	g eq. PO4	9.35E+03	9.37E+03	9.34E+03	9.42E+03	9.45E+03	9.11E+03	9.35E+03	1.08E+04
IPCC-Greenhouse effect (direct, 100 years)	g eq. CO2	3.93E+07	3.94E+07	3.92E+07	3.95E+07	3.94E+07	3.87E+07	3.92E+07	4.02E+07
IPCC-Greenhouse effect (direct, 20 years)	g eq. CO2	4.14E+07	4.16E+07	4.13E+07	4.17E+07	4.14E+07	4.08E+07	4.12E+07	4.23E+07
IPCC-Greenhouse effect (direct, 500 years)	g eq. CO2	3.83E+07	3.85E+07	3.82E+07	3.85E+07	3.85E+07	3.78E+07	3.83E+07	3.92E+07
USES 1.0-Aquatic Ecotoxicity	g eq. 1-4-dichlorobenzene	1.25E+05	1.25E+05	1.25E+05	1.25E+05	1.25E+05	1.29E+05	1.25E+05	1.25E+05
USES 1.0-Human Toxicity	g eq. 1-4-dichlorobenzene	5.93E+06	5.93E+06	5.93E+06	6.02E+06	6.02E+06	5.74E+06	5.92E+06	5.95E+06
USES 1.0-Terrestrial Ecotoxicity	g eq. 1-4-dichlorobenzene	7.20E+08	7.20E+08	7.20E+08	7.41E+08	7.22E+08	6.63E+08	6.54E+08	7.43E+08
WMO-Depletion of the ozone layer (high)	g eq. CFC-11	2.77E+00	2.77E+00	2.77E+00	3.10E+00	2.77E+00	1.89E+00	2.77E+00	2.77E+00
WMO-Depletion of the ozone layer (low)	g eq. CFC-11	1.61E+00	1.61E+00	1.61E+00	1.80E+00	1.61E+00	1.10E+00	1.61E+00	1.61E+00
WMO-Photochemical oxidant formation (high)	g eq. ethylene	1.55E+04	1.55E+04	1.54E+04	1.61E+04	1.55E+04	1.45E+04	1.54E+04	1.64E+04
WMO-Photochemical oxidant formation (low)	g eq. ethylene	4.91E+03	4.93E+03	4.89E+03	5.00E+03	4.92E+03	4.70E+03	4.90E+03	5.14E+03
Environmental impact	**Units**	**Landfill**							
CST-Aquatic Eco-toxicity	eq. Zn water	6.89E+03					6.15E+03		6.89E+03
CST-Human Toxicity	eq. Pb air	3.87E+05					2.86E+05		3.87E+05
CST-Terrestrial Eco-toxicity	eq. Zn air	1.26E+03					1.12E+03		1.26E+03
EB(R*Y)-Depletion of non renewable resources	yr-1	2.08E+06					1.30E+06		2.08E+06
ETH-Air Acidification	g eq. H+	1.38E+04					1.17E+04		1.38E+04
CML-Eutrophication	g eq. PO4	8.10E+03					6.03E+03		8.24E+03
IPCC-Greenhouse effect (direct, 100 years)	g eq. CO2	3.81E+07					2.89E+07		3.80E+07
IPCC-Greenhouse effect (direct, 20 years)	g eq. CO2	4.92E+07					3.94E+07		4.91E+07
IPCC-Greenhouse effect (direct, 500 years)	g eq. CO2	3.34E+07					2.46E+07		3.35E+07
USES 1.0-Aquatic Ecotoxicity	g eq. 1-4-dichlorobenzene	3.36E+04					3.03E+04		3.36E+04
USES 1.0-Human Toxicity	g eq. 1-4-dichlorobenzene	6.96E+06					6.35E+06		6.96E+06
USES 1.0-Terrestrial Ecotoxicity	g eq. 1-4-dichlorobenzene	4.28E+09					3.51E+09		4.28E+09
WMO-Depletion of the ozone layer (high)	g eq. CFC-11	5.31E+00					4.18E+00		5.31E+00
WMO-Depletion of the ozone layer (low)	g eq. CFC-11	3.09E+00					2.43E+00		3.09E+00
WMO-Photochemical oxidant formation (high)	g eq. ethylene	2.00E+04					1.56E+04		1.98E+04
WMO-Photochemical oxidant formation (low)	g eq. ethylene	3.36E+03					1.86E+03		3.33E+03

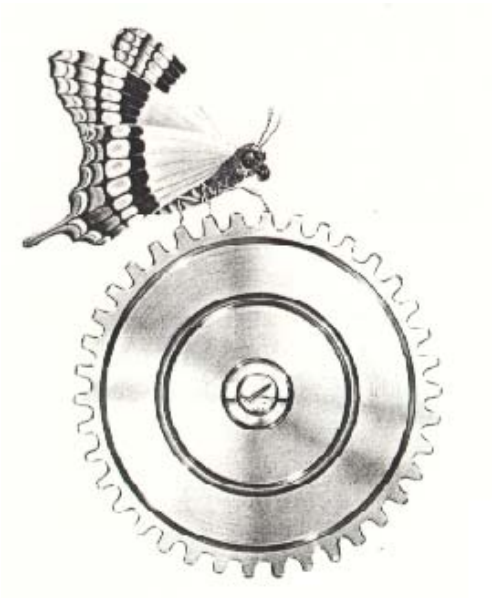
Appendix 5: Inventory of printer trade-in costs

Printer trade-in activity / sub-process	Total cost / revenue	% of total cost / revenue	Collection & reverse distributio	Processing cost	End processing cost	Chennal manageme nt cost
Costs						
Management & administration	£3,260	18%		£1,020		£2,240
Sorting	£2,210	12%		£2,210		
Refurbishment	£2,340	13%		£2,340		
Dismantling	£3,940	22%		£3,940		
Recycling / waste disposal	£1,340	6%		£1,250	£99.70	
Storage	£200	1%		£200		
Transport	£3,030	17%	£3,030			
Sales commission	£1,740	10%			£1,740	
Profit share	£0.00					
Total cost	£18,100	100%	£3,030	£11,000	£1,840	£2,240
% of total cost	100%		17%	61%	10%	12%
Cost per unit (3261 units)	£5.54		£0.93	£3.36	£0.56	£0.69
Cost per collection (9)	£2,010		£337	£1,220	£204	£249
Cost per Kg (21,642)	£0.83		£0.14	£0.51	£0.08	£0.10
Revenues						
Revenue on product resale	£6,610	37%				
Net revenue from material recycling	£330	2%				
Customer revenue / funding	£11,100	61%				
Compliance funding	£0.00					
Total revenue	£18,100					
Net profit	£0.00					

Brunel and Surrey Engineering Doctorate Programme in Environmental Technology

Chapter 2, Vol. 1

An Investigation of the Implications and Effectiveness of Producer Responsibility for the Disposal of WEEE.



The use and disposal of IT products in the commercial sector

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Abstract

New European environmental legislation requiring producers to recycle electrical and electronics products at so-called "end-of-life" is likely to introduce new areas of competition to the global market for IT products.

This report presents the findings of a study investigating the use and disposal of IT equipment by 151 companies in the UK. Although 80% of companies disposed of their equipment as waste, other "disposal" routes were found to be of greater significance, such as charitable donations, transfer to employees, and resale to second-hand dealers. Therefore it is argued that the current legal definition of "waste" may be too restrictive to be applied to end-of-life IT equipment within the commercial sector.

Markets for new products were found to be limited, as only 5% of companies replaced IT products within 2 years. In contrast, 76% of respondents identified a need for improved services to manage their redundant IT equipment. Therefore, it is argued that the provision of product "end-of-life management" services to commercial customers (in compliance with legislation or otherwise) could help IT producers add-value to their services beyond the immediate production and consumption of new technologies. Specific details of the type of services that would be required have also been investigated, and are evaluated within.

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Please see Appendix 1 for a statement of contributions to this project

Contents

Foreword

This report presents a study investigating patterns of the use and disposal IT equipment by companies in the UK, forming the second chapter of the first volume of the Research Engineer's project Portfolio (Chapter 2, Vol. 1). The research has been completed as part of the Engineering Doctorate programme in Environmental Technology at Brunel and Surrey Universities. The previous chapter in this thesis (Chapter 1, Vol. 1) presented the findings of a study investigating the environmental impact and costs to producers of the proposed WEEE Directive using Life Cycle Assessment and Costing methods. In next chapter (Chapter. 3, Vol. 1), research investigating patterns of use and disposal of household appliances in the UK is presented. An overall summary of the portfolio, including reader's guidelines, is presented in the Executive Summary, Vol. 1.

1. Introduction

This report focuses on the use and disposal of IT equipment within the commercial business-to-business market sector. As the European Commission have now proposed new environmental legislation forcing producers of electrical and electronic equipment[1] to organise the collection, treatment, and recycling of their equipment at "*end-of-life*" (COM[2000] 347 – 2000/0158[COD]), this in an area of increasing concern to the IT sector.

The research has been completed as part of the Engineering Doctorate programme in Environmental Technology at Brunel and Surrey Universities. This report forms the second volume of the first part of the Research Engineer's project Portfolio (Chapter 2, Vol. 1).

This "*Producer Responsibility*" legislation has been under development since the early nineties, and has been deployed in many developed nations worldwide. The European Union has already implemented Producer Responsibility Directives on packaging wastes (94/62 EC), batteries (91/157 EEC), and automobiles (2000/53/EC). For a more comprehensive evaluation, see Mayers and France (1999).

Producer Responsibility is a market-based instrument of government policy. It is based on the principle that the "*polluter pays*". By internalising the external costs of environmental degradation (in this case waste disposal) to the costs of products and services, it has been argued that consumers would be encouraged to adopt purchasing habits "*better*" for the environment and society (Jacobs, 1991; Pearce, 1992).

Waste Electrical and Electronic Equipment end-of-life equipment has been defined as:

> *"…electrical or electronic equipment which is waste within the meaning of Article 1(a)of Directive 75/442/EEC, including all components, sub-assemblies and consumables, which are part of the product at the time of discarding; comes from private households and from commercial, industrial, institutional and other sources which, because of its nature and quantity, is similar to that from private households;"* - COM[2000] 347 – 2000/0158[COD]: Article 3

Using the example of the use and disposal of IT equipment in the UK commercial sector, this report argues that this view belies important and complex post-sales behaviours. Any financial benefits created by opportunities for environmental improvement from such legislation may therefore be limited.

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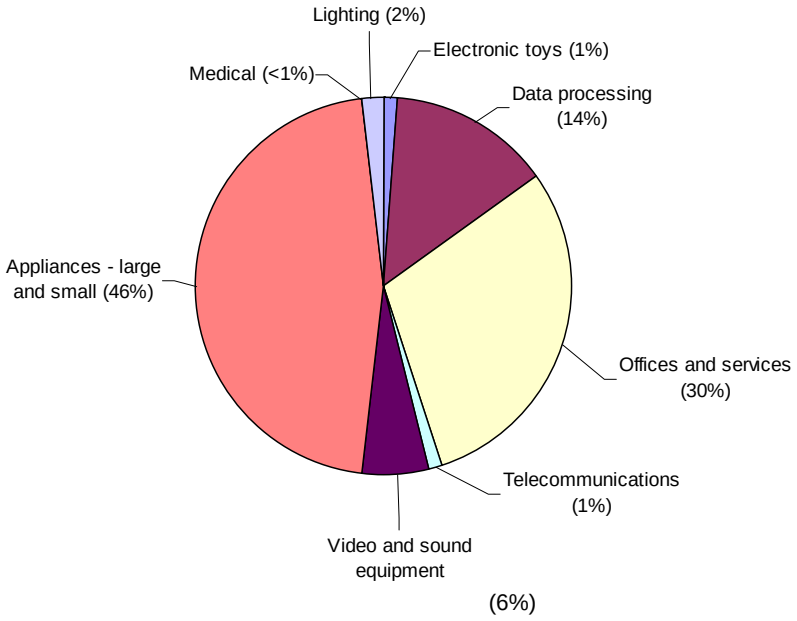
1 EU definition "*equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields*" (DG XI.E3/FE D[97]).

As a background to the research, current understanding on the use and disposal of electrical and electronic equipment, and of IT products within the commercial sector, is discussed in Sections 1.1 and 1.2 below. Finally in Section 1.3, the research study is outlined.

1.1 The disposal of WEEE in the UK

In the UK it has been estimated that around 12 million items of electrical and electronic equipment reach "end-of-life" each year (DOE, 1995). Estimates on the total mass of this waste vary between 0.65-0.9 million tonnes/yr. (ICER, 1998 [a]), which is only 1.3-1.7% by mass of industrial, commercial, and domestic wastes, and only 0.15-0.21% by mass of total wastes arising each year (*op cit.*, 1995). Large and small appliances (domestic or "white" goods such as toasters and refrigerators) make up the largest proportion of this waste stream at 46% by mass, and telecommunications and medical equipment the smallest at only 1% by mass or less (as shown in Fig. 1.1 below). Information Technology, office imaging, and telecommunications goods ("grey" goods) together account for 45% of the waste stream whereas videos, sound equipment, and televisions ("brown" goods) only make up 6% by mass.

Figure 1.1: Electrical and electronic waste arising in the UK (percentage by mass)



Source: ICER (1998[a]:1)

By mass, approximately 75-90% of "white goods", 8% of "grey goods", and 6% of "brown goods" are presently recycled (ICER, 1998 [b]; Poll, 1993). It has been assumed that the remaining "end-of-life" electrical and electronic equipment is either sent to landfill or incinerated (DOE, 1995). However, as these estimates are based on market volumes and average product life expectancies, they do not necessarily reflect actual

quantities of electronic appliances recycled, landfilled, or incinerated. For example, in the United States it has been suggested that up to 75% of "end-of-life" electronic products are held in storage e.g. in warehouses or homes prior to final disposal (Pitts, 1996). Similarly a recent survey on take-back of mobile phones in the UK and Sweden showed that 55% and 47% of people (respectively) retained their old mobile phones after they had finished using them, as they believed they still had some value (ECTEL, 1997).

In the UK, various pilot WEEE recycling schemes have been completed in preparation for Producer Responsibility legislation (see Table 1.1). Complicated patterns in the use and disposal of electronic products appear to have limited the success of these pilots. For example, a project completed by the European Telecommunications and Professional Electronics Industries (ECTEL) group only recovered around 1% by mass of products sold two years previously through retail outlets in the UK and Sweden (ECTEL, 1997).

Table 1.1: Electronics recycling pilots in the UK

Scheme	Location	Project duration and date	Products collected	Coverage	Quantity recovered (tonnes)	% of equipment reaching end-of-life	Ref-erences
ECTEL (European Telecommunicatio ns and Professional Electronics Industry)	UK and Sweden	6 months (1997)	Mobile phones	110 retail outlets in the UK	5633(UK) 879 (Sweden)	<1%	ECTEL 1997
EMERG (the Electronic Manufacturers Recycling Group)	Lothian region and Edinburgh	15 months (1996)	Mainly IT and office equipment. Some domestic appliances.	128 workplaces, 5 civic amenity sites	107	<1%†	LEEP 1997
ICER (the Industry Council for Electronic Recycling)	West Sussex and Croydon	19 months (1995 to 1997)	Mainly domestic appliances.	Civic amenity sites, and doorstep collections using grey bags.	27	Approxim-ately 2%†	Inform-ation provided by ICER 1998.
SWAP (Save Waste and Prosper)	Leeds, Bradford, and the Humber	6 months (1998)	Information technology	Larger organisations and companies	17	Un-known	SWAP 1998 (a)

†Assuming 9.25 kg electronics waste per person per year. Assuming 0.75 million tonnes total WEEE per year, 70% from domestic sector - 48% domestic appliances & assumed 50% data / office products arising in the home (ICER, 1998 [a]). Total population of Great Britain 56.75 million (Regional Trends, 1996).

For both domestic and commercial sectors, very little information is available on the use and disposal of end-of-life electronic equipment. The few social and market research studies available have revealed that people can deal with their end-of-life products in a variety of ways (as shown in Table 1.2). Some researchers similarly investigating consumer disposal (Boyd *et al.*, 1996) and post-sales behaviours (Harrell and M^{c}Concha,

1992) for durable products have argued that these activities have substantial implications for policy-making, marketing, product development, and logistics planning. These authors suggest that better understanding of such post-sales behaviours could create opportunities to develop products and services of better value to customers. However, research in these areas to date has not been statistically representative on any large scale, and has generally focused on specific regions, product types, or operations.

Extensive market and social research has been undertaken on domestic recycling programmes (including paper, aluminium, and glass recycling). However, this has focused on attitudinal, motivational, and behavioural factors of public participation, primarily to evaluate how recycling activities can be incentivised and increased (as reported in Schultz *et al.*, 1995; Thørgesen, 1996). The use and disposal of IT products is discussed more specifically below.

Table 1.2: End-of-life pathways of electronic products in households and businesses

Household end-of-life options	*Business end-of-life options*
(a) Sell privately second-hand (b) Give to family and friends (c) Store within the home (d) Return to retailers and manufacturers (e) Take to local authority civic amenity sites as "scrap" for recycling (f) Dispose of as waste	(a) Transfer or sell to employees (b) Dispose of as waste (c) Donate to public institutions, charities, and schools (d) Sell to second-hand brokers (e) Return to manufacturers or distributors (f) Dispose of as waste (g) Store in offices or warehouse
Sources: 1. ECTEL (1997) 2. VROM Miniserie (1993) in Voute (1994) 3. Information on commercial research also provided by Domestic and General, Comet, and ICER (1998)	**Sources:** 1. The Corporation of London (1996) 2. SWAP (1998 [b]) 3. Information on commercial research also provided by Hewlett-Packard GmbH (1997)

1.2 Current patterns of use and disposal for IT products

Below, the processes by which IT products may reach end-of-life are outlined. This description has been put together from an evaluation of studies conducted to date, and discussions with industry experts including IT producers, waste and recycling officers within local authorities, electronics recyclers, computer brokers, and charitable organisations:

I. IT manufacturers may sell products to customers in domestic or commercial markets. They may also sell their products directly through their own retail channels, or through distributors. Methods of distribution may include:

- Wholesalers and distributors
- Value added resellers
- Dealers
- Mail order
- Retailers
- Internet

II. From discussions with UK and European environmental and recycling managers of 11 of the largest IT producers[2], it was determined that IT companies themselves generate electronics waste internally from manufacturing, repair work, product returns, and internal equipment use. Typically a company may recycle this through their own recycling centres, or through sub-contracted service providers.

III. Once products reach "end-of-life" in the commercial sector they may be (The Corporation of London, 1996; Pitts, 1996):

- Held in storage
- Returned to supplier or lessor
- Sold to dealers or brokers
- Sold or removed by employees
- Donated to charity
- Sold to scrap merchants
- Disposed of as waste
- Removed by a third party

IV. Large organisations themselves may provide a market for second hand IT equipment, alongside non-commercial organisations such as churches, charities, and schools[3], and domestic users of second-hand equipment (Roy, 1991; Bylinsky, 1995).

V. In the domestic sector it has been assumed that products may pass from friends and family in stages of subsequent use e.g. from parents to children or close relatives. After periods of use products may be stored or may be sold second hand either privately or through specialist dealers. Finally products may be disposed of as general waste (if small enough to fit into a bin), may be taken to a civic amenity site for disposal, or may be illegitimately disposed of in builder's skips or "fly tipped" [4].

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[2] Discussions held at a meeting attended and organised by the author (the names of companies have been withheld for reasons of confidentiality).
[3] Discussion with 2 electronics recycling companies and the coordinator of a UK collective of "charitable recyclers", also based on information provided by Hewlett-Packard GmbH (1997).
[4] Based on discussions with 4 local authority waste and recycling officers (1997)

VI. Electronics waste is produced from all the stages of IT product use and disposal described in I to V above. This will be either disposed of in landfill, or collected by recyclers e.g. either through direct contract with specialist recyclers, through intermediate scrap brokers, or through "*totters*" (individuals who salvage electronics scrap from civic amenity sites for recycling or resale)[5].

The term "*end-of-life*" and the classification of used electrical and electronic appliances as waste appears to be based on the assumption that there is a "*point*" at which these products must be disposed of. However, this does not account for the fact that they may enter waste streams through more complex mechanisms and processes at end-of-life. This research has been undertaken to investigate and gain a more detailed understanding of the use and disposal of IT equipment within the commercial sector. An outline of the research has been provided below.

1.3 Research outline

This study examines the use and disposal of IT equipment in the UK commercial sector, including:

- PCs and computers
- Printers and peripherals
- Mainframes and servers
- Office imaging equipment
- Telecommunications
- Point-of-sale equipment

This list has been selected for study as it includes the main categories of electronic equipment used by businesses (as explained below in Section 1.2). The commercial sector has been selected because it is the most lucrative area for producer-organised end-of-life management services due to the potential volumes and resale value of equipment.

Overall, the aim of this survey was to investigate the use and disposal of IT products sold into the commercial market, and to investigate the effectiveness of different solutions aimed at increasing recycling or extending product use (through reuse). The objectives of this research were to investigate:

1. The causes of product end-of-life
2. How end-of-life equipment is currently managed
3. The likely effectiveness of different end-of-life management services

As described above, it has been estimated that around 650,000 - 900,000 tonnes of electrical and electronic equipment reaches end-of-life each year in the UK (ICER, 1998 [a]). This may cost the electronics industry a predicted £100 million per year under future Producer Responsibility legislation for WEEE (Roy, 1990). In the context of the

[5] Information provided by ICER, Domestic and General, and Comet (1997)

development and adoption of Producer Responsibility approaches world wide, the results of this study are of relevance for IT producers internationally.

The methodology used in this study is detailed in Section 2. This is followed by an analysis of results in Section 3, and a discussion of results in Section 4. Finally, the conclusions of the study are presented in Section 5.

2. Methodology

In this section, the methodology used in this research is described in detail. This includes sections on considerations for methodology development, sampling, survey method, the pilot survey, and statistical methods used.

2.1 Considerations for methodology development

While a wide variety of research has been carried out on behavioural and motivational factors in waste disposal and recycling within communities (as reported in Schultz *et al.*, 1995; Thørgesen, 1996), generally it appears very little research has been conducted on waste management and recycling within organisations:

> *"...although there are many anecdotal reports about recycling efforts in the commercial sector, no systematic empirical studies have described and evaluated this important domain of recycling activity."* - Oskamp *et al.*, 1994

Only two relatively recent empirical studies were found carried out in this area by the author (*op cit.*, 1994; Lee *et al.*, 1995). In developing the methodology used in this research, the methods used in a selection of environmentally related studies regarding purchasing, technology development, waste management, and stakeholder interests were reviewed from sociological, marketing, and environmental literature. In addition, two private commercial studies commissioned by the Corporation of London (1996) and Hewlett-Packard Limited[6] on the disposal of electronics waste by companies also served as useful references. Key issues for methodology development outlined in these surveys are described below.

2.1.1 Locating key informants

As environmental issues may affect a variety of activities and people within an organisation, the methods used to locate"key informants" for a particular study must be considered:

- IBM surveyed 75 people from 6 identified stakeholder categories in face-to-face interviews using contact lists available from within the company (Brink *et al.*, 1996).
- In a separate private study commissioned by Hewlett-Packard in Germany, a sample of 12 major commercial customers was used to investigate disposal of electronic equipment.
- Another study investigating research, design, and investment in UK companies, obtained key informants relevant for a mail survey from a list of 800 companies that

[6] Based on discussions with environmental managers at Hewlett-Packard (1997)

had expressed an interest to the UK Department of Trade and Industry (DTI) in a specific environmental technology programme. This sample included research and development directors and senior environmental executives in larger firms, and managing directors in smaller firms (Green *et al.*, 1994).

- One study of office recycling in Taiwan simply targeted the employees of 32 companies in the city of Tapei as sources of information on office recycling (Lee *et al.*, 1995).

In other studies where lists of established contacts were unavailable, telephone interviews were used alongside business listings to locate key informants within companies (Oskamp *et al.*, 1994; The Corporation of London, 1996).

2.1.2 Use of nationally representative samples

None of the studies reported that the samples used were *statistically* representative on a national basis. For example, a study of paper recycling in the Los Angeles County used a stratified sample of 112 companies (with 88% response rate) randomly drawn from a business listing containing 300 companies in the area (Oskamp *et al.*, 1994). Although this was likely to have been representative of the area under study, results were not representative on a national scale.

Another study used descriptive and bivariate analysis in combination with more sophisticated statistical techniques[7] to compare and interpret results. However, details of the statistical significance of the sample itself (employees drawn from 32 "selected" companies) were not reported (Lee *et al.*, 1995).

Overall, no systematic empirical studies could be found examining waste management behaviour within organisations on a nationally representative scale. Such research is essential in the development of effective government waste management policy.

2.1.3 Qualitative vs quantitative data

The surveys reviewed requested mostly qualitative information rather than quantitative data from respondents. This was due to the poor and unreliable quality of data available on waste and environmental issues. Through the pilot survey conducted in this study, it was clear that although key informants were frequently found to be responsible for the disposal of redundant IT equipment, records were not kept on the amount disposed. In these circumstances, where quantitative data is unavailable, the existence of certain behaviours can be determined quantitatively in terms of the number of companies with particular programmes in place, and qualitatively in terms of the frequency of disposal. For example, one study used a three-point scale ranging from "frequently" to "never" to investigate recycling behaviour in office settings (Lee *et al.*, 1995).

[7] Using metric factor analysis (with orthogonal varimax rotation) and a structural equation model known as LISREL.

The importance of using qualitative techniques was emphasised in a study of environmental purchasing criteria within businesses:

> *"Qualitative methods are essential to generate theory that is grounded in data in areas for which previous work is scant…"* - Drumwright (1994)

From a review of available literature it can be concluded that:

- Telephone inquiry can be an effective method of locating key informants within a company when specialised contact lists are unavailable.
- There is a need for greater statistical qualification of population samples if results are to be representative of wider populations.
- Qualitative information on environmental issues can enhance understanding of company trends and activities by helping to contextualise and evaluate findings based on quantitative data.

These findings have been used in the selection of the methodology used is this research, which is described in detail in the following section.

2.2 Sampling

This section discusses the sampling method used, including sample size determination and sample selection.

In scoping the research, IT products were defined as data processing, telecommunications, office imaging, and point-of-sale products (to avoid the introduction of new terminology or rarely used terms such as *"grey goods"*). This covers the main categories of electronic equipment used by large organisations. However, with the recent proliferation of mobile phones, the use and disposal of this equipment should be treated as a separate category in future research. Large organisations were determined as those with over 500 employees. This was believed to be an effective cut-off as it represented around 96% of the commercial IT market (excluding domestic and residential business markets, as shown in Table 2.1).

Table 2.1: Breakdown of UK IT Spend by Size of Business (% of value), 1995 and 1996

No. of employees per business	1995	1996	% Change Year-On-Year
0-500	4.2	3.9	-7.1
500-5000	32.8	31.8	-3.0
5000+	57.4	56.7	-1.2
Residential Individuals	5.6	7.6	+3.6
Total	100	100	

Source: Key Note (1997)

The survey focussed on organisations in the manufacturing, transport, distribution, finance, and public service sectors. Companies without significant interest in IT products (in the farming and agriculture, and mines and quarries industry, making up only around 4% of the market value, as shown in Table 2.2) were excluded from the research. In addition, companies that were involved in the IT or waste management industries (likely to already have significant involvement in collecting and managing the disposal of IT products from other companies) were also excluded from the study. Appendix 2 contains a specific breakdown of industry sectors excluded from the research by SIC code.

With the exclusion of smaller businesses and IT market sectors, it was estimated that this particular survey was representative of 90% of the commercial IT market. It was noted that residential business markets were growth areas (+3.6% year-on-year growth in 1996, as shown in Table 2.1), and so this emphasised the need for subsequent research in the domestic sector.

Having determined the population of interest, the selection of the most suitable sampling frame[8] is explained below.

Table 2.2: Breakdown of UK IT Business Spending (£000 and %), 1996

	Spend per Installation £000	% of Total Business Spend
Finance	12,248	24.5
Manufacturing	3,447	6.9
Retail/Distribution	4,639	9.3
Public Administration	4,442	8.9
Utilities	9,483	19.0
Computer Services	8,072	16.1
Process Industry	3,160	6.3
Education/Research	2,400	4.8
Other	2,133	4.3
Total	50,024	100

Source: Key Note (1997).

[8] The sampling frame refers to the list of possible survey participants from which the sample is selected (Parasuman, 1991).

2.2.1 Selection of sampling frame

The most important factor in choosing a sampling frame was inclusion of full contact details for each organisation (including address and telephone number). Secondly, the frame had to rank organisations by number of employees so an appropriate cut-off point could be selected (companies with less than 500 employees). Details of industry type were also needed to ensure that appropriate industry sectors could be eliminated from the study. Finally the sampling frame had to be complete i.e. must list all companies within the described population. Missing individuals or duplicate records within a sampling frame are sources of non-sampling error (known as non-coverage and over-coverage error; Churchill, 1996; Parasuraman, 1991), which should be reduced to a minimum.

Sample frames shortlisted included:

- 2 business directories (Dunn and Bradstreet, 1997; UKs 10,000 Largest Companies, 1996)
- The Electronic Yellow Pages (*http://www.yell.co.uk*)
- 1 trade body directory (Kompass CD Book, 1996)
- Hewlett-Packard or Intex customer lists
- Fortune 500 list

The Dunn and Bradstreet Directory was chosen (Dunn and Bradstreet, 1997) as it included:

1. Full contact details for 50,000 UK companies
2. Comprehensive listing of top 5,000 UK companies
3. CD-ROM version of lists to aid data collation and searching
4. Easy to reference list of UK companies ranked by number of employees
5. Full Standard Industrial Classification code (SIC) listing and cross-referencing
6. Full description of selection criteria for sampling frame (see Table 2.3)
7. All publicly quoted UK companies
8. Low and estimable sampling frame error (1% identifiable non-coverage error, 1.8% estimated over-coverage error)

The DTI have estimated that there are around 3,400 companies in the UK with 500 or more employees (DTI, 1996). This list contained 4,690 companies (or around 4,600 including estimate of over-coverage error) with 500 or more employees, which is much higher than the DTI estimate. This was probably due to a better recognition of the division of large corporations into autonomous product or service aligned business units.

For example, the ISS group alone had 4 entries in the final sample – ISS Contract Clean, ISS Mediclean, ISS London, and ISS Food Hygiene, and the inclusion of public services (which the DTI estimate may not have included).

Table 2.3: Criteria for Inclusion within Dunn and Bradstreet List.

- The Top 200 Banks selected by total assets
- The Top 100 Building Societies selected by total assets
- The Top 50 Accountancy Practices selected by fee income
- The Top 50 Solicitors Firms selected by number of employees
- The Top 100 Architectural, Surveying and Engineering business selected by number of employees
- The Top 1000 Partnerships selected by number of employees
- The Top 300 Proprietorships selected by number of employees
- The Top 2000 Financial Services Companies selected by total assets
- All Publicly quoted companies
- The top 42,000 Companies across all lines off business selected by their sales turnover; the minimum sales figure on this basis is 1,000,000.

Note that:

- A small number of business, less than 1% of those contacted, declined to appear in the title
- Checks were carried out (by Dunn and Bradstreet) to ensure that the Top 100 Companies as defined by Net Worth and by Employees have been included.

Source: Dunn and Bradstreet (1997)

Procedures for correcting errors in samples caused by inaccuracies in sampling frames have been described (Sudman, 1994). In cases where there was duplication in the sample due to inter-organisational complexities (as described for ISS above), this was viewed as part of the diversity and variability of the sample under study and so these were not corrected. Where actual duplications (the same contact referenced twice) occurred on the list, correct details were confirmed and only one entry returned to the sample. A new number was drawn from the sampling frame, and the overall percentage error rate calculated. There were only 8 over-coverage errors (1 ineligible entry and 7 duplicate listings) found in the sample of 500 (1.8% of the sample) – these were all corrected. A 1% non-coverage error was identified (through omission, as described in Table 2.3), no

attempt was made to correct this due to it being very low and probably very difficult to improve (the directory did not give details of companies omitted).

The determination of a statistically representative sample is discussed below.

2.2.2 Sample size determination

In selecting a sample that is statistically representative on a national scale, sample size is a critical consideration. Sample size can be determined using binomial statistics (Mace, 1964, Kish, 1965). In a binomial distribution, the distribution of sample proportions is centred about the population proportion (the population mean), and the standard error can be calculated as shown below (Churchill, 1996: 532-559, Parasuraman, 1991: 494-503):

$$n_{\min} = \frac{z^2 \pi (1 - \pi)}{H^2}$$

Where:

$n_{\min}$	Minimum sample size require
z	Z-score (level of confidence, at 95% z = 1.96)
H	Difference required to be detected as significant (0.1)
π	Population proportion (0.5 is the proportion at which the standard deviation is the greatest, as discussed below)

Table 2.4: The curve of binomial variation

π	0.001	0.005	0.01	0.05	0.10	0.20	0.30	0.50	0.70	0.80	0.90
σ_p^2	0.001	0.005	0.010	0.048	0.090	0.160	0.210	0.250	0.210	0.160	0.090

Source: Kish 1965: 260

When $\pi = 0.5$, sample variation is greatest (as shown in Table 2.4 above). Therefore this is the value used in calculating minimum sample size at "worst case". Therefore, using binomial statistics, the size of sample required to give 95% confidence limits of ±10%[9] can be calculated as:

[9] To be 95% confident that the true population proportion lies within ±10% of any quoted sample proportion.

$$n_{\min} = \frac{1.96^2 \text{ x } 0.5(1 - 0.5)}{0.1^2}$$

$$n_{\min} = 96.04$$

Based on the results of the pilot study (discussed in Section 2.4), a response rate of 27% was expected. Therefore a sample of 500 companies employing more than 500 people in the UK were randomly selected from the Dunn and Bradstreet 1997 Key British Enterprises Directory to ensure a minimum of 96 companies would be obtained. This sample was estimated to be representative of 90% of the UK business-to-business or commercial market for Information Technology products (Key Note, 1997)[10], excluding independent home office users.

The required sample size of 96 companies was not dissimilar to the studies reviewed in Section 2.1 which investigated the "company" as the subject of interest, and used samples of 169 (Green *et al.*, 1994), 89 (Oskamp *et al.*, 1994), and 66 companies (Corporation of London, 1996). The estimation of a statistically significant sample size is very important if the results of this study are to be declared as being "true for the whole of the UK". Without this degree of confidence the results can only be qualified as "likely to be important for UK businesses". Therefore, provided non-sampling error is minimised, the findings of the research can be developed based on statistically verified, rather than anecdotal evidence or circumstantial opinions.

In the following section, the sample selection method used in the research is discussed.

2.2.3 Sample selection

Stratified sampling provides a very effective method of obtaining a demographically representative sample (by maintaining the structure of some of its diversity and proportions; Parasuraman, 1991). However, a suitable stratified sample could not be easily selected as data could be stratified by several different factors, such as by employees, turnover, industry sector, and geographic region. In combination these would result in many different combinations of categories across strata, which would be difficult to obtain given the effort also needed to locate key informants. Quota and cluster sampling (which do not need complete sampling frames) were not considered due to the need to qualify the sample as statistically significant for industry in the UK (Sapsford and Jupp, 1996).

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[10] The remaining market being made up of smaller business users (3.9%), and users from primary industry sectors (6.3%) excluded from the study (Key Note, 1997).

Simple random sampling was deemed satisfactory for the broad analysis of "industry and commerce" required in this study. As described in Section 3, random sampling was in this case effective in obtaining a statistically representative sample of UK companies.

Random number lists were generated using a programme written in Visual Basic 4.0, using the computer timer as a random number generator seed. The ranking in the business directory was used as a convenient reference for sample selection, thus each company in the sampling frame had an "equal and non-zero chance of selection". Numbers selected are listed in Appendix 3. A sample of 500 companies was selected based on the need for a minimum sample of 100, and predicted response rate of 27%. This allowed for a substantial margin of error (as explained in Section 2.2.2).

Following the discussion of sample selection above, the survey methods used in the research are explained below.

2.3 Survey method

In order to locate the appropriate key informants from within companies, a structured survey method was developed combining initial contact by telephone, followed by postal questionnaire. It has been argued that the use of a combination of data collection techniques in this way can be particularly effective in business market surveys, where key informants must be located within organisations (Schwartz, 1978; Fitch, 1988).

Non-response in surveys is an additional source of non-sampling error that must be minimised. By employing well-developed techniques (see Table 2.5) some researchers have been able to achieve up to 90% response rates from mailed surveys (Lockhart and Russo, 1994). However, reduction in non-response rate does not necessarily eliminate non-sampling error. Great care must also be taken in wording of the questions to avoid biased, overly ambiguous, or incomplete responses (Bagozzi, 1994).

In this section, the survey method is explained in detail, including survey development and procedure.

2.3.1 Survey development

Various factors were considered in developing the wording and format of both the telephone contact protocol and the questionnaire used in this research to maximise return rates, increase the clarity of questions, and reduce potential biases in response. These were developed in series of stages (as explained in Appendix 4), which included critical review by academic and industrial experts, and a test on 15 companies within the pilot survey (described later in Section 2.4). The use of a pilot survey can be important in developing both individual questions and their sequence in a survey.

Table 2.5: Hypothesised stages of mailed questionnaire response

Stage	Survey good practice
Receiving the questionnaire	Accurate sampling lists Accurate addresses Proper addressing and stamping
Opening the mail	Organisational affiliation Personalising address Type name and address on envelope
Forming an overall impression	Quality of paper used Using a commemorative stamp Cover page
Answering the questions	Well written questions Questions appropriate to audience Providing an 800 number
Dealing with reminders	Send several stages of mail reminders Provide second questionnaire Use telephone reminders
Returning the questionnaire	Provide self addressed stamped envelope Use commemorative stamp Questionnaire fits in return envelope

Source: Lockhart and Russo (1994: 145)

Copies of the final telephone protocol and mail questionnaire are presented in Appendices 5 and 6 respectively. The telephone protocol ensured consistent approaches were employed between different researchers. The mail questionnaire included:

- A clear and simple layout
- Questionnaires printed on quality recycled paper
- A personalised corporate Hewlett-Packard cover letter
- Information on academic and commercial allegiances to the sponsoring organisations included in cover letter
- A free-phone enquiry service
- A free-post reply envelope
- Quality white envelopes
- A number for fax responses
- Demographic information positioned at the end of the survey. This can help to encourage complete responses, as a respondent's attention for in-depth questions can diminish towards the end of a questionnaire (Robertson and Sundstrom, 1990)
- Printed address labels on envelopes

- Only 4 pages long
- Easy to answer "check box" responses
- "*Information not available*" response options to reduce non-response to individual questions
- Questions clearly and logically ordered into four sections (three sections including research questions, and a section on demographics)

2.3.2 Procedure

A summary of the survey procedure is given below (see Appendix 5 for a more detailed description):

1) The company IT manager was contacted in order to locate the person responsible for or best-informed about redundant IT equipment arising within the company (pretesting revealed that the IT manager was usually the best informed and most easy to access first point of contact). If no contact could be found within 4 initial calls, a questionnaire was sent to the IT manager.

2) The designated person was contacted and asked to participate in the mail survey. If after 4 calls they could not be contacted, this was recorded, and they were sent a questionnaire without verbal agreement. If they refused to participate they were recorded as a non-respondent. If they agreed to participate their contact details were checked, and they were sent a questionnaire.

3) If after four weeks if no response was received, the respondent was contacted by phone for a second time to check whether the questionnaire had been received, and to recheck contact details. If the contact was absent a message was left on voicemail or on answering machines. A second questionnaire was posted after this call. Finally, at the end of the survey a third questionnaire was then posted to all non-respondents.

Different cover letters were used as reminders on each stage of questionnaire mailing (which are included in Appendix 7). The survey procedure, mail questionnaire, and telephone contact protocol were tested through an initial pilot survey, which is explained below.

2.4 The pilot survey

Before the research was carried out, a pilot survey was conducted with 15 companies to test the effectiveness of the research methodology. Overall, three responses were received from eleven original contacts, giving a response rate of 27%. A further 4 companies were contacted from personal contacts to test the sequence and format of the questionnaire (making a total of 15 companies contacted). Minor changes were made to

the questionnaire itself as a result of pretesting, but the phone protocol was developed substantially as a result of this test:

- IT managers were used as effective first points of contact instead of receptionists, facilities managers, or procurement and purchasing managers (who where not well informed on who to contact) or environmental managers (who did not always exist).

- The sequence, wording, and structure of the telephone protocol was edited and improved to encourage and facilitate commitment from potential respondents. By trial and error, the most effective sequence was found to be:

  - Initially contact the IT manager within the company
  - State the subject of the call "*the management of redundant IT equipment*" to gain the interest of contact
  - Summarise the research project and participants to gain credibility
  - State the nature of the request to gain the agreement or support of contact
  - Identify potential respondent as key informant, or locate appropriate key informant within company through contact
  - Once key informant is located, check address details and send mail questionnaire

The telephone protocol used is included for reference in Appendix 5. The final part of the research method, the statistical methods used, has been explained below.

2.5 Statistical methods

In order to ensure a degree of confidence and check the significance of any observed differences in the results, both binomial statistics and Chi^2 tests were used. These statistical methods have been explained further below.

2.5.1 Binomial statistics

Upper and lower confidence limits are provided at the 95% confidence level for different values of p (observed population frequency) and n (sample size) in Table 2.6 below. Unless the number of responses to an individual question is below the minimum sample size of 100, or a sample proportion lies above 80% or below 20%, there is 95% confidence that the observed sample proportion will lie within ±6% to ±10% of the true population proportion (from binomial statistics). For results outside of these ranges, confidence limits have been provided in Table 2.6.

Within this study, trinomial data (which provides useful qualitative information) has been converted to binomial data by combining categories. For example, disposal behaviours

classified as "frequent" and "infrequent" were combined to give information of the number of companies disposing of redundant IT equipment by any particular method.

Table 2.6: Upper and lower bounds of confidence at the 95% level with sample size and observed population frequency

p	n = 50		n = 100		n = 150	
	Lower limit	Upper limit	Lower limit	Upper limit	Lower limit	Upper limit
0.01	0.00	0.10	0.00	0.05	0.00	0.05
0.05	0.01	0.15	0.02	0.11	0.02	0.10
0.10	0.03	0.22	0.05	0.18	0.06	0.16
0.25	0.13	0.40	0.17	0.35	0.18	0.33
0.50	0.35	0.64	0.40	0.60	0.42	0.58
0.75	0.60	0.87	0.65	0.83	0.67	0.82
0.90	0.78	0.97	0.82	0.95	0.84	0.94
0.95	0.83	0.99	0.89	0.98	0.90	0.98
0.99	0.90	1.00	0.94	1.00	0.95	1.00

These figures have been validated against binomial values provided in Fisher and Yates (1963: 65).

2.5.2. The chi-square method

Chi^2 tests have been used in the following section to determine the significance of differences in disposal behaviour and future service requirements by industry sector. Chi^2 (denoted by the symbol χ^2):

> "*A measure of the discrepancy existing between observed and expected frequencies is supplied by the statistic χ^2 (read chi-square)"* – Spiegel (1972: 201)

The Chi^2 value is calculated from (Spiegel, 1972: 201):

$$\chi^2 = \sum_j \frac{(o_j - e_j)^2}{e_j}$$

Where:

χ^2 = Chi^2 value
o_j = observed frequencies
e_j = expected frequencies

Degrees of freedom must also be calculated to determine the statistical significance of a Chi^2 result using the appropriate statistical tables (White *et al.*, 1974: 17-18). For Chi^2 tests, the degree of freedom is given by (*op cit.*, 1972: 202):

$$v = k - 1$$

Where:

v = Degrees of freedom
k = Number of columns

Finally, normal statistical notation has been used to describe the statistical significance of any tests conducted:

N.S.	No significant differences found
*	Significant difference found at the 95% level (between 1% and 5% chance that differences are due to random sample variation)
**	Significant difference found at the 99% level (between 0.1% and 1% chance that differences are due to random sample variation)
***	Significant difference found at the 99.9% confidence level or above (less than 0.1% chance that differences are due to random sample variation)

In summary, the methodology selected in this study was based on the use of telephone interviews to locate and contact key informants within organisations, and the use of a mail survey to obtain detailed information on the use and disposal of IT products. A sample of 500 companies was selected using random sampling (in order to give a statistically representative sample of more than 96 companies from an expected response rate of 27%). The results of this survey are presented in the following section (Section 3).

3. Results

The survey was conducted between August 1997 and May 1998. In total 151 responses were received, comprising of around 4% of the business IT markets studied, and giving a response rate of 30%. As can be seen in Table 3.1, the industry sector profile of the sample was very similar to that of the directory. This indicates that the sampling strategy used was plausible, and the sample obtained was representative of industry and commerce in the UK as a whole. The companies that responded employed between 503 to 105,000 people, with a median of 1010 employees (for a frequency distribution of number of employees by company, see Fig. 3.1).

Table 3.1: Responses by industry type.

Sector	Sample	Key British Enterprises directory, 1997
Manufacturing	38%	45%
Transportation and communications	13%	10%
Wholesale and retail	18%	15%
Finance, insurance, and real estate	9%	10%
Services	23%	20%

n = 144

3.1 Number of employees by company

The detailed results of the survey are presented below in Sections 3.1 and 3.4, covering different aspects of product use and disposal, and the development of redundant IT equipment management services.

3.1 Management responsibility for redundant IT equipment

The majority (89%) of respondents (who were all pre-qualified as key informants, as described in Section 2.3.2) claimed to be responsible for the management of redundant IT equipment within their companies. This not only qualified the legitimacy of their knowledge and responses, but provided evidence that redundant IT equipment presented UK companies with significantly large enough problems (or opportunities) to need "managing".

As shown in Table 3.2, it was found that for 84% of companies sampled, redundant IT equipment was managed by departments also potentially involved in the purchase of new products including IT, finance and accounts, and purchasing. Thus, the provision of value-adding product disposal services could potentially help producers and distributors of IT equipment to win new customers and build loyalty amongst existing customers (particularly as 76% of respondents identified a need for better services to manage their redundant IT equipment). This is an important finding of the research, discussed further below.

In the following section, results relating to the ownership and use of products by companies are presented.

Table 3.2: Responsibility of redundant IT equipment by department.

Department with responsibility for redundant IT equipment	Percentage of companies
IT	77%
Other	9%
Finance & accounts	6%
Technical support	3%
Administration	2%
Facilities	1%
Purchasing	1%

3.2 Product use

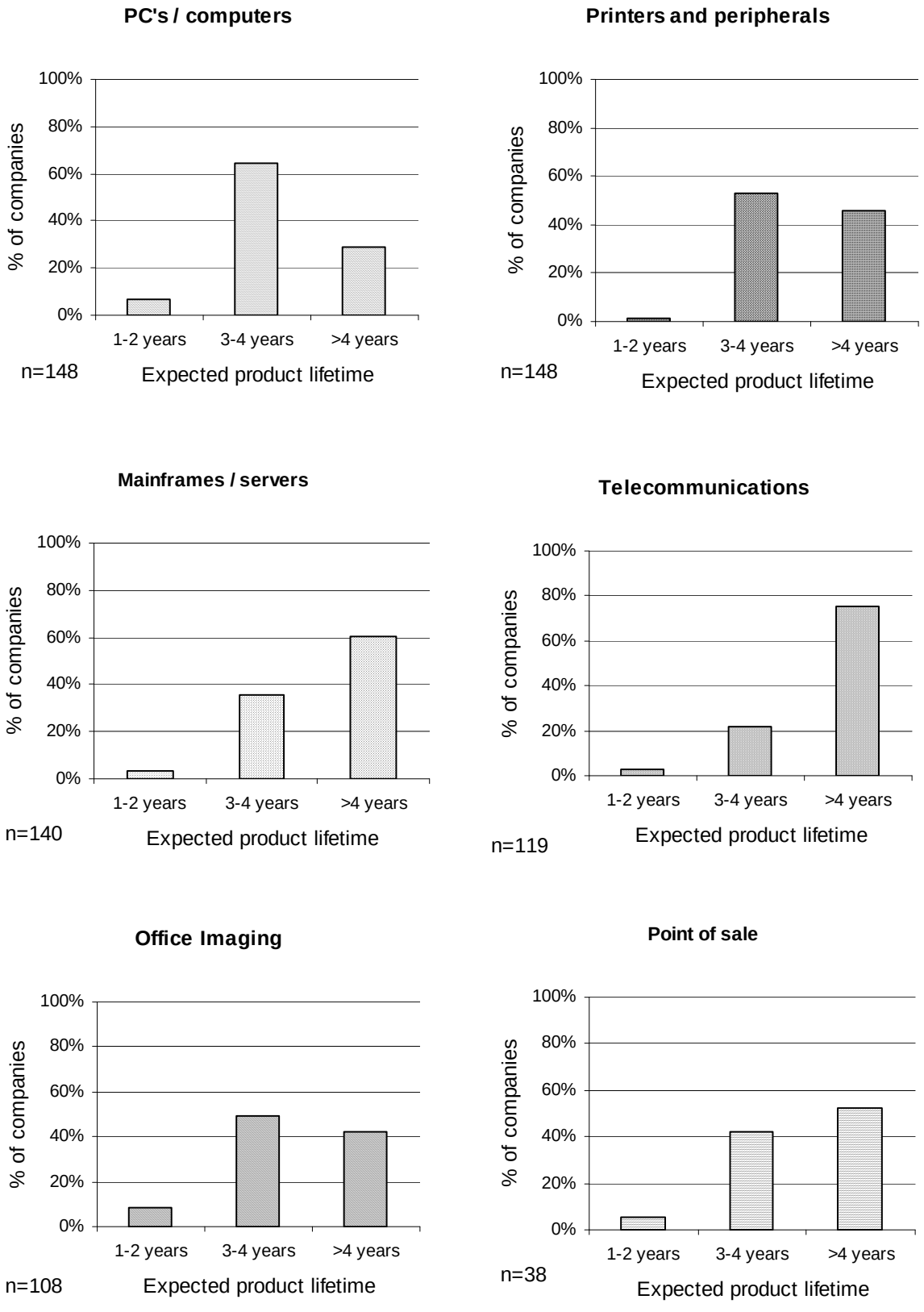
With respect to product use, issues of product lifetime, brand loyalty, and causes of product obsolescence were investigated, which are described below.

3.2.1 Duration of use

An average of 95% of companies (taken across product categories) used IT products for longer than 2 years (see Fig. 3.2). Over half the companies surveyed used computer products within a 3 to 4 year time-span (64% of companies for computers, and 53% for printers and peripherals). The response rate for point-of-sale equipment was low at n = 38 as only companies in the service and wholesale and retail sectors used these products on a large scale[11].

[11] Refer to Section 2.5.1 for an indication of confidence limits for all proportional data presented in this study

Figure 3.2: Product life time of IT equipment in UK companies



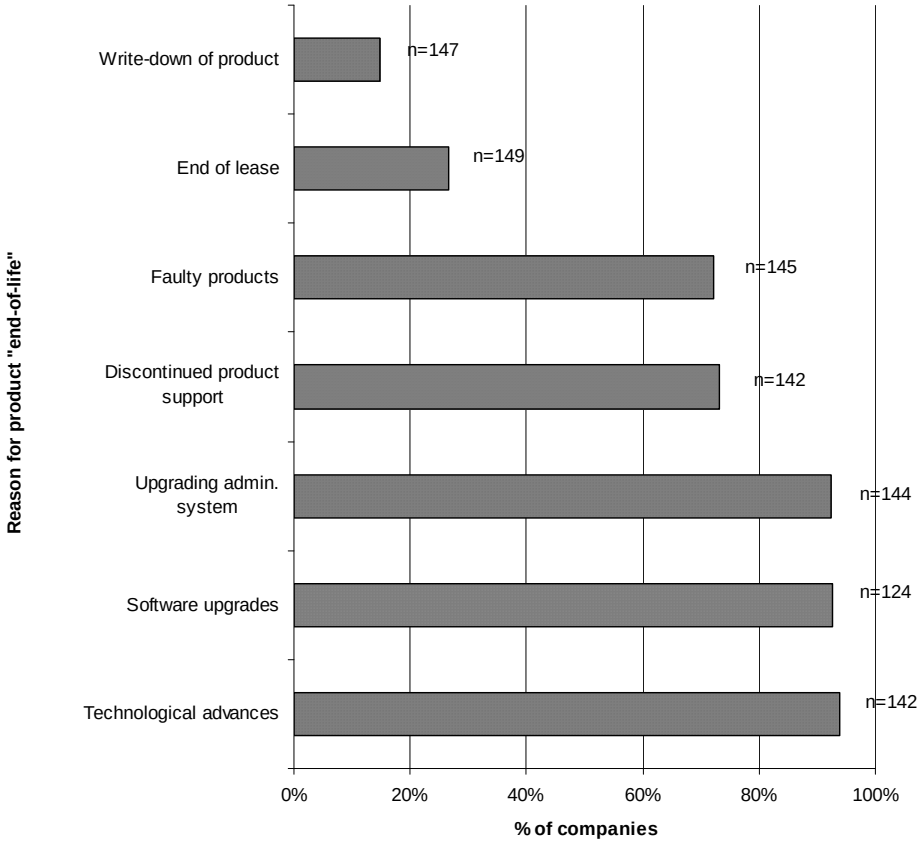
On average 51% of companies used IT products for more than 4 years (with a maximum of 76% for telecommunications equipment, and a minimum of 29% for PCs and computers). This makes some industry estimates on the average lifetime of "IT products" sound highly improbable at 11 months before replacement (Hatley, 1998). It would appear that such estimates ignore the fact that the lifetime of IT equipment may be extended as it is passed on and used further both within and outside of companies.

3.2.2 Brand loyalty

Different levels of brand loyalty were found for different product types. Only 57% of companies were loyal to only 1 to 2 brands of computer products (for PCs, printers, and peripherals). Significantly more companies were found to be loyal to only 1 or 2 brands of networked products (mainframe and point of sale products at 79% and 77%[12] respectively)

.

Figure 3.3: Reasons for "end-of-life"



[12] n = 43, due to sector specific use of point-of-sale equipment

3.2.3 Causes of product obsolescence

Technology related obsolescence was identified as a major cause of product end-of-life (see Fig. 3.3). Technological advances, software upgrades, and upgrading of internal administration systems were given as important antecedents for end-of-life by 94%, 93%, and 92% of respondents respectively. Discontinued product support and faulty products were also described as important by 73% and 72% of respondents. Only 27% of respondents believed that end-of-lease and only 15% of respondents believed that write down of product (accounting related issues) were important.

3.3 Product disposal

A total of 80% of companies disposed of redundant IT equipment as waste (see Fig. 3.4), with 37% describing this as a "frequent" activity. However, several other important product end-of-life "pathways" were found to be of similar and even greater significance, most resulting in the reuse of products in households and second-hand markets. These included transfer of equipment to employees for use in the home (87%), donation to charity (76%), and sale to brokers or dealers by (70%) by number of companies. Indeed, 23% of companies purchased second-hand equipment themselves, provided it had a reputable brand, was of high enough quality, and had been refurbished responsibility. In addition 64% of companies stored some of their redundant equipment, 39% returned equipment to suppliers and lessors, 39% traded with scrap merchants, and 37% and traded with recyclers. Disposal categories were selected based on previous studies of the commercial sector (as shown in Table 1.2) and through disposal routes suggested by respondents in the pilot study.

Results on the costs of equipment disposal, the current status of environmental management in relation to the disposal of redundant IT equipment, and equipment disposal routes are presented below.

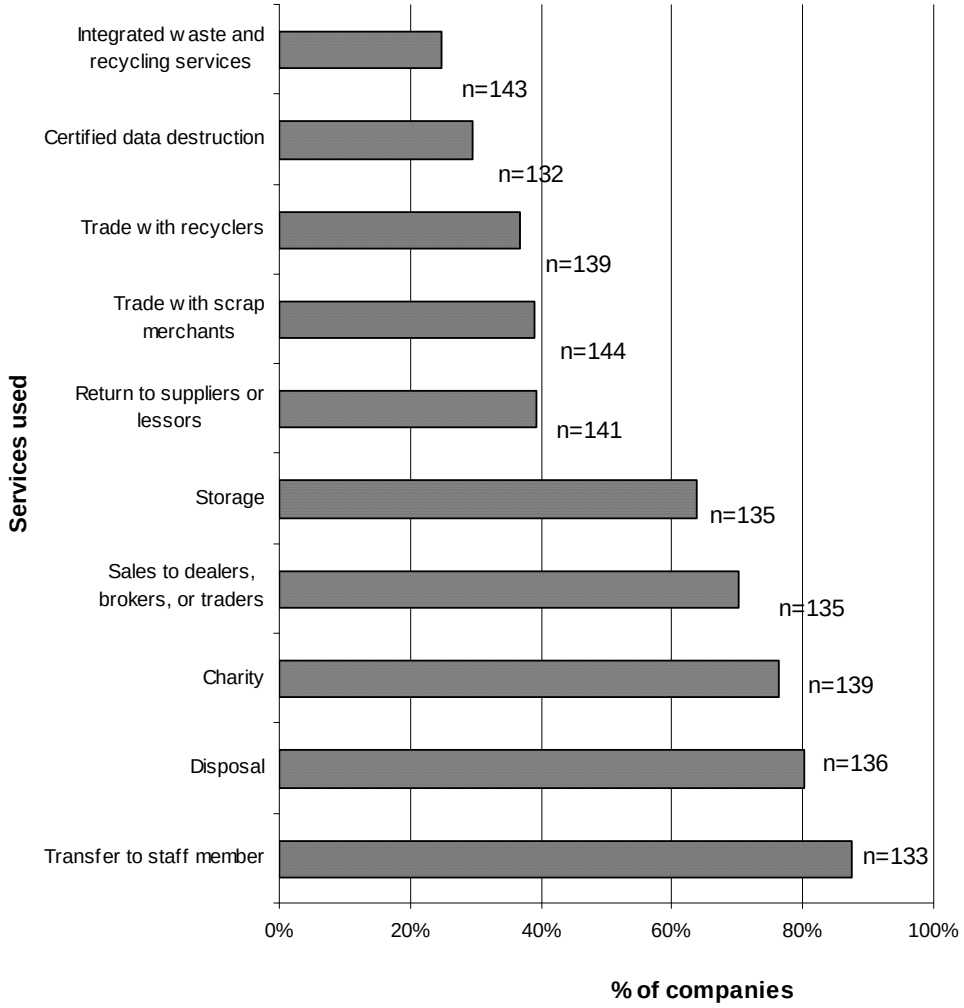
3.3.1 The cost / income of managing redundant IT equipment

Although 56% of companies received income from the sale of their redundant equipment, only 15% of respondents described these products as assets. In comparison, only 20% of companies paid for product disposal, but as much as 43% of respondents described this equipment as waste. Clearly respondents saw little value in their redundant IT equipment, 11% even described it as "*neither an asset nor waste*".

3.3.2 Environmental management

With respect to environmental management, 75% of companies were potentially breaching Duty of Care (Waste Management) legislation by failing to check vendors for waste management licenses and only 9% had environmental policies covering waste equipment. Only 28% of respondents were aware of the then draft EU WEEE Directive.

Figure 3.4: Services used for the disposal of redundant IT products



3.3.3 Disposal rates

IT product disposal rates were calculated in units per 100 employees for each product type. This was to investigate disposal patterns and trends, and evaluate possible predictors of disposal behaviour. Rates were calculated for each company from the range-medians[13] of products in use within each company and the duration of product use, and information on total employees from the KBE Directory (Dunn and Bradstreet, 1997).

It was found that disposal rates varied widely by up to 3 orders of magnitude between different industry sectors (as shown in Table 3.3). Generally and perhaps not surprisingly, the highest disposal rates were found for PCs and printers (used on an individual basis by

[13] The median of a stated range. For example, the range-median of the range 2 to 3 years is 2.5.

employees) with median disposal rates of 15.4 and 5.5 units disposed of per 100 employees per year respectively. Other equipment surveyed (perhaps being larger and more expensive) appeared to be disposed of less frequently.

Table 3.3: Estimated products disposed of per 100 employees / year

Product type		PCs and computers	Printers and peripherals	Mainframes and servers	Telecommunications	Office imaging	Point of sale
Manufact-uring	Median	15.32	4.89	0.66	0.80	0.69	0.29
	Range †	3.93-33.31	2.17-14.27	0.29-2.18	0.26-5.87	0.26-2.96	0-1.76
	n	57	57	56	50	50	13
Transport and communic-ations	Median	16.06	4.62	0.56	1.78	1.72	1.21
	Range †	3.13-35.39	2.35-12.36	0.28-1.19	0.46-8.21	0.25-4.62	0-9.38
	n	19	19	18	15	18	8
Wholesale and retail	Median	13.64	4.24	0.61	0.61	0.49	4.57
	Range †	7.05-25.66	2.32-10.27	0.18-0.82	0.21-2.47	0.18-1.2	1.38-23.44
	n	26	26	25	22	24	21
Finance, insurance, and real estate	Median	38.02	4.94	1.79	1.82	1.62	0.11
	Range †	6.89-106.76	2.67-26.69	0.11-5	0.11-48.02	0-19.23	0-1.03
	n	13	13	13	9	10	5
Service	Median	11.33	7.07	0.83	2.01	0.77	8.21
	Range †	2.13-28.06	4.22-28.06	0.38-5.06	0.54-7.07	0.4-2.96	0-223.16
	N	21	21	19	21	20	10
Overall	Median	15.41	5.51	0.67	0.92	0.80	1.76
	Range †	4.59-41.97	2.49-15.73	0.28-2.74	0.39-5.86	0.26-2.96	0-9.38
	N	148	148	143	126	133	57

† Where n>10, inter-quartile range is shown, where n<11, full range (minimum and maximum values) is shown
Where length of use of product given as >6 years, 7 years used
Where number of products used is given as > 5000, 5001 products used

Financial institutions were found to dispose of a higher volume of PC's and computers than other sectors (with a median of 38.0 computers per 100 employees per year). Unsurprisingly, disposal rates for point-of-sale equipment were higher within the wholesale and retail, and service sectors than any other industry sector (with medians of 4.6 and 8.2 products per 100 employees per year respectively).

Although there may be inaccuracies in this data due to errors in reporting of numbers of employees in the business listings, or in the estimation of products used and their expected lifetimes by respondents, this is unlikely to explain the great variation in this data. Although this data provides useful insight into rates of replenishment and disposal of IT equipment in companies, it must be treated and interpreted with caution due to its wide variability.

An analysis of the market for redundant IT services within companies is provided below.

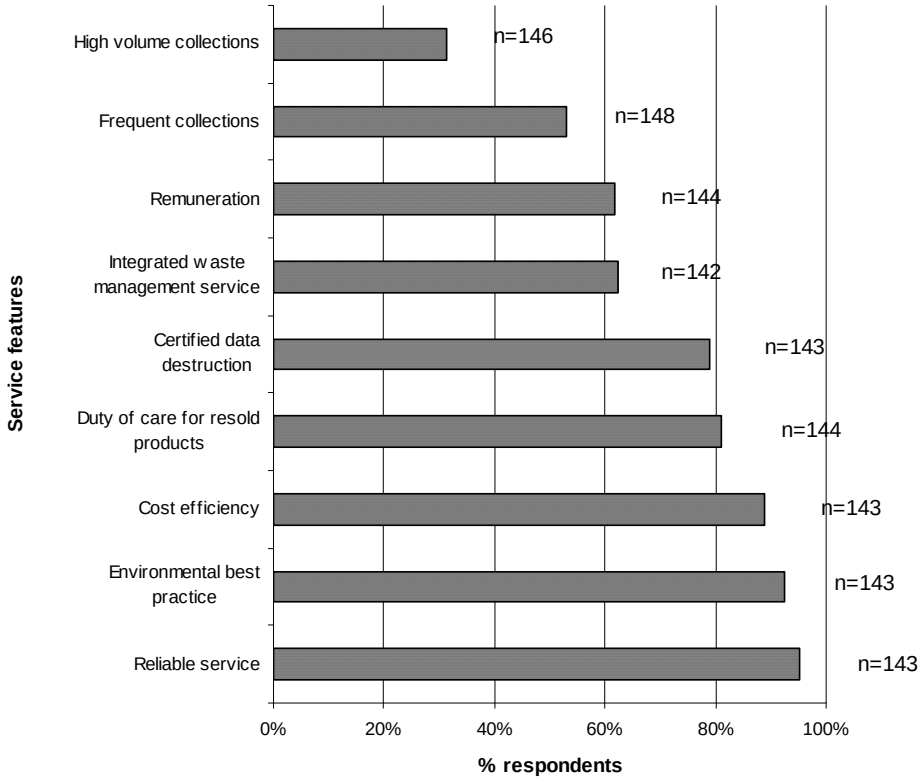
3.4 The market for redundant IT equipment management services

Within this section, the market for redundant It services is analysed, including survey results on service requirements and market segmentation.

3.4.1 Service requirements

Notably, 76% of respondents indicated that they *"had a need for better-developed services to manage their redundant IT equipment"*. The important features of such services were investigated in more detail (see Fig. 3.5): 95% of respondents indicated reliability was an important element of service success, 93% environmental best practice, 89% cost efficiency, 81% duty of care for resold products, and 79% certified data destruction (51% describing this as very important). There was a significantly greater need for frequent rather than high volume collections (with 53% of respondents describing the former as important compared to 31% for the latter).

Figure 3.4: Perceived important features of a recycling / reuse service:



3.4.2 Service coverage

In terms of the provision of services to manage redundant IT equipment, it was found that:

- 77% of companies required national coverage (with sites distributed across the UK).
- 42% of companies required site-by-site collections, with 1 to 16 sites per company. These companies were relatively large, with a median of 4941 employees (and an inter-quartile range of 3499 to 6111 employees).
- 58% of companies consolidated their redundant equipment to only 1 to 4 sites for collection purposes and possibly for storage. Each of these sites was found to consolidate their equipment from a further 5 to 140 sites (with a median of 23 sites). These companies were relatively small, with a median of 1062 employees (and an inter-quartile range of 706 to 2392 employees).

From these results it is clear that companies with just a few large sites (with more employees) were most likely to need site by site collection services for their redundant IT equipment. Companies with many small sites (with fewer employees, and consequently less of a critical mass of equipment for disposal) were most likely to consolidate their equipment to a few centralised points.

3.4.3 Market segmentation

Information on current disposal behaviours and service requirements was broken down by industry sector and company size (by number of employees) to identify market needs in greater detail. Using the chi-square method (explained in Section 2.5.2), significant differences were found both in current disposal patterns (the results of which can be found in Tables A8.1 and A8.2 in Appendix 8) and in future service requirements (as shown in Tables A8.3 and A8.4 in Appendix 8) between these groupings.

Significant differences were found in service requirements concerning collection between industry sectors, and financial arrangements between companies of different sizes. Perhaps not unsurprisingly, the number of respondents from financial institutions describing high volume and frequent collections as important service needs was twice that expected from overall sample responses. In comparison, respondents from larger companies (with >1500 employees) indicated that both remuneration and cost efficiency were important service requirements (with 25% and 15% more respondents describing these as important than expected from overall sample responses).

Return to suppliers and lessors was the only disposal method which differed significantly between industry sectors. Around one third more manufacturing companies disposed of their redundant IT equipment through suppliers and lessors than was expected, compared to around two thirds less transport and communications and wholesale and retail companies. Certified data destruction services were used 20% more than expected by both larger and smaller companies (those with greater than 1500 or less than 750 employees). In comparison, companies with 750-1500 employees used certified data destruction services only half as much as expected.

Greater differences may have been found between industry sectors and companies of different sizes if statistically representative samples of each sector had been obtained (with over 100 respondents in each). Thus further research is required to investigate the specific needs of these different market sectors in greater detail.

Within this section, results on the ownership, use, and disposal of IT products within the UK commercial sector have been presented. In the following section (Section 4), these results are evaluated and discussed in further detail.

4. Discussion

Within this section, the implications and significance of the research results are discussed, including findings on the development of government policy and of redundant IT equipment management services by producers of IT equipment.

4.1 Product use, obsolescence, and disposal

Examination of product use provided interesting insights. Very few companies appeared to purchase products at the rate that new technologies are created. For example, if product technology development cycles last around 6 to 9 months, then the majority of companies (using their products for more than 2 years) will only purchase new products after at least 3 to 4 generations of new technology have passed. Regardless, it appeared that companies were more likely to replace their products to keep pace with these technological advances, rather than because of functional obsolescence i.e. products breaking down irreparably.

At present, the IT industry is continually cutting prices to encourage first time buyers in the consumer market, and existing commercial markets are becoming saturated (Gross, 1998). This point is perhaps illustrated by the 33% of respondents not expecting future increases in the number of products used. It appears for now that IT producers looking to technology development to gain market share will focus on an increasingly smaller number of high specification users. Meanwhile, extensive second-hand markets appear to have developed independently of producers. For example, where only 39% of companies returned their redundant equipment to suppliers or lessors, 70% sold equipment privately to second-hand dealers and brokers. Indeed, 23% of companies were found to purchase second-hand equipment themselves.

A large variation in the rate of disposal of redundant IT equipment was found between companies making interpretation difficult. However, it was found that finance companies disposed of PCs and computers, and retail and service companies disposed of point-of-sale equipment at a much higher rate than companies in other sectors.

4.2 The definition of waste

Under the proposed EU directive, producers will be forced to address the waste that (supposedly) results from the rapid turnover of technology. The current EU definition of waste is:

> *"...any substance or object… which the holder discards or intends to discard or is requires to discard"* (75/442/EEC)

This view does not accommodate for the complexity of existing patterns of product use and disposal within the commercial sector. As shown earlier, most companies already manage their redundant IT equipment to a certain extent which results in a variety of different "*disposal*" pathways at end-of-life.

A large proportion of companies pass equipment on for reuse in businesses, households, public institutions, charities, and international markets via brokers and dealers, charities, and employees. It would be difficult to distinguish when these products reach *"end-of-life"* and become waste, as their use may be extended by several users with different perspectives on when a product has reached end-of-life. Ultimately these products will reach an end-of-life either in landfill, or perhaps in various recovery processes. However, the sources, availability, and opportunities for reuse and recycling of this equipment will be critically dependent upon a company's individual disposal practices.

For redundant IT products disposed by the commercial sector, product end-of-life would be best considered as an extended process in which equipment is used by more than one user, and during which it will devalue, degrade, and disperse through society.

4.3 New market opportunities

There clearly is a market demand for improved services to help large companies manage their redundant IT equipment. These services should be reliable and allow customers to dispose of their redundant IT equipment in a cost effective and responsible manner. Services that could be developed competitively as market differentiators include:

- Certified data destruction (used only by 27% of companies at present, but perceived as an important by 75% of respondents). Such services may be particularly useful for medium sized companies with between 750 and 1500 employees, which were found to use such services significantly less than other companies.
- Brand name support for second hand sale of products.
- Acceptance of all brands of returned products (as many companies were not loyal to any particular brand).
- Provision of nation-wide collection services (as 77% of companies were found to have sites distributed across the UK).

However, industry sectors or companies of different sizes may be more effectively serviced as separate market segments. For example, the finance and insurance sector appeared to produce higher volumes of redundant IT equipment than companies in other sectors. Consistent with this finding, they also had a significantly greater need for frequent and high-volume collections for disposal.

Although 93% of respondents claimed that "environmental best practice" was an important service need, this result should be regarded with caution due to the apparent

lack of environmental policy commitment and awareness within each company (previously discussed):

- Only 9% of companies had environmental policies covering the disposal redundant IT products.
- Only 28% of companies were aware of the EU draft Directive on WEEE.
- Up to 75% of companies may have been in breach of waste management regulation in the disposal of their redundant IT equipment.

4.4 Current market developments

Many IT producers already provide redundant equipment management services to their commercial customers, even though not yet legally mandated to do so. Examples include:

- Extended product-leasing, e.g. as provided by Xerox for office imaging products (where the leasing company retains title of the equipment, and therefore manages its disposal).

- Take-back services as offered by the Digital Equipment Corporation (now owned by Compaq) and Dell across Europe.

- The resale of refurbished second-hand products supported by leading product brands. For example, ICL sell various brands of refurbished second-hand computers under a recently launched service brand called "Star" or "Second Time ARound", which are sold through up to 300 dealers nationally (Price, 1998). Similarly, Compaq have recently launched and marketed a new range of refurbished computers supported by full manufacturer's warrantees, known as "Digital Classic".

Strategic "channel partnerships" between IT producers and companies responsible for the refurbishment and resale of 2nd hand equipment are therefore likely to be of importance in the future development of IT markets.

4.5 Implications for IT producers

The increased levels of reuse and recycling resulting from the development of redundant IT equipment management services for the commercial sector could help producers to meet their future obligations under Producer Responsibility legislation. In addition, producers could profit financially from second-hand sale of products while exerting greater control over the quality and competitiveness of these markets.

At present 39% of companies were already found to return their redundant equipment to suppliers. This was especially notable for manufacturing companies (with 50% returning

equipment via this route), whereas transport and communications and wholesale and retail companies used this route far less frequently than other sectors (at 15% and 11% of companies respectively). For future growth and expansion of these producer and supplier "take-back" services under Producer Responsibility, the individual needs of these different end-of-life market and industry segments must be addressed.

Through the development and provision of such product "end-of-life management" services, producers could gain increased access and additional influence over new and existing customers. For the majority of companies (84%), departments given responsibility for managing redundant IT equipment were also involved in the purchase of new products. *This clearly is an important marketing opportunity.*

In summary, the extension of customer support services by the IT industry to include the recycling and disposal of redundant IT equipment from the commercial sector could help tackle two related environmental and economic concerns. These are: concerns over the environmental effects of resource consumption and materials disposal from the production of IT products, and concerns over the development of more enduring customer relationships through the provision of full product life-cycle services. The benefits to the environment from product reuse will depend upon the extent to which second-hand products substitute for the production of new products. This has been investigated through parallel research on the domestic sector (described below).

4.6 Future research

As larger IT producers supply markets on a global basis, future research on the use and disposal of redundant IT products by commerce in different countries may be useful. This would help producers to determine the level at which such services should be provided (nationally or globally). In addition, the development and continued provision of product end-of-life services will require a more detailed knowledge of (in order of priority):

1. Market segmentation
2. The most effective "service channels" or methods of service delivery
3. Service pricing

Given the broader remit of the EU Directive on Waste Electrical and Electronic Equipment, research is also required on the use and disposal of electrical and electronic products more broadly in the consumer and public sectors. This has been reported within Chapter 3, Vol. 1 of the research portfolio, entitled "*Prospects for Household Appliances*".

5. Conclusions

Patterns of the use and disposal of redundant IT equipment in the commercial sector have been investigated through a survey of 151 companies employing 500 or more people in the UK. This was to investigate why IT products reach end-of-life, how these products are currently managed, and the scope for the development of future services in respect of European Union Producer Responsibility legislation.

Results indicated that only around 5% of companies (averaged across product categories) used IT products for less than 2 years. Therefore it is argued that producers focussing on rapid turnover of product technologies could find it increasingly difficult to gain increased market share.

Most companies had employees with specific responsibility for the management of redundant IT equipment. Although 80% of companies disposed of some of their equipment as waste, several other pathways were found to be of similar importance. These included transfer of equipment to company employees, donation to charity, and sales to dealers or brokers through which equipment may be resold and reused. In this context it is argued that existing conceptions of product consumption, and legal definitions of "waste" do not sufficiently reflect the complexity of pathways by which this equipment may progress *through* the different stages of end-of-life. It is suggested that it is inappropriate to define end-of-life as a *point of disposal* (or even purchase as a *point of consumption*) for IT equipment sold into and passed out of the commercial sector. This equipment retains significant utility and may be passed onto subsequent users, thus entering a *process of extended use*.

There are some signs that the European Commission now at least in part recognise this. The term "end-of-life" was removed and replaced with the term "waste" in the second draft of the WEEE Directive (WEEE – July 1998). However, redundant IT equipment itself has been classified as an EC "green list" wastes, which means it is legally classified as non-hazardous waste regardless of any intentions of reuse.

Finally, it is argued that there are market opportunities for producers wishing to provide redundant IT equipment management services to larger business customers. It is concluded that, provided there is sufficient consideration of the needs of different market segments, the provision of such services could help producers meet their future requirements under Producer Responsibility legislation. It may also add-value to an IT producer's existing post-sales services, beyond the immediate production and consumption of new product technologies, and potentially contribute to the establishment of longer lasting relationships with commercial customers. To support the continued development of services in this area, it is argued that future research would need to focus more specifically on market segmentation, service pricing, and the effectiveness of different service delivery channels.

Having completed this chapter (Chapter 2, Vol. 1) on the use and disposal of IT equipment within companies, the subsequent chapter in the portfolio (Chapter 3, Vol. 1)

presents parallel research on the use and disposal of household appliances in the UK (as initially described within the Executive Summary, Vol. 1).

Glossary of terms

The terms in the following list are defined in the context of this article.

Brown goods:	General term for entertainment electronics e.g. HI-FI, televisions, & video**.**
EEE:	EU definition "equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields" (DG XI.E3/FE D[97]).
Electrical products:	Products relying on the supply of electricity e.g. vacuum cleaners.
Electronic products:	(1) Products containing integrated circuitry e.g. computers. (2) Used more generally to include electrical and electronic products
Electronic wastes:	Abbreviated and convenient term for WEEE used in this article.
End-of-Life (EOL):	EU definition: electrical or electronic equipment which is a waste within the meaning of Article 1(a) of Directive 75/442/EEC Proposed definition: a process by which electrical or electronic equipment devalues, degrades, and disperses throughout society
End-users:	Users of a product at end-of-life.
Grey goods:	General term for IT electronics e.g. computers, photocopiers, & phones.
Producer:	A manufacturer or importer of a product or service within a country.
Recycling:	The reuse of materials or even products (when used more ambiguously) reclaimed from waste or at end-of-life.
Reuse:	The effective re-deployment of functional components and products reclaimed from waste or at end-of-life e.g. microchips & second-hand washing machines.
White goods:	General term for convenience electronics e.g. refrigerators & kettles.
WEEE:	Waste from Electrical and Electronic Equipment - official EU working term. European definition of waste applies to EEE (defined above) in the definition of WEEE

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Appendix 1: Statement of contributions

The following statement concerns the research project outlined in this report. This study was completed between 15/06/97 and 15/08/98, and was sponsored by Hewlett-Packard Limited and Intex Computers Limited. Research was completed primarily by Kieren Mayers at Brunel University, with the support of Susanna Planas at Imperial College London, and Lefteris Kabouris at the University of Bradford during the initial stages of survey development and pre-testing. Support was also provided on the use of statistical methods by Ann Cleverly. However, this report and its contributions to knowledge were completed principally by the author, Kieren Mayers.

Appendix 2: SIC codes excluded from study

The companies with the following SIC codes were eliminated from this study:

Any company with a SIC code beginning with 0 or 1 (agriculture, forestry, fishing, mining, or construction companies).

Any companies with SIC codes listed below:

3651 to 3679 - electronics manufacturers
4811 - telephone communication
4821 - telegraph communication
4899 - communication services
4953 - refuse systems
5043 - photographic equipment and supplies
5063 to 5065 - electronic appliances, apparatus, parts and equipment
5093 - scrap and waste materials
5722 - household appliances shops
5732 - radio and television shops
7394 - equipment rental and leasing services
7622 - radio and television repair shops
7629 - electrical and electronic repair shops.

Companies eliminated from the study were replaced with a new randomly selected company (using a list of 1,000 non-sequential random numbers generated from the same random umber seed as the original sample) from the sampling frame. Every new selection was checked against numbers already selected, and also against the SIC codes mentioned above.

Appendix 3: List of randomly selected sample numbers

Selected sample numbers (from Dunn and Bradstreet 1997) **n = 500**

1 / 7 / 9 / 10 / 62 / 64 / 65 / 72 / 97 / 101 / 113 / 121 / 122 / 167 / 176 178 / 180 / 185 / 186 / 188 / 199 / 214 / 236 / 242 / 255 / 256 / 258 / 262 278 / 293 / 296 / 303 / 306 / 315 / 328 / 330 / 345 / 357 / 361 / 364 / 376 / 382 / 385 / 395 / 406 / 412 / 430 / 435 / 451 / 462 / 481 / 482 / 484 / 495 / 499 / 516 / 521 / 537 / 542 / 547 / 548 / 552 / 566 / 569 / 577 / 599 / 604 / 612 / 625 / 628 / 638 / 641 / 670 / 692 / 700 / 711 / 727 / 741 / 746 / 760 / 764 / 793 / 802 / 806 / 814 / 819 / 822 / 830 / 835 / 849 / 854 / 856 / 857 / 860 / 867 / 868 / 872 / 889 / 914 / 935 / 946 / 947 / 957 / 959 / 962 / 978 / 982 / 983 / 993 / 997 / 1020 / 1032 / 1039 / 1054 / 1069 / 1072 / 1079 / 1082 / 1114 / 1129 / 1137 / 1161 / 1164 / 1195 / 1205 / 1209 / 1216 / 1223 / 1235 / 1243 / 1245 / 1261 / 1287 / 1292 / 1293 / 1301 / 1309 / 1337 / 1357 / 1367 / 1379 / 1384 / 1412 / 1431 / 1432 / 1449 / 1454 / 1488 / 1499 / 1503 / 1509 / 1528 / 1557 / 1559 / 1584 / 1587 / 1593 / 1634 / 1652 / 1655 / 1661 / 1663 / 1664 / 1672 / 1675 / 1680 / 1687 / 1694 / 1709 / 1711 / 1716 / 1717 / 1734 / 1743 / 1750 / 1751 / 1783 / 1786 / 1797 / 1811 / 1818 / 1819 / 1834 / 1837 / 1842 / 1843 / 1858 / 1869 / 1912 / 1937 / 1940 / 1941 / 1943 / 1944 / 1974 / 1981 / 1983 / 2005 / 2008 / 2017 / 2025 / 2027 / 2029 / 2031 / 2032 / 2042 / 2056 / 2071 / 2081 / 2105 / 2116 / 2119 / 2121 / 2122 / 2125 / 2137 / 2144 / 2149 / 2159 / 2161 / 2179 / 2184 / 2199 / 2201 / 2202 / 2217 / 2222 / 2236 / 2243 / 2245 / 2281 / 2290 / 2298 / 2299 / 2339 / 2345 / 2353 / 2354 / 2356 / 2364 / 2370 / 2375 / 2379 / 2386 / 2387 / 2389 / 2400 / 2418 / 2423 / 2428 / 2437 / 2454 / 2460 / 2477 / 2486 / 2497 / 2500 / 2505 / 2518 / 2533 / 2561 / 2563 / 2573 / 2576 / 2584 / 2604 / 2605 / 2608 / 2612 / 2613 / 2632 / 2636 / 2639 / 2640 / 2669 / 2675 / 2678 / 2694 / 2713 / 2715 / 2716 / 2718 / 2719 / 2722 / 2725 / 2767 / 2768 / 2775 / 2783 / 2784 / 2796 / 2799 / 2811 / 2826 / 2827 / 2828 / 2835 / 2845 / 2859 / 2865 / 2890 / 2905 / 2911 / 2912 / 2920 / 2922 / 2931 / 2940 / 2945 / 2946 / 2961 / 2974 / 2982 / 2992 / 3000 / 3011 / 3012 / 3025 / 3032 / 3038 / 3040 / 3047 / 3056 / 3057 / 3069 / 3070 / 3083 / 3096 / 3107 / 3111 / 3116 / 3119 / 3121 / 3123 / 3136 / 3141 / 3148 / 3157 / 3159 / 3166 / 3174 / 3179 / 3182 / 3185 / 3187 / 3190 / 3198 / 3200 / 3203 / 3214 / 3221 / 3223 / 3231 / 3233 / 3241 / 3242 / 3249 / 3252 / 3257 / 3259 / 3263 / 3264 / 3265 / 3275 / 3288 / 3292 / 3296 / 3309 / 3313 / 3325 / 3352 / 3367 / 3377 / 3378 / 3382 / 3403 / 3409 / 3415 / 3426 / 3430 / 3433 / 3437 / 3439 / 3442 / 3452 / 3460 / 3512 / 3516 / 3527 / 3540 / 3552 / 3561 / 3569 / 3609 / 3619 / 3623 / 3624 / 3632 / 3636 / 3637 / 3647 / 3665 / 3676 / 3694 / 3707 / 3710 / 3718 / 3726 / 3730 / 3758 / 3768 / 3779 / 3800 / 3840 / 3843 / 3846 / 3848 / 3850 / 3854 / 3857 / 3858 / 3859 / 3863 / 3871 / 3879 / 3886 / 3892 / 3904 / 3917 / 3952 / 3954 / 3955 / 3969 / 3970 / 3971 / 3980 / 4018 / 4031 / 4037 / 4055 / 4068 / 4076 / 4113 / 4114 / 4119 / 4127 / 4137 / 4198 / 4248 / 4273 / 4274 / 4296 / 4313 / 4315 / 4325 / 4330 / 4336 / 4339 / 4354 / 4360 / 4370 / 4381 / 4383 / 4386 / 4387 / 4391 / 4394 / 4410 / 4415 / 4420 / 4426 / 4427 / 4438 / 4447 / 4448 / 4461 / 4499 / 4506 / 4515 / 4522 / 4524 / 4526 / 4528 / 4531 / 4533 / 4538 / 4549 / 4560 / 4564 / 4569 / 4573 / 4586 / 4588 / 4613 / 4642 / 4651 / 4671 / 4675 / 4677 / 4689

Appendix 4: Questionnaire development

VERSION 1: Initial Draft.

VERSION 2: 2nd Draft.

Developed with help from business marketing surveying specialists, electronics recycler (Intex), electronics manufacturer (HP), and academic researchers.

- Opened out questions to cover different product ranges (grid format used).
- Added detailed options to questions that were too brief.
- Rearranged questions in a logical order.
- Combined, added, and deleted questions to make the questionnaire more relevant to the study.

VERSION 3: 3rd Draft.

Developed with help of project partners and supervisors.

- Corrected spelling mistakes.
- Worded some questions better (for understanding).
- Developed clearer and more specific answer options for questions.
- Agreed on appropriate categories for products.
- Added "don't know" and "not applicable" options to eliminate sample bias from non-responses.

VERSION 4: 4th Draft.

Amended by project partners with some expert academic guidance from market and social research fields.

- Arranged into 3 sections generally covering product use, old products, and future products.
- Developed better questionnaire and question guidelines for respondents.
- "Information not available" seen as a better non-response option than "don't know" or "not applicable" - as it is less of a "get out clause".
- More work on the structure of questions and answer options to make them clearer and more specific to the survey.

VERSION 5: Final Draft.

Final review completed by project partners and team, supervisors, and academic experts in marketing and social research methods.

- Final corrections made to structure of survey and questions.
- Consideration of academic comments to expend some questions more thoroughly.

VERSION 6: Pilot Questionnaire.

Developed by project team.

- Improved presentation and layout of questionnaire.

- Added final new questions.

VERSION 7: Draft Final.

Developed from examination of pilot responses.

- Some questions explained more clearly in order to ensure questions were completed correctly.
- Better explanation of scope of survey i.e. of "the company" in "the UK".
- Added new options to the suggested answers of some questions.

VERSION 8: Final Questionnaire.

Supervisors and project partners finally approve the survey.

- Spelling mistakes corrected.
- Final changes to wording of guidelines text

Appendix 5: Phone survey protocol

1. To the operator:

* Hello my name is _____
* I am calling on behalf of Hewlett-Packard Limited
* Please can I speak to the IT manager?

2. To the IT manager:

* Hello my name is _____
* Are you responsible for IT equipment?
* Does this include redundant end-of-use equipment, or equipment that has to be returned lessors?

IF NO, SAY:

"Sorry to have bothered you, so you know who I could talk to? Please could you give me their telephone number?"

IF NO AGAIN, SAY:

Thank you for your time, OK, Bye.

IF YES... PROCEED WITH THE FOLLOWING:

"Hewlett-Packard have formed a research partnership with Intex Logistics (an electronics recycling company). This is supported with academic expertise from Imperial College London, Brunel University, and the University of Bradford.

We are undertaking a research project on RECYCLING IT EQUIPMENT in view of expected European Union legislation. As part of this we are conducting a postal survey of large organisations in the UK to find out what happens to redundant or end-of-use products.

The information you could give us is very important, we would really appreciate your help by filling in our questionnaire."

(PAUSE FOR RESPONSE)

IF THEY ARE UNSURE OVER WHETHER TO COMPLETE THE QUESTIONNAIRE THEN SAY:

"THIS INFORMATION COULD BE VERY HELPFUL TO BUSINESSES LIKE YOURSELVES TO MEET POTENTIALFUTURE BUSINESS AND ENVIRONMENTAL REQUIREMENTS. IT WILL ONLY TAKE 10-15 MINUTES. YOUR HELP AND FEEDBACK WILL BE EXTREMELY VALUABLE AND WILL BE TREATED WITH THE STRICTEST CONFIDENCE."

IF THEY SAY NO, THEN TERMINATE THE CONVERSATION SAYING:

"THANK YOU VERY MUCH ANYWAY, GOODBYE"

IF THEY SAY OK THEN SAY:

"We will send you a pre-paid business reply envelope with the questionnaire in the next 2-3 days. Responses can also be faxed back!"

Ensure you have their correct phone number, mail address, and job title. Then ask:

"Is there anything else you need to know?"

(If you can't answer their question, then refer them to

"...the research co-ordinator, Kieren Mayers, he will be happy to explain and discuss this with you further - his number is 01344 362 019)"

And finally:

"Thank you very much for your time"

END OF CALL

Guidelines

* Try to follow script as best as possible to ensure a consistent approach is used by all surveyors - but not to the extent that it conflicts with your natural style of conversation. At best ensure the approach you use is consistent and covers the points given in this protocol.

* Read through attached articles for background information. If there are any questions you feel you cannot answer then refer respondent onto Rebecca May (Intex) or Kieren Mayers (HP).

* **If you are asked "what do you mean be IT products" : we mean:**
  PC's / computers, printers / peripherals, mainframes / servers, phones, photo-copiers, and point-of-sale equipment.

* If you cannot find a contact for redundant or end-of-use products after being referred to 4 different people / sites, then close the enquiry. If you cannot speak to the contact within 4 calls then send on a questionnaire anyway. This should be recorded in the spreadsheet as "Q sent - no previous contact".

Making second calls

Call back 4 weeks after a questionnaire, and say (even if to an answer machine / voicemail):

* My name is _____ , and I am calling on behalf of Hewlett-Packard

* You may remember being contacted a few weeks ago by (myself / one of our researchers / name) about a survey on electronics recycling.

* We sent you a questionnaire, to which we haven't received a response yet

* We would like to send you a second copy and would be very grateful if you could complete it and send it back as soon as possible

Check you have the right address and contact details if they haven't received your initial questionnaire. If potential respondents need additional information, then follow the protocol outlined for first calls:

> "Hewlett-Packard have formed a research partnership with Intex Logistics (an electronics recycling company). This is

> supported with academic expertise from Imperial College London, Brunel University, and the University of Bradford.
>
> We are undertaking a research project on RECYCLING IT EQUIPMENT in view of expected European Union legislation. As part of this we are conducting a postal survey of large organisations in the UK to find out what happens to redundant or end-of-use products.
>
> The information you could give us is very important, we would really appreciate your help by filling in our questionnaire."

Then send on a second copy of the questionnaire with the corresponding second mailing cover letter (with the exception of calls with no previous contact - in these instances send questionnaire again with another no previous contact letter. Record as "2nd Q sent".

What to record:

* Number of people contacted / sites transferred to (excluding receptionist) before best contact is established
* Last date respondent was contacted, next date to contact, and reason for calling back
* Phone number, mailing address, contact name, and job title
* If respondent agrees to participate, record this, use "C" to indicate a respondent must be called back, and "Q" to indicate a questionnaire must still be sent. This ensures records can be understood by all researchers in the event of a hand-over.
* Remember to keep records fully updated at all times - we are contacting a lot of people!
* Periodically please email or send on disk updated records to: kieren_mayers@Non-HP-UnitedKingdom-om9.om.hp.com
* Date of receipt of responses
* Upon receipt of a questionnaire from the first mailing "Q received" should be recorded. On receipt of a response to a second mailing "Q received - 2nd mailing " should be recorded.

Appendix 6: Mail questionnaire

Please note: some of the formatting has been lost in transposing this questionnaire into this report.

Survey of redundant and end-of-use IT equipment

How to complete the survey: Please answer all questions to the best of your knowledge. Please mark your answers by putting a tick in the relevant boxes or by following the answer more extensively in the space provided. Thank you for your help!

Reference number

If you have any queries regarding the completion of this questionnaire, then please ring Freephone 0800 731 1032 quoting your reference number.

IT product use

Q1: Which of the following electronic product types does your company currently use?
(Please tick approximate number for each product type in use)

	0	1-10	11-100	101-500	501-1000	1001-5000	>5000	Info. not available
PCs / computers								
Printers and peripherals								
Mainframes / servers								
Telecommunications								
Office Imaging (copiers)								
Point of sale								

Q2: For which products are you brand specific?
(Please tick as appropriate for each product type in use)

	1-2 brands	Mixed brands	Info. not available
PCs / computers			
Printers and peripherals			
Mainframes / servers			
Telecommunications			
Office Imaging (copiers)			
Point of sale			

Q3: What is the approximate lifetime for each product type:
(Please tick approximate number for each product type in use)

(Years)	1-2	3-4	5-6	>6	Info. not available
PCs / computers					
Printers and peripherals					
Mainframes / servers					
Telecommunications					
Office Imaging (copiers)					
Point of sale					

Q4: Do you lease any IT equipment? (Please tick as appropriate)
☐ Yes, all equipment ☐ Yes, some equipment ☐ No ☐ Don't know

Q5: Do you purchase second user (secondhand) equipment?
☐ Yes ☐ No ☐ Don't know

IF YES, please indicate the relative importance of the following factors in purchasing - including the "other" category if used:

	Very important	Important	Unimportant	Info. not available
Brand of product				
Low cost				
Quality assurance				
Environmental factors				
Other: ----------				

Redundant or end-of-use IT equipment

Q6: Is electronic waste mentioned specifically in your corporate environmental policy?
☐ Yes ☐ No ☐ Don't know

Q7: What are the most important factors leading to redundant or end-of-use IT equipment?
(Please tick as appropriate for each factor- including the "other" category if used)

	Very important	Important	Unimportant	Info. not available
Technological advances				
End of lease				
Upgrading internal admin. systems				
De-valuation of products				
Faulty products				
Software upgrades				
Discontinued product support				
Other: ----------				

Q8: Do you see redundant or end-of-use IT equipment as a waste or asset? (Please tick as appropriate)
☐ Waste ☐ Both ☐ Asset ☐ Neither

Q9: Is there an audit trail for redundant or end-of-use products, such as an asset register?
☐ Yes ☐ No ☐ Don't know

Q10: How often does your organisation use any of the following services for redundant or end-of-use IT equipment?

(Please tick as appropriate for each service - including the "other" category if used)

	Frequent	Infrequent	Never	Info. not available
Certified data destruction				
Storage				
Transfer to staff member				
Charity				
Return to suppliers or lessors				
Sales to dealers, brokers, or traders				
Trade with scrap merchants				
Trade with recyclers				
Integrated waste and recycling services				
Disposal				
Other: ----------				

Q11: Do you receive remuneration for any redundant or end-of-use IT products? ☐ Yes ☐ No ☐ Don't know

Q12: Do you pay for the collection of any redundant or end-of-use IT products? ☐ Yes ☐ No ☐ Don't know

Q13: Do any of your service providers hold a waste carrier's license? ☐ Yes ☐ No ☐ Don't know

Your potential future requirements

Q14: Do you see a need for better developed services for your redundant or end-of-use IT equipment? ☐ Yes ☐ No ☐ Don't know

Q15: What would be the most important features you would look for in a reuse / recycling collection service?

(Please tick as appropriate for each factor- including the "other" category if used)

	Very important	Important	Unimportant
Certified data destruction			
Reliable service			
High volume collections			
Frequent collections			
Remuneration			
Integrated waste management service			
Cost efficiency			
Environmental best practice			
Duty of care for resold products			
Other: ----------			

Q16: How many sites would have to be visited as part of a collection service? |___|___|___|

Q17: In the next five years, do you think that the amount of IT equipment used and disposed of will:
- ☐ Reduce
- ☐ Remain constant
- ☐ Increase
- ☐ Don't know

Q18: Prior to this questionnaire, were you aware of the proposed legislation on recycling electronics wastes?
- ☐ Yes
- ☐ No

Company details

Q19: Company name: _____

Location of this branch: _____

Location of UK headquarters: _____

Number of UK sites: _____

Within the UK does your company operate nationally or regionally?
- ☐ Nationally
- ☐ Regionally

Q20: Does your job involve the responsibiity for the disposal of redundant IT products?
- ☐ Yes
- ☐ No

Department: _____

Your name: _____

Tel: |_|_|_|_|_|_|_|_|_|_|_| Fax: |_|_|_|_|_|_|_|_|_|_|_|

☐ Please tick if you would be willing to discuss your answers with one of our researchers

PLEASE FAX YOUR COMPLETED QUESTIONNAIRE A.S.A.P. TO: (01705) 594 888 OR POST USING THE BUSINESS REPLY ENVELOPE ENCLOSED

THANK YOU VERY MUCH FOR YOUR HELP

Appendix 7: Cover letters

All letters were printed on Hewlett-Packard corporate letterhead.

PILOT LETTER

Dear *[name]*,

Thank you for agreeing to complete the enclosed questionnaire as part of our pilot study. As the environment has become an issue of increasing importance, as businesses we all have had to think more carefully about our roles in society and our effects on the environment. New legislation will be adopted in the UK and throughout Europe under the title of "Producer Responsibility". This will require producers, distributors, retailers, and consumers of electronic products to assume responsibility for the collection and recycling of redundant electronic products.

Hewlett-Packard Limited have formed a market research partnership with **Intex Logistics** (a UK based electronics recycling company operating in the UK and Ireland) with academic expertise and direction provided by researchers at **Imperial College**, London, **The University of Bradford**, West Yorkshire, and **Brunel University**, Uxbridge.

It is hoped this particular research project will give us insight into any issues surrounding redundant or end-of-use information technology products within larger organisations in the UK. This information is very important if we are to address and provide solutions to the Producer Responsibility challenge.

Through your involvement in our pilot study, we hope that you can help us to test the structure of both our questions and overall survey. Any feedback you can provide will be very gratefully received and dealt with in the strictest of confidence.

Thank you once again for agreeing to complete this survey at such short notice. The questionnaire takes about 10 minutes to complete. I enclose a pre-paid envelope for its return.

We can be contacted on Freephone 0800 731 1032 for any queries concerning this survey.

We look forward to receiving your response as soon as possible, and hopefully no later than the 25th July.

Yours Sincerely,

C.K.Mayers
Environmental Research Engineer
Hewlett-Packard Limited

1st CONTACT LETTER

Dear *[name]*,

Thank you for agreeing to complete the enclosed questionnaire as part of our survey on redundant or end-of-use electronics. As the environment has become an issue of increasing importance, as businesses we all have had to think more carefully about our roles in society and our effects on the environment. New legislation will be adopted in the UK and throughout Europe under the title of "Producer Responsibility". This will require producers, distributors, retailers, and consumers of electronic products to assume responsibility for the collection and recycling of redundant electronic products.

Hewlett-Packard Limited have formed a market research partnership with **Intex Logistics** (a UK based electronics recycling company operating in the UK and Ireland) with academic expertise and direction provided by researchers at **Imperial College**, London, **The University of Bradford**, West Yorkshire, and **Brunel University**, Uxbridge.

It is hoped this particular research project will give us insight into any issues surrounding redundant or end-of-use information technology products within larger organisations in the UK. This information is very important if we are to address and provide solutions to the Producer Responsibility challenge.

Thank you once again for agreeing to participate in this survey. The questionnaire takes about 10 minutes to complete. I enclose a pre-paid envelope for its return.

We can be contacted on Freephone 0800 731 1032 for any queries concerning this survey. We look forward to receiving your response soon.

Yours Sincerely,

C.K.Mayers
Environmental Research Engineer
Hewlett-Packard Limited

2nd CONTACT LETTER

Dear *[name]*,

You may remember being contacted by one of our researchers about our survey on recycling redundant IT equipment, and agreeing to complete our questionnaire. We haven't received a response from you yet, so we have sent another copy (attached) as a reminder, and also in case the first did not get to you. The survey is being conducted in anticipation of new legislation which will be adopted in the UK and throughout Europe under the title of "Producer Responsibility". This will require producers, distributors, retailers, and consumers of electronic products to assume responsibility for the collection and recycling of redundant electronic products.

Hewlett-Packard Limited have formed a market research partnership with **Intex Logistics** (a UK based electronics recycling company operating in the UK and Ireland) with academic expertise and direction provided by researchers at **Imperial College**, London, **The University of Bradford**, West Yorkshire, and **Brunel University**, Uxbridge.

It is hoped this particular research project will give us insight into any issues surrounding redundant or end-of-use information technology products within larger organisations in the UK. This information is very important if we are to address and provide solutions to the Producer Responsibility challenge.

The questionnaire takes about 10 minutes to complete. I have enclosed another a pre-paid envelope for its return.

We can be contacted on Freephone 0800 731 1032 for any queries concerning this survey. We look forward to receiving your response soon.

Yours Sincerely,

C.K.Mayers
Environmental Research Engineer
Hewlett-Packard Limited

3rd CONTACT LETTER

Dear *[name]*,

Up to several months ago you were contacted by one of our researchers about our survey on recycling redundant IT equipment. As the survey is drawing to a close we wanted to offer a final opportunity to respond. We have enclosed a final copy of the questionnaire for your attention. To date we have received around 130 responses from UK industry. We will forward a summary of results to all those that have participated in the survey.

The survey is being conducted in anticipation of new legislation which will be adopted in the UK and throughout Europe under the title of "Producer Responsibility". This will require producers, distributors, retailers, and consumers of electronic products to assume responsibility for the collection and recycling of redundant electronic products.

Hewlett-Packard Limited have formed a market research partnership with **Intex Logistics** (a UK based electronics recycling company operating in the UK and Ireland) with academic expertise and direction provided by researchers at **Imperial College**, London, **The University of Bradford**, West Yorkshire, and **Brunel University**, Uxbridge.

It is hoped this particular research project will give us insight into any issues surrounding redundant or end-of-use information technology products within larger organisations in the UK. This information is very important if we are to address and provide solutions to the Producer Responsibility challenge.

The questionnaire takes about 10 minutes to complete. I have enclosed a pre-paid envelope for its return.

We can be contacted on Freephone 0800 731 1032 for any queries concerning this survey. Thank you for your attention, and we look forward to receiving your response soon.

Yours Sincerely,

C.K.Mayers
Environmental Research Engineer
Hewlett-Packard Limited

NO INITIAL CONTACT LETTER

Dear *[name]*,

As the environment has become an issue of increasing importance, as businesses we all have had to think more carefully about our roles in society and our effects on the environment. We are at present conducting a survey on the recycling of redundant or end-of-use IT equipment (including equipment to be returned to lessors), in anticipation of new legislation which will be adopted in the UK and throughout Europe under the title of "Producer Responsibility". This will require producers, distributors, retailers, and consumers of electronic products to assume responsibility for the collection and recycling of redundant electronic products.

Hewlett-Packard Limited have formed a market research partnership with **Intex Logistics** (a UK based electronics recycling company operating in the UK and Ireland) with academic expertise and direction provided by researchers at **Imperial College**, London, **The University of Bradford**, West Yorkshire, and **Brunel University**, Uxbridge.

It is hoped this particular research project will give us insight into any issues surrounding redundant or end-of-use information technology products within larger organisations in the UK. This information is very important if we are to address and provide solutions to the Producer Responsibility challenge.

We have attempted to contact you by phone to ascertain if you were the appropriate contact and would be willing to participate. Please could you either pass the survey to an appropriate contact, or complete it yourself? The questionnaire takes about 10 minutes to complete. I have enclosed another a pre-paid envelope for its return.

We can be contacted on Freephone 0800 731 1032 for any queries concerning this survey. We look forward to receiving your response soon.

Yours Sincerely,

C.K.Mayers
Environmental Research Engineer
Hewlett-Packard Limited

Appendix 8: Chi^2 tests

See following pages.

Table A8.1: Disposal of redundant IT equipment by industry sector

		Manu-facturing	Transport-ation and commun-ications	Whole-sale and retail	Finance, insurance, and real estate	Services	Total	Results
n		57	20	27	13	21	138	
Certified data destruction	Observed	16.00	3.00	5.00	4.00	7.00	35.00	
	Expected	14.46	5.07	6.85	3.30	5.33		p>0.05 NS
	(Oj-Ej)2/Ej	0.22	1.13	0.67	0.20	0.70		$\chi^2 = 2.93$
Storage	Observed	30.00	14.00	17.00	7.00	14.00	82.00	
	Expected	33.87	11.88	16.04	7.72	12.48		p>0.05 NS
	(Oj-Ej)2/Ej	1.09	0.93	0.14	0.17	0.46		$\chi^2 = 2.78$
Transfer to staff member	Observed	52.00	13.00	22.00	11.00	17.00	115.00	
	Expected	47.50	16.67	22.50	10.83	17.50		p>0.05 NS
	(Oj-Ej)2/Ej	2.56	4.84	0.07	0.02	0.09		$\chi^2 = 7.57$
Charity	Observed	43.00	14.00	19.00	9.00	13.00	98.00	
	Expected	40.48	14.20	19.17	9.23	14.91		p>0.05 NS
	(Oj-Ej)2/Ej	0.54	0.01	0.01	0.02	0.85		$\chi^2 = 1.42$
Return to suppliers or lessors	Observed	29.00	3.00	3.00	5.00	9.00	49.00	
	Expected	20.24	7.10	9.59	4.62	7.46		p<0.01 **
	(Oj-Ej)2/Ej	5.88	3.67	7.02	0.05	0.50		$\chi^2 = 17.12$
Sales to dealers, brokers, or traders	Observed	41.00	14.00	18.00	10.00	11.00	94.00	
	Expected	38.83	13.62	18.39	8.86	14.30		p>0.05 NS
	(Oj-Ej)2/Ej	0.38	0.03	0.03	0.46	2.39		$\chi^2 = 3.30$
Trade with scrap merchants	Observed	22.00	8.00	8.00	6.00	7.00	51.00	
	Expected	21.07	7.39	9.98	4.80	7.76		p>0.05 NS
	(Oj-Ej)2/Ej	0.07	0.08	0.62	0.47	0.12		$\chi^2 = 1.36$
Trade with recyclers	Observed	22.00	10.00	6.00	4.00	6.00	48.00	
	Expected	19.83	6.96	9.39	4.52	7.30		p>0.05 NS
	(Oj-Ej)2/Ej	0.37	2.04	1.88	0.09	0.36		$\chi^2 = 4.73$
Integrated waste management	Observed	15.00	6.00	4.00	2.00	5.00	32.00	
	Expected	13.22	4.64	6.26	3.01	4.87		p>0.05 NS
	(Oj-Ej)2/Ej	0.31	0.52	1.06	0.44	0.00		$\chi^2 = 2.35$
Disposal	Observed	43.00	12.00	17.00	8.00	17.00	97.00	
	Expected	40.07	14.06	18.98	9.14	14.76		p>0.05 NS
	(Oj-Ej)2/Ej	0.72	1.01	0.69	0.48	1.14		$\chi^2 = 4.05$

v = 4

Table A8.2: Disposal of redundant IT equipment by company size

		500-749 emp-loyees	750-1500 emp-loyees	>1500 emp-loyees	Total	Results
n		42	54	42	138	
Certified data destruction	Observed	15.00	6.00	14.00	35.00	
	Expected	10.65	13.70	10.65		p<0.01 **
	(Oj-Ej)2/Ej	2.38	5.79	1.41		$\chi^2 = 9.58$
Storage	Observed	22.00	29.00	31.00	82.00	
	Expected	24.96	32.09	24.96		p>0.05 NS
	(Oj-Ej)2/Ej	0.86	0.73	3.61		$\chi^2 = 5.20$
Transfer to staff member	Observed	37.00	44.00	34.00	115.00	
	Expected	35.00	45.00	35.00		p>0.05 NS
	(Oj-Ej)2/Ej	0.69	0.13	0.17		$\chi^2 = 0.99$
Charity	Observed	25.00	40.00	33.00	98.00	
	Expected	29.83	38.35	29.83		p>0.05 NS
	(Oj-Ej)2/Ej	2.69	0.25	1.17		$\chi^2 = 4.10$
Return to suppliers or lessors	Observed	14.00	19.00	16.00	49.00	
	Expected	14.91	19.17	14.91		p>0.05 NS
	(Oj-Ej)2/Ej	0.09	0.00	0.12		$\chi^2 = 0.21$
Sales to dealers, brokers, or traders	Observed	26.00	35.00	33.00	94.00	
	Expected	28.61	36.78	28.61		p>0.05 NS
	(Oj-Ej)2/Ej	0.75	0.27	2.11		$\chi^2 = 3.13$
Trade with scrap merchants	Observed	17.00	17.00	17.00	51.00	
	Expected	15.52	19.96	15.52		p>0.05 NS
	(Oj-Ej)2/Ej	0.22	0.69	0.22		$\chi^2 = 1.14$
Trade with recyclers	Observed	18.00	16.00	14.00	48.00	
	Expected	14.61	18.78	14.61		p>0.05 NS
	(Oj-Ej)2/Ej	1.21	0.63	0.04		$\chi^2 = 1.88$
Integrated waste management	Observed	12.00	11.00	9.00	32.00	
	Expected	9.74	12.52	9.74		p>0.05 NS
	(Oj-Ej)2/Ej	0.68	0.24	0.07		$\chi^2 = 1.00$
Disposal	Observed	30.00	39.00	28.00	97.00	
	Expected	29.52	37.96	29.52		p>0.05 NS
	(Oj-Ej)2/Ej	0.03	0.10	0.26		$\chi^2 = 0.39$

v = 2

Table A8.3: Future disposal service requirement by industry sector

		Manufacturing	Transportation and communications	Wholesale and retail	Finance, insurance, and real estate	Services	Total	Results
n		63	20	27	13	21	144	
Certified data destruction	Observed	43.00	16.00	16.00	10.00	17.00	102.00	
	Expected	44.63	14.17	19.13	9.21	14.88		$p>0.05$ NS
	(Oj-Ej)2/Ej	0.20	0.81	1.75	0.23	1.04		$\chi^2 = 4.04$
Reliable service	Observed	53.00	19.00	23.00	13.00	18.00	126.00	
	Expected	55.13	17.50	23.63	11.38	18.38		$p>0.05$ NS
	(Oj-Ej)2/Ej	0.66	1.03	0.13	1.86	0.06		$\chi^2 = 3.73$
High volume collections	Observed	15.00	7.00	6.00	8.00	4.00	40.00	
	Expected	17.50	5.56	7.50	3.61	5.83		$0.025<p<0.05$ *
	(Oj-Ej)2/Ej	0.49	0.52	0.42	7.39	0.80		$\chi^2 = 9.61$
Frequent collections	Observed	26.00	10.00	12.00	12.00	10.00	70.00	
	Expected	30.63	9.72	13.13	6.32	10.21		$0.025<p<0.05$ *
	(Oj-Ej)2/Ej	1.36	0.02	0.19	9.94	0.01		$\chi^2 = 11.51$
Remuneration	Observed	31.00	12.00	16.00	12.00	12.00	83.00	
	Expected	36.31	11.53	15.56	7.49	12.10		$p>0.05$ NS
	(Oj-Ej)2/Ej	1.83	0.05	0.03	6.40	0.00		$\chi^2 = 8.31$
Cost efficiency	Observed	49.00	17.00	22.00	12.00	16.00	116.00	
	Expected	50.75	16.11	21.75	10.47	16.92		$p>0.05$ NS
	(Oj-Ej)2/Ej	0.31	0.25	0.01	1.15	0.26		$\chi^2 = 1.98$
Integated waste management services	Observed	35.00	13.00	13.00	6.00	14.00	81.00	
	Expected	35.44	11.25	15.19	7.31	11.81		$p>0.05$ NS
	(Oj-Ej)2/Ej	0.01	0.62	0.72	0.54	0.93		$\chi^2 = 2.82$
Environmental best practice	Observed	52.00	20.00	23.00	12.00	18.00	125.00	
	Expected	54.69	17.36	23.44	11.28	18.23		$p>0.05$ NS
	(Oj-Ej)2/Ej	1.00	3.04	0.06	0.34	0.02		$\chi^2 = 4.47$
Duty of care for resold products	Observed	45.00	17.00	21.00	9.00	16.00	108.00	
	Expected	47.25	15.00	20.25	9.75	15.75		$p<0.05$ NS
	(Oj-Ej)2/Ej	0.43	1.07	0.11	0.23	0.02		$\chi^2 = 1.85$

v = 4

Table A8.4: Future service requirements by company size

		500-749 employees	750-1499 employees	>1500 employees	Total	Results
n		47	54	43	144	
Certified data destruction	Observed	31.00	38.00	33.00	102.00	
	Expected	33.29	38.25	30.46		$p>0.05$ NS
	(Oj-Ej)2/Oj	0.54	0.01	0.73		$\chi^2 = 1.27$
Reliable service	Observed	38.00	47.00	41.00	126.00	
	Expected	41.13	47.25	37.63		$p>0.05$ NS
	(Oj-Ej)2/Oj	1.90	0.01	2.42		$\chi^2 = 4.33$
High volume collections	Observed	12.00	12.00	16.00	40.00	
	Expected	13.06	15.00	11.94		$p>0.05$ NS
	(Oj-Ej)2/Oj	0.12	0.83	1.91		$\chi^2 = 2.86$
Frequent collections	Observed	19.00	28.00	23.00	70.00	
	Expected	22.85	26.25	20.90		$p>0.05$ NS
	(Oj-Ej)2/Oj	1.26	0.23	0.41		$\chi^2 = 1.90$
Remuneration	Observed	20.00	32.00	31.00	83.00	
	Expected	27.09	31.13	24.78		$0.025<p<0.05$ *
	(Oj-Ej)2/Oj	4.38	0.06	3.68		$\chi^2 = 8.12$
Cost efficiency	Observed	36.00	40.00	40.00	116.00	
	Expected	37.86	43.50	34.64		$0.025<p<0.05$ *
	(Oj-Ej)2/Oj	0.47	1.45	4.27		$\chi^2 = 6.19$
Integated waste management services	Observed	26.00	29.00	26.00	81.00	
	Expected	26.44	30.38	24.19		$p>0.05$ NS
	(Oj-Ej)2/Oj	0.02	0.14	0.31		$\chi^2 = 0.47$
Environmental best practice	Observed	39.00	48.00	38.00	125.00	
	Expected	40.80	46.88	37.33		$p>0.05$ NS
	(Oj-Ej)2/Oj	0.60	0.20	0.09		$\chi^2 = 0.90$
Duty of care for resold products	Observed	31.00	41.00	36.00	108.00	
	Expected	35.25	40.50	32.25		$p>0.05$ NS
	(Oj-Ej)2/Oj	2.05	0.02	1.74		$\chi^2 = 3.82$

v = 2

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