



# CEDA 3.0

## User's Guide

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# CEDA 3.0 User's Guide

A Comprehensive Environmental Data Archive  
for Economic and Environmental Systems Analysis

*CEDA 3.0 contains*

Resources Consumption • Greenhouse Gas Emissions •  
Land Use • Toxic Emissions • Particulate Matter Emissions  
• Pesticide Use • Ozone Depleting Substance Emissions •  
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*by 480 US commodities and services*

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Product Policy • Screening and Hybrid Life Cycle  
Assessment • Environmental Input-Output Analysis •  
Material Flow Analysis • Substance Flow Analysis •  
Analysis of Environmental Impacts of Products and  
Services • Environmental Design.

## **CEDA 3.0 User's Guide**

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# 1. What is CEDA 3.0 ?

## 1.1. A brief background

CEDA 3.0 is the successor of MIET 2.0, a missing inventory estimation tool for Life Cycle Assessment (LCA) developed by CML (Suh 2001, Suh and Huppel, 2002). Over 500 MIET users worldwide have registered since its first release in 2001. In 2004 MIET 2.0 was updated to MIET 3.0, which has substantially improved data quality by using additional data sets and the most up-to-date data sources and is now included in the standard data package SimaPro, an LCA software tool by PRé Consultants. There are many MIET users who are not LCA practitioners, however, and who wish to continue using the MIET package. These users have been applying MIET for various kinds of analysis, including environmental and economic policy modeling, Integrated Product Policy (IPP), environmental Input-Output Analysis (IOA), Material Flow Analysis (MFA), Substance Flow Analysis (SFA), analyses of consumption and its environmental impacts, and alternative material selection in environmental design. Furthermore, some of the LCA users were keen to see an easy-to-use software tool with which to quickly access detailed data and perform a number of essential analyses for screening and hybrid LCAs. To satisfy the needs of both LCA practitioners and other MIET users, the software tool CEDA 3.0 described in this User's Guide was designed by EnviroInformatica, Co., an environmental data processing and warehousing company.

## 1.2. What kinds of data sets does CEDA 3.0 contain?

CEDA 3.0 comprises three main database modules: (1) an economic input-output database module, (2) an environmental intervention database module, and (3) a characterization factor database module for impact assessment.

The *input-output database module* is derived from a variety of economic statistics, including 1998 US make and use accounts, the 1992 US capital flow matrix, a standard comparison table between US Standard Industry Classification (SIC) codes and the input-output industry codes of the US Bureau of Economic Analysis (BEA), and producer's price change data from the US Bureau of Labor Statistics (BLS). The input-output data module contains information on the structure of inter-industry exchanges of materials and energy throughout the supply chains for

production and consumption of 480 commodities and services in the US. The level of resolution of US input-output statistics is among the best in the world, and they encompass a great many of the production technology mixes in widespread use today. The commodity categories included in the input-output data module are listed in **Appendix A**.

The *environmental intervention database module* contains information on generation of 1344 environmental interventions. It is derived from various environmental databases, including the Toxics Releases Inventory (TRI), National Toxics Inventory (NTI), National Environmental Trend (NET) databases, greenhouse gas emissions and sinks data, agricultural chemical and fertilizer use data, mineral and fossil fuel resource use database, energy consumption data, and land use data from the US. Data sources include the Census Bureau (2001), the Environmental Protection Agency, the Energy Information Administration of the Department of Energy, the National Agricultural Statistics Service and Natural Resources Conservation Service of the Department of Agriculture, the National Center for Food and Agricultural Policy, and the United States Geological Survey. The interventions covered include resource use (6 items), land use (1 item), and environmental emissions to air (551 items), to freshwater (331 items), to industrial soil (236 items), and to agricultural soil (219 items) and relate to over 480 commodities produced in the US. The environmental interventions compiled in CEDA 3.0 are the main driving causes of major environmental impacts such as global warming, ozone layer depletion, various toxic impacts to humans and ecosystems, acidification, eutrophication, land use, resource depletion, etc. A full list of the environmental interventions covered is provided in **Appendix B**.

Lastly, for a total of 1700 environmental interventions employed in 86 widely referenced methods of environmental impact assessment, the *characterization factor database module* contains characterization factors that allow users to aggregate environmental interventions into environmental impact scores. The selected impact assessment methods include Global Warming Potentials (GWPs), Ozone Depleting Potentials (ODPs), CML2002 methods and Eco-Indicator 99 methods. A description of environmental Life Cycle Impact Assessment (LCIA) methods, including those selected for inclusion in CEDA 3.0, can be found in Guinée *et al.* (2002). A complete list of selected characterization methods is provided in **Appendix C**.

### 1.3. What kind of analysis can CEDA 3.0 do?

Users can employ CEDA 3.0 to calculate the overall, economy-wide environmental interventions generated throughout an economy in producing a certain product or service by simply searching or browsing the name of the product or service and entering its price in monetary terms. In the context of an LCA, this result is generally termed the *inventory result*. Users may enter the price as either a producer's or a consumer's price, but need to specify which it is. If entered as a consumer's price, CEDA 3.0 automatically converts it to a producer's price based on the commodity-specific transportation cost and retail and wholesale margins. The inventory result can be exported to a spreadsheet. Users can then quantify the environmental impacts of the product or service throughout an economy by choosing the



option “Environmental Impact Assessment”. CEDA 3.0 then matches relevant impact assessment factors with the inventory result to calculate the sum total of environmental impacts. This result is generally referred to as the *characterized result*. The operational procedure for generating characterized results is as simple as that for inventory results, and the results can again be exported to a spreadsheet or text file.

CEDA 3.0 performs contribution analyses for both inventory results and characterized results. A typical contribution analysis identifies those products and services whose direct generation of environmental interventions or impacts contributes most to the total in the supply chain of the product or service under study. With the results of a contribution analysis users can pinpoint key contributing processes in a given supply chain. This type of contribution analysis will be referred to here as *output contribution analysis*. CEDA 3.0 performs output contribution analysis for all interventions or impact assessment methods simultaneously and once more exports the results to a spreadsheet or text file.

CEDA 3.0 is also capable of another powerful kind of contribution analysis: *input contribution analysis* (Suh, 2003a; Suh 2003b). The products or services identified in an output contribution analysis as being key upstream contributors may be rooted in still higher upstream processes over which the producer of the product or service under study has no control. A practical issue for producers is then the extent to which their environmental performance can be reduced by sourcing input materials from alternative suppliers. Input contribution analysis therefore seeks to identify which direct inputs to the product or service under study are responsible for the greatest environmental intervention or impact through their upstream supply chains. By performing a series of input contribution analyses users can gain detailed insight into the structure of the environmental interventions or impacts induced through the supply-demand structure of a given product system. Such analyses have a variety of uses, including setting data collection priorities and initial system boundary setting for a product LCA, screening alternative production materials and other applications in the field of industrial ecology.

CEDA 3.0 can also be directly used for tiered hybrid LCA (Suh and Hupples, 2002; Suh *et al.*, 2004). By adding particular inventory or impact assessment results beyond the cut-off point of an existing LCA result, users can expand the system under analysis towards national borders for little extra expenditure of time or resources. By employing CEDA 3.0 at the outset of an LCA study, users can make more efficient use of the time and resources available for data collection through a process of iterative screening, collecting data on the key processes identified and performing a hybrid LCA.

CEDA 3.0 also provides data export functions, permitting advanced analysis of basic data sets using professional software packages such as MatLab and Mathematica.

## 2. CEDA 3.0 Methodology

### 2.1. Introduction

CEDA 3.0 utilizes a standard input-output framework and environmental life cycle impact assessment methods for analyzing product and service supply chains and quantifying their environmental impacts, respectively. Some of the basics of Input-Output Analysis (IOA), LCA computations and basic analyses facilitated by CEDA 3.0 are described below. For more details of IOA and LCA, however, the reader is referred to the literature referenced at the end of this guide, e.g., Miller and Blair (1985), Heijungs and Suh (2002), and Guinée *et al.* (2002).

### 2.2. Input-Output Analysis

#### *Leontief multiplier*

Input-output analysis reveals how industries are interlinked through chains of commodity supply and usage. Its basic point of departure is an input-output coefficient table, derived from inter-industry transaction records, in which each column cites coefficients representing the relative amount of inputs required to produce one dollar's worth of output of the industry in question. In fixing these coefficients it is assumed that any magnitude of output of the given industry will require inputs from other industries proportional to these coefficients. This is the proportionality assumption of conventional input-output analysis. The question is then: what amount of inputs is required to meet final demand for the product? This cannot be readily answered by a few simple steps of addition, since every industrial output required for producing a given product requires outputs from other industries, too, and so on. If every industry has  $N$  inputs, then the number of input paths on the  $k$ th tier will be  $N^k$ .

W. Leontief elegantly solved this problem by introducing a few assumptions and a simple matrix inversion known as a Leontief multiplier (Leontief 1970). Leontief's solution can be summarized as a system of non-homogeneous equations (1).

$$(1) \quad \begin{aligned} x_1 &= a_{11}x_1 + a_{12}x_2 + \dots + a_{1n}x_n + y_{1n} \\ x_2 &= a_{21}x_1 + a_{22}x_2 + \dots + a_{2n}x_n + y_{2n} \\ \vdots & \quad \quad \quad \vdots \quad \quad \quad \ddots \quad \quad \quad \vdots \quad \quad \quad \vdots \\ x_n &= a_{n1}x_1 + a_{n2}x_2 + \dots + a_{nn}x_n + y_{nn} \end{aligned}$$

The  $i$ th element of  $\mathbf{x}$ ,  $x_i$  is the total annual output of the  $i$ th industry, while  $a_{ij}$  stands for the fractional output of the  $i$ th industry consumed by the  $j$ th industry in producing one unit of its output. It is assumed in IOA that the coefficients  $a_{ij}$  are fixed, i.e., the ‘recipe’ of each product or service remains unchanged regardless of the volume of production. Thus,  $a_{ij}x_j$  gives the fraction of  $i$ th industry output consumed in producing the total annual output of the  $j$ th industry. The  $i$ th element of the last column,  $y_i$  is the quantity of  $i$ th industry output consumed by households. Overall, equations (1) represent the supply-demand balance of a national economy, where total annual production equals total consumption by industry plus total consumption by households.<sup>1</sup>

Using matrices and vectors the equations (1) can be rewritten as:

$$(2) \quad \mathbf{x} = \mathbf{Ax} + \mathbf{y},$$

which can be rearranged into:

$$(3) \quad \mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{y}.$$

The inverse matrix in equation (3) is referred to as a *Leontief multiplier* and it represents the amount of industry output required directly or indirectly through supply chains to produce one unit of each industry output. The Leontief multiplier permits a variety of economy-wide analyses to be carried out. For instance, the economy-wide primary energy requirement  $\mathbf{e}$  required to meet an arbitrary final demand  $\mathbf{y}$  is calculated as:

$$(4) \quad \mathbf{e} = \hat{\mathbf{e}}(\mathbf{I} - \mathbf{A})^{-1}\mathbf{y},$$

where  $\hat{\mathbf{e}}$  denotes a diagonalized vector of direct energy input to each industry per dollar's worth of output of each sector. If good detailed statistics are available, input-output analysis can yield reliable information on the economy-wide use of energy, employment, resources, water, etc. industries.

### ***Supply and use framework***

---

<sup>1</sup> For the sake of simplicity, imports, exports, changes in stocks, etc., are excluded from consideration here.

The aggregate direct and indirect requirements of industrial output for meeting a given final demand, calculated using equation (3), provide no information on individual ‘commodity’ requirements. Industries generally produce more than one product and depending on the industry in question the amount of secondary and tertiary products may be considerable. The ‘supply and use’ framework provides a methodological basis for dealing with commodities in input-output systems (Stone *et al.*, 1963).

Since the introduction of the System of National Accounts (SNA) (United Nations 1968), many countries have employed this supply and use framework for their national accounts system. Since 1972, US DOC has prepared supply and use matrices and used these to derive a total requirement matrix. The usefulness of the supply and use framework is dual. First, the method greatly improves statistical quality, because the products and services consumed and produced by each individual establishment are better known than the sectors to which they belong. Second, the framework makes an explicit distinction between commodity output and industry output permitting appropriate treatment of secondary products and scrap (Konijn, 1994).

CEDA 3.0 utilizes a commodity  $\times$  commodity total requirements matrix derived from 1998 supply and use matrices using an industry-technology model. The general calculus used to derive the total requirement matrix is shown in BEA (1995b).

## 2.2. Life Cycle Assessment

LCA is widely used for assessing the environmental aspects of a product or service. LCA consists of four major steps: goal and scope definition, inventory analysis, impact assessment and interpretation (ISO, 1998). In the goal and scope definition phase, the objective of the study, its intended application, the required data quality, system boundary and so on are set. In the inventory analysis phase, data on environmental interventions are collected or calculated, on-site from an appropriate industry or using LCA databases, respectively. In Life Cycle Inventory (LCI) analysis, the computational algorithm is also based on matrix inversion and is essentially the same as that used in IOA (Heijungs and Suh, 2002). In the impact assessment phase, the environmental impacts of the product or service are assessed by multiplying LCI results by relevant characterization factors quantifying the relative contribution of each environmental intervention to a particular environmental impact category such as global warming or ozone layer depletion (Guinée *et al.*, 2002). To arrive at more aggregate indicators, this ‘characterization’ step may be followed by a number of additional steps, including normalization, grouping and weighting. These post-characterization steps are not incorporated in CEDA 3.0 but may be pursued by individual users.

The characterization step is dealt with in more detail below. The notion of characterization has been developed independently within several scientific communities. In LCA, Global Warming Potentials (GWPs) and Ozone Depleting Potentials (ODPs) are among the most familiar characterization indicators currently employed. Once generated, any environmental

intervention goes through a series of physical and chemical processes before eventually culminating an environmental problem. For instance,  $\text{SO}_2$  emissions combine with water to form  $\text{H}_2\text{SO}_4$ , which may be ionized to  $2\text{H}^+$  and  $\text{SO}_4^{2-}$ . As precipitation transfers these hydrogen ions to the soil system and lowers soil pH, the resultant acidification process may impact on vegetation and forestry. Together, these successive processes are referred to as an environmental mechanism. Some environmental mechanisms are fairly simple, but most are complex and involve a multitude of physical and chemical transformations and fate and exposure routes. In an LCIA, a category indicator is chosen along with the environmental mechanism in such a way that the indicator reflects an important causal and quantitative relationship with the category endpoint. For instance, the total number of hydrogen ions generated in the process of acidification may provide a good category indicator. Using selected category indicators, each environmental intervention can be represented in terms of its equivalence to a reference intervention in the impact category in question. In the case of global warming, for instance, the radiative force of each greenhouse gas is chosen as category indicator (termed Global Warming Potential) and  $\text{CO}_2$  as reference intervention for 1 GWP.

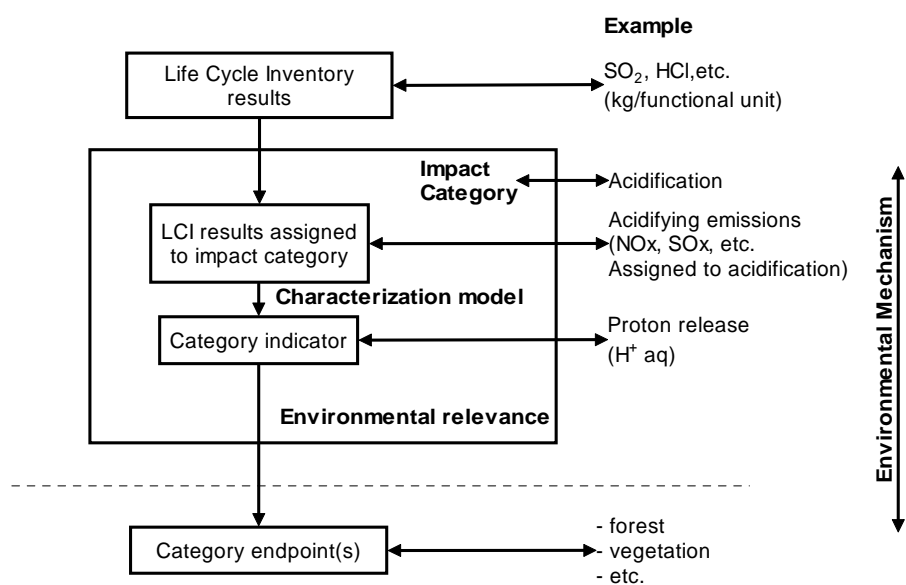


Figure 1. Concept of category indicators (ISO, 1999)

Characterization factors are simply a set of factors for converting LCI results into the equivalent terms of a reference intervention. Depending on the characterization model used, the time horizon considered and the physical location of the category indicator, however, a number of different approaches are available to this end. The 86 methods included in CEDA 3.0 cover and embrace the characterization factor sets that are most widely referenced and are linked internally to all other interventions to avoid errors in linking interventions with appropriate factors.

## 2.3. Basic analytical tools of CEDA 3.0

This section describes the basic analytical tools incorporated in CEDA 3.0. Non-technical users may skip this section.

Let  $k$  and  $j$  index commodity,  $i$  environmental intervention, and  $b$  impact category. Let  $\mathbf{A}$  be the commodity-by-commodity input-output structural coefficient matrix or direct requirements matrix, with an element of  $\mathbf{A}$ ,  $a_{jk}$  denoting the amount of  $j$  directly required to produce one unit of  $k$ . In CEDA 3.0 imports and capital flows are endogenized in the direct requirements matrix  $\mathbf{A}$ . Let  $\mathbf{B}$  be the environmental intervention matrix, with an element of  $\mathbf{B}$ ,  $b_{ij}$  denoting the amount of  $i$  generated or required to produce one unit of  $j$ . Let  $\mathbf{y}$  denote final demand, with an element of  $\mathbf{y}$ ,  $y_k$  denoting final demand for  $k$ . In general, the overall environmental interventions generated due to final demand  $\mathbf{y}$  is then calculated as

$$(4) \quad \mathbf{m} = \mathbf{B}(\mathbf{I} - \mathbf{A})^{-1} \mathbf{y}.$$

The column vector  $\mathbf{m}$  has a dimension of  $i \times 1$  and represents the overall environmental interventions generated directly and indirectly by industry in supplying the final demand  $\mathbf{y}$  (cf. equation (3)). In an LCA context,  $\mathbf{m}$  is regarded as an *inventory* of the ‘functional unit’ satisfied by  $\mathbf{y}$ . The final demand  $\mathbf{y}$  can be entered as either a producer’s or consumer’s prices. If users know the exact 1998 producer’s price of the commodity at stake, they can enter the price by selecting “Producer’s price” in the dialogue box. A set of default conversion factors devised for CEDA 3.0 convert consumer’s prices into producer’s prices. The vector  $\mathbf{m}$  is the calculation result that a user will see having chosen the “Inventory” radio button in the workspace. CEDA 3.0 allows only one final demand item to be entered at a time; an inventory comprising multiple final demand items can be calculated by running the query a number of times and summing the results.

If desired, users can also perform a contribution analysis by clicking either “Input contribution” or “Output contribution” in the dialog box “Results”. One key question addressed by LCA contribution analysis is “what environmental interventions (or environmental impacts) are generated in which upstream or downstream processes?”, providing insight into key indirect contributors to supply-chain burden. This type of analysis will be referred to here as *output contribution* analysis (cf. Suh, 2004; Heijungs and Suh, 2002).

Using the above formula and definition, the output contribution is calculated as

$$(5) \quad \mathbf{M}^{\Omega,i} = \bar{\mathbf{B}}_i (\mathbf{I} - \mathbf{A})^{-1} \mathbf{y},$$

where  $\bar{\mathbf{B}}_i$  is a diagonalized  $i$ th row of  $\mathbf{B}$ , and  $\mathbf{M}^{\Omega,i}$  represents the contributions of each commodity to environmental intervention  $i$ . As CEDA 3.0 calculates the contributions of all relevant commodities to all environmental interventions, the dimension of the resultant matrix

is rather large. Consequently, the result of a contribution analysis is not displayed but can be exported to spreadsheet or text format for further analysis by users. Although output contribution analysis is eligible as a method for identifying upstream and downstream processes that generate significant environmental interventions, it does not indicate which particular direct inputs to the commodity under study are responsible for inducing them. This information may be sought by users in order to prioritize input materials and the processes using them for further improvement. This type of analysis is referred to in this manual as *input contribution* analysis (cf. Suh, 2003a; Suh, 2004).

The input contribution is calculated as

$$(6) \quad \mathbf{M}^{\Lambda,i} = \mathbf{B}_i (\mathbf{I} - \mathbf{A})^{-1} \overline{\mathbf{A}\mathbf{y}},$$

where  $\overline{\mathbf{A}\mathbf{y}}$  is a diagonalized column vector,  $\mathbf{A}\mathbf{y}$ , and  $\mathbf{M}^{\Lambda,i}$  is the contribution to the environmental intervention  $i$ .

As the number of environmental interventions covered by CEDA 3.0 is rather large and the same chemical may have several different names, matching inventory results with characterization factors can be a time-consuming job and may create additional errors. For this reason CEDA 3.0 links the inventory results with 86 of the most widely referenced characterization methods. The links between environmental interventions and characterization factors are established internally using Chemical Abstract Service (CAS) numbers and own identifiers, as follows.

Let  $b$  index characterization methods and  $\mathbf{C}$  be the characterization factor matrix, where an element of  $\mathbf{C}$ ,  $c_{bi}$  represents the characterization factor for environmental intervention  $i$  in characterization method  $b$ . A characterized result is then calculated as

$$(7) \quad \mathbf{q} = \mathbf{CB}(\mathbf{I} - \mathbf{A})^{-1} \mathbf{y}.$$

As with the inventory results, users can perform an additional contribution analysis on the characterized results. The equation

$$(8) \quad \mathbf{Q}^{\Omega,h} = (\overline{\mathbf{CB}})_h (\mathbf{I} - \mathbf{A})^{-1} \mathbf{y},$$

where  $(\overline{\mathbf{CB}})_h$  is a diagonalized  $h$ th row of  $\mathbf{CB}$ , calculates the output contribution using characterized results. Input contributions are calculated as

$$(9) \quad \mathbf{Q}^{\Lambda,h} = (\mathbf{CB})_h (\mathbf{I} - \mathbf{A})^{-1} \overline{\mathbf{A}\mathbf{y}}$$

The results may also be exported to a spreadsheet or text format for further analysis.

## 2.4. Derivation of environmental matrix

A detailed description of the data used for the environmental database module as well as their respective sources is provided in the next chapter. In this section we deal, in brief, with the computational aspect only.

Generally speaking, the overall economy-wide direct and indirect environmental interventions caused by a given final demand for commodity  $\mathbf{y}$  is calculated by means of equation (4). Since a commodity  $\times$  commodity matrix is utilized for the input-output part, the dimension of  $\mathbf{M}$  should likewise be intervention  $\times$  commodity. For instance, the equation

$$(10) \quad \mathbf{m}^* = \mathbf{B}^I (\mathbf{I} - \mathbf{A})^{-1} \mathbf{y},$$

where  $\mathbf{B}^I$  is the environmental intervention  $\times$  industry matrix representing the overall environmental interventions caused by the production of 1 dollar's worth of industry output, encountered in some of the literature, is not in fact congruent.

The consequence of the confusion between industry and commodity in equation (10) may be significant, at least in the US, where the proportion of secondary products produced in each industry is considerable (Miller and Blair, 1985). According to the recent input-output table prepared by BEA, up to 77.8% of the market share of each commodity is dependent on industries that do not produce the commodity as a primary product. In the US economy, furthermore, the portion of secondary products generated by each industry may be up to 88.6% of total output in monetary terms. For all these multiple output processes, there thus arises the problem how to allocate environmental interventions and impacts appropriately. In CEDA this problem is resolved by using the 'make and use' framework (*cf.* Suh and Huppel, 2002).

Equation (4), which calculates aggregate direct and indirect environmental interventions for a given final demand, uses the intervention  $\times$  commodity matrix  $\mathbf{B}$ . However, information on environmental interventions is compiled mainly on an industry rather than commodity basis.  $\mathbf{B}$  must therefore be derived from  $\mathbf{B}^I$ , by assigning the aggregate environmental intervention of each industry to its secondary products and scrap as well as its primary product. In LCAs many allocation methods have been proposed and used for ascribing particular environmental interventions to co-products (Huppel *et al.* 1994; Guinee *et al.* 2002; Frischknecht 2000). The allocation procedure adopted should preferably be based purely on physical causality between environmental intervention and production of secondary and primary products. As strict causality cannot always be established with any degree of precision, however, allocation based on the economic value of the products in question has therefore been widely adopted in LCAs, as the economic value of process output reflects the driving force of the processing operation in question.

Assuming that the sum total of environmental interventions by a given industry is assigned



proportionally to its primary and secondary products based on their economic value, the average environmental intervention due to a dollar's worth of commodity can then be calculated on the basis of market share as

$$(11) \quad \mathbf{B} = \mathbf{B}'\mathbf{D},$$

where  $\mathbf{D}$  is a market share matrix derived from make and use matrices. Equation (11) gives the aggregate environmental intervention by industries producing a given commodity based on market share. This method corresponds to the industry-technology assumption used for deriving the direct requirements matrix  $\mathbf{A}$  in CEDA 3.0.

Alternatively, one can assume that each commodity generates its own characteristic environmental interventions, irrespective of the industry producing it. Under this assumption, the total environmental intervention of a primary product of a given industry is calculated by subtracting the total environmental intervention due to secondary products, indexed to industries producing these secondary products as primary products. In LCA this method is referred to as the 'avoided impact' allocation method or 'system expansion' method and corresponds to the commodity-technology assumption in the make and use framework.

## 2.5. Hybrid analysis

Just about every functional output dealt with in LCA involves a near-infinite number of processes embodying both direct and indirect input/output relations. A motor vehicle, for example, is manufactured using a wide variety of parts and equipment, most of which require numerous raw and ancillary materials as well as energy, capital and so on. These interconnections, which can be seen as a 'commodity flow web', proliferates enormously through upstream processes, although the importance of certain flows may taper off as they become incorporated in indirect relations far upstream. In practice, most LCAs deal only with a limited number of these processes - hopefully the important ones - underlying production of a given functional output, establishing a cut-off point beyond which processes are ignored. To establish which processes are to be taken as the starting point for the subsequent iterative procedure, ISO (1998) suggests three criteria: mass, energy and environmental relevance. Of these, mass and energy are the most frequently used, although in some case studies mass has been found to be a poor indicator. In most cases environmental relevance has very limited applicability as a cut-off criterion, since the very problem in selecting 'promising processes' resides in the fact that the importance of flows is not usually known prior to actual collection of detailed data. The basic problem of cut-off is that we are required to choose between inputs or outputs of which we as yet have no precise knowledge (for a detailed discussion see Suh *et al.* 2004).

One of the most popular ways of solving this problem proceeds from the assumption that the overall environmental significance of a process can already be reliably intimated from a few elementary traits of the process and the products it embodies. These can then be directly and

efficiently employed as cut-off criteria on for each individual process. Analyzing the simplest such traits, mass and energy content, Reynolds *et al.* (2000a) concluded that these two alone cannot generally serve as reliable indicators. In Reynolds *et al.* (2000a, 2000b) they found that combining mass and energy with economic factors, yielded a more satisfactory system boundary cut-off criterion. This approach seems reasonably justified, as costs are always driven by economic activities, which are very likely to be related to environmental interventions.

In view of the multitudinous origins and major variability of pollutant environmental impacts, however, generalization of the relationship between a few simple traits and overall environmental impact based on some deductive inference seems very problematical.<sup>2</sup> Hunt *et al.* (1998) tested 10 different methods for streamlining LCI and concluded that the validity of any such trait can only be judged on a case-by-case basis.<sup>3</sup>

It is generally very difficult to justify omitting any flows, although this is in fact required by ISO (1998). It is therefore necessary to cover the omitted flows, rather than cut them off. On the other hand, it is impossible in practice to gather all the site-specific data associated with every single process involved in the production of a given functional output. As an alternative to process LCA, therefore, an LCI based on IOA has been suggested (Lave *et al.*, 1995; Hendrickson *et al.*, 1998). An input-output table is then prepared on the basis of national statistics covering, in principle, all economic activities involving monetary transaction, which is thus taken to be more encompassing as a system boundary. Input-output tables have limitations of their own, however, particularly their level of resolution, which is generally too poor to be used as a full substitute for a detailed, process-level LCA.

Hybrid analysis combines process LCA (for foreground processes) and input-output LCA (for background processes) and maximizes their respective advantages of process specificity and encompassing system boundary (Suh and Huppes, 2005; Suh, 2004; Suh *et al.*, 2004; Joshi, 1999). There are several possible ways to combine the process LCA and IOA. The simplest of these is tiered hybrid analysis (Bullard *et al.*, 1978, Moriguchi *et al.*, 1993), whereby overall results are calculated simply by adding the results of an input-output LCA (usually only for cut-offs) to those of a process LCA. With the tiered hybrid method, users can expand the system boundary to the national economy at little additional cost. In addition, the method can be used as a screening tool for identifying further data collection priorities. As tiered hybrid analysis highlights important contributors beyond the system boundary, LCA practitioners can efficiently improve overall data quality by directing their resources first to these key contributors.

Users preferring to adopt more sophisticated analytical tools such as Monte Carlo analysis and perturbation analysis may consider performing an integrated hybrid analysis in which input-output matrix and process matrix are combined into a single matrix (Suh, 2004).

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<sup>2</sup> Reynolds *et al.* also limited the area of application of their method to combustion-related emissions.

<sup>3</sup> On the other hand, if there does exist a reliable indicator correlating perfectly with overall environmental impact, it is better to use that indicator for calculating the inventory than employing a cut-off point.

## 2.6. Limitations of the CEDA 3.0 methodology

CEDA 3.0 uses US input-output accounts and LCIA methodology for its calculations, and the limitations inherent in each therefore also apply to CEDA 3.0.

Lave *et al.* (1995) addressed the limitations of the input-output approach for undertaking detailed analysis. Since even the most detailed input-output tables subsume different commodities under a single classification, input-output based analysis can enable comparison at a generic, sectoral level only. Input-output based methods are therefore inadequate for detailed process-level analysis. More fundamentally, in setting matrix **A** in equation (3), IOA is based on an assumption of proportionality, i.e. it ignores both 'economies' and 'diseconomies' of scale as well as 'the law of diminishing return'. Another source of uncertainty is discrepancy between the base year of the input-output table and that of the study. Although this kind of error can be mitigated by employing the most recently available input-output table, this may be insufficient in the case of certain rapidly changing sectors. Although input-output methods considerably extend the upstream reach of analysis, the system boundary is still not in principle truly encompassing, as the national economy is ultimately linked with international trade. For countries relying heavily on trade, truncation at the national borders may significantly reduce the usefulness of IOA. In the US, however, the amount of imports and exports is relatively small compared with domestic production, limiting possible errors due to cross-boundary commodities. In CEDA 3.0, it is assumed that imports have been produced using exactly the same technology as in the US, thus further reducing possible errors due to truncation of imports.

## 3. Data and data sources

### 3.1. Input-Output data

CEDA 3.0 uses the US 1998 annual input-output tables compiled by BEA (BEA 2002) and a calculation procedure that follows the standard US make and use framework provided in BEA (1995a).<sup>4</sup> However, the 1998 annual input-output tables contain no information on capital flows. The most recent capital flow matrix available is for the year 1992 (BEA 1995c). Although the decision to use the 1992 capital flow table ensues largely from the problem of data availability, it has been deemed reasonable to assume that the capital goods invested in 1992 were still in use in 1998 in most industries apart from rapidly developing sectors like the information technology (IT) sector, for which current estimates based on 1992 capital investments may be misleading. The amount of capital goods used by each sector has been inflated or deflated depending on price change information and gross output differences between 1992 and 1998 for the sector in question. In a 1992 benchmark survey by BEA, uses of 163 capital goods by 64 industries were compiled on the basis of SIC code. These have been reassigned to the relevant IO categories for inclusion in a use matrix.

In CEDA 3.0, any data involving SIC code are first assigned to the most detailed set of SIC codes, which distinguish 1037 different industries, and then reclassified under a BEA code to preserve as far as possible the detail of the primary data.

### 3.2. Environmental data

#### 3.2.1. Greenhouse gas emissions

##### *Carbon dioxide*

Total US greenhouse gas (GHG) emissions, including but not restricted to carbon dioxide (CO<sub>2</sub>) emissions, are fairly well established. Apart from the CO<sub>2</sub> emission data for the electric utility sector compiled by EIA and EPA, however, data at the level of individual sectors are

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<sup>4</sup> The basic principles of input-output analysis, including the make and use framework, are summarized well in a book by Miller and Blair (1985).

not readily found. Consequently, the rest of the estimation procedure for combustion-oriented CO<sub>2</sub> emissions focuses on other sectors than electric utility sector.

With regard to transportation, there are two categories of CO<sub>2</sub> emissions to be distinguished: those of domestic transportation and industrial transportation. CEDA assumes that the use of all trucks, buses, aircraft, boats and vessels and locomotives are part of industrial activities. CO<sub>2</sub> emissions from international bunker fuel combustion, construction equipment and agricultural vehicles are also assigned to industrial use. Industrial and commercial combustion-oriented CO<sub>2</sub> emissions have been assigned on the basis of BEA fuel use data and the data on combustion-oriented CO<sub>2</sub> emissions by fuel type compiled by EPA (EPA, 2002a). Non-combustion-oriented CO<sub>2</sub> emissions have been assigned based on the source process cited by EPA (2002a).

**Table 1. Direct US industrial carbon dioxide emissions, by sector<sup>5</sup>**

	Aggregated sector	Sources	Emission (Tg CO <sub>2</sub> )	Share
Combustion-oriented	Electric utility	Electric utility	2160.3	46%
	Industry (based on fuel consumption)	Coal	137.8	21%
		Natural gas	484.1	
		Petroleum	194.2	
		Lubricant oil	12.7	
		Other petroleum	171.3	
	Transportation	Light duty trucks	356.4	24%
		Other trucks	257.9	
		Buses	12.4	
		Aircraft	183.0	
		Boats and vessels	47.8	
		Locomotives	33.8	
		Construction and agricultural equipment	93.0	
Commercial (based on fuel consumption)	Coal	8.7	5%	
	Natural gas	163.5		
	Petroleum	47.2		
Non-combustion-oriented	Industrial processes	Iron and steel	67.4	4%
		Cement manufacturing	39.2	
		Waste combustion	20.3	
		Ammonia manufacturing	20.1	
		Limestone and dolomite	21.9	
		Natural gas flaring	6.3	
		Soda ash manufacturing	5.8	
		Titanium dioxide	4.3	
		Ferroalloys	1.8	
CO <sub>2</sub> consumption	1.4			
Total			4665.5	100%

<sup>5</sup> Based on EPA (2002a), EIA (2002) and own calculations.

In CEDA, the GHG emissions of the sources under the headings ‘industry’ and ‘commercial’ have been assigned to individual IO industries based on the transaction records for the commodities in question. The remaining emission sources could be allocated directly to the appropriate IO industrial sectors.

### **Methane**

In 1998, emissions of methane (CH<sub>4</sub>) accounted for 9.3% of total industrial and households US GHG emissions (627.1 Tg CO<sub>2</sub>-equivalents). Besides enteric fermentation (particularly by ruminants), industrial processes such as landfills, natural gas systems and coal mining are the predominant sources, and these ‘area sources’ can be readily assigned to a relevant IO classification.

Given the CH<sub>4</sub> emission factors for residential and commercial coal combustion (300 and 10, respectively) and respective consumption of the two sectors in 1998 (13 Tbtu and 92 Tbtu), based on coal consumption, only 19% of CH<sub>4</sub> emissions from ‘stationary’ sources have been assigned to intermediate industries (EPA 2002a and EIA 2002). According to EPA (2002a) 42% of CH<sub>4</sub> emissions from mobile sources were due to passenger cars. Assuming other means of transportation can be assigned to intermediate industries, 58% of ‘mobile’ CH<sub>4</sub> emissions can then be assigned on the basis of transportation service transaction records, and this has been done in CEDA.

**Table 2. US industrial Methane emissions, based on direct emission<sup>6</sup>**

Source	Emission (Gg CH <sub>4</sub> )	Emission (Tg CO <sub>2</sub> -eq.)	Share (%)	
Landfills	9571	216.6	41%	
Natural gas systems	5820	125.7	24%	
Coal mining	3235	73.5	14%	
Manure management	Dairy cattle	624	34.8	7%
	Swine	864		
	Beef cattle	161		
	Sheep	2		
	Goats	1		
	Poultry	130		
	Horses	29		
Wastewater treatment	1326	26.8	5%	
Petroleum systems	1114	24.2	5%	
Stationary sources	334	8.2	2%	
Rice cultivation	376	7.6	1%	
Mobile sources	123	4.8	1%	
Petrochemical production	78	1.5	0%	
Agricultural residue burning	37	0.7	0%	
Total	23984	524.4	100%	

<sup>6</sup> Based on EPA (2002a).

### ***Nitrous oxide emissions***

Because of their very minor contribution to overall GHG emissions, only two N<sub>2</sub>O sources have been deemed significant: 'agricultural soil management' and 'mobile sources', contributing 1.0 Tg and 0.2 Tg of CO<sub>2</sub>-equivalent GHG emissions (963 Gg and 191 Gg as N<sub>2</sub>O), respectively. Following the same line of reasoning as for CH<sub>4</sub>, 46% of N<sub>2</sub>O emissions from mobile sources have been assigned to intermediate industries on the basis of transportation service utilization.

### ***Other greenhouse gas emissions***

CEDA 3.0 also covers the following greenhouse gases: trichloromethane, sulfur hexafluoride, tetrachloromethane, perfluorobutane, perfluorocyclobutane, perfluoroethane, perfluorohexane, perfluoromethane, perfluoropentane, perfluoropropane, methylbromide, methyl cyclohexane, HALON-1211, HALON-1301, 7 different HCFCs, 13 different HFCs, 6 different CFCs, and Dichloromethane. However, their contribution is generally insignificant for most industries.

### **3.2.2. Criteria pollutants**

The term 'criteria pollutants' refers to six air pollutants: carbon monoxide (CO), nitrogen oxides (NO<sub>x</sub>), sulfur dioxide (SO<sub>2</sub>), particulate matter (PM)<sup>7</sup>, ozone (O<sub>3</sub>) and lead (Pb). Four of these, CO, NO<sub>x</sub>, SO<sub>2</sub> and PM, have been compiled and maintained by the U.S. National Emission Trend (NET) database, which is now being absorbed into the National Emission Inventory (NEI) database together with the National Toxic Inventory (NTI) database for Hazardous Air Pollutants (HAPs) (EPA 2002c, 2002d). The NET database covers both point sources and non-point sources, including area sources and mobile sources. The point source emissions compiled in the NET database provide detailed information on emission sources at the facility level and also indicates the SIC code of the facility. The point source section of the database can therefore be readily assigned to the appropriate industry on the basis of SIC codes. In CEDA 3.0 the most detailed SIC code set has been used to assign SIC-based information without losing resolution. The NET database for point source criteria pollutant emissions covers a total of 1037 SIC industries, and these emissions have been converted into 500 BEA industry codes, based primarily on the standard comparison between SIC and BEA codes prepared by BEA. In cases where a SIC code can be subsumed under more than one BEA heading, additional data sources such as main source facility type or total amount of industry output have been employed. Non-point sources have no SIC code, but as these are described in detail they can readily be tied to an IO industry classification code. For non-point sources, including both mobile and area sources, NET provides a more aggregated classification of emission sources (less than 200 elements). Criteria pollutant emissions from non-point sources have been converted to the BEA industry classification based on several assumptions. For instance, CO emissions from "agricultural fires" have been assigned to 16 agricultural industries in the BEA classification based on their share of total output, and NO<sub>x</sub> emissions from "on-road vehicles" have been assigned to 500 BEA industries based on the

<sup>7</sup> PM10 and PM2.5 have been distinguished.

rate of on-road vehicle utilization by each industry, assuming that use of truck and bus services represents industrial use of on-road vehicles. Non-anthropogenic sources such as forest wildfires have not been assigned.

### 3.2.3. Volatile Organic Compounds (VOC) and ammonia

These two pollutants are also covered by the NET database and the procedure and data sources employed in CEDA to compile these pollutants are similar to those used for the criteria pollutants.

### 3.2.4. Toxic pollutants

The toxic pollutants part of the database is the most challenging, even in the US, which probably has the most advanced monitoring and reporting system for toxic chemicals in the world. In the US, toxic emissions are dealt with under a number of different initiatives, including the Toxics Releases Inventory (TRI), National Toxics Inventory (NTI) and National Center for Food and Agricultural Policy (NCFAP) database (EPA 2002b, 2002c, 2002d, NCFAP 2000). These databases comprise extensive arrays of toxic chemicals: 535 in TRI98, 188 in NTI and 235 in NCFAP. Nonetheless, certain important chemicals could be missing. The list is based on current knowledge of toxic chemicals, however, and identification and quantification of other toxic chemical releases was not considered a priority in CEDA 3.0. Thus, only those chemicals listed in the cited databases have been included, supplemented by those compiled under other initiatives such as the NET databases.

In CEDA, attention has been focused on solid coverage of emission sources rather than on inclusion of additional toxic pollutants. Table 3 summarizes the scope of the three databases in terms of emission source types, industries, environmental media and emissions from facilities below the threshold limit.

**Table 3. Coverage of toxic emission databases**

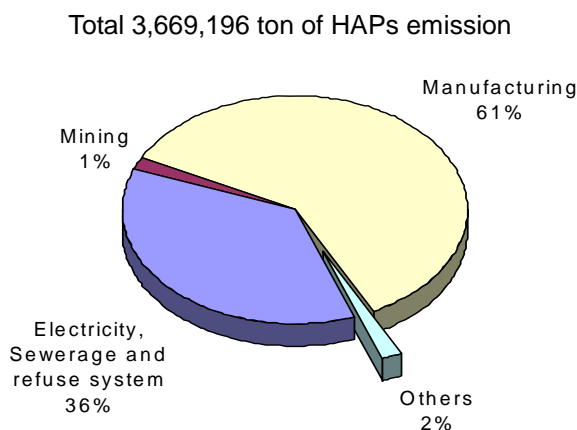
Scope of database		TRI	NTI	NCFAP
Source type	Area		V	V
	Mobile		V	
	Point	V	V	
Industry	Agricultural and mining	*	v	V
	Manufacturing	V	V	
	Services	*	V	
Environmental medium	Air	V	v	
	Water	V		
	Soil	V		v**
Coverage within industries	Reports from larger facilities only	v	V	
	Estimation for facilities below thresholds		V	
	Chemical use data			V

\* Since 1998 some of these activities have been covered by TRI.

\*\* Whether the pesticide applied is an emission to air, water or soil depends very much on the properties of the applied chemical, climate conditions, etc. However, here the arguments are postponed to the stage of impact assessment method specification, and the emission itself is regarded as an emission to soil.



A glance at table 3 indicates that none of the databases cover emissions to water and land (other than pesticides) by mobile and area sources, NTI covering only Hazardous Air Pollutants (HAPs) and TRI mainly point sources only. While toxic pollutant emissions to environmental media other than air by mobile sources are not considered to be significant, those from area sources, such as leachate emissions from landfills, could be considerable. These gaps have meanwhile been fairly well filled, however, following a recent extension of the TRI databases, especially for Mining (SIC1021 to SIC1474), Logistic services (SIC4212 to SIC4581), Sewerage and refuse systems (SIC4952 and SIC4953) and Solid waste management (SIC 9511). In addition to these sectors, since 1998 most major chemical-handling sectors have also been included in the TRI database, and industry coverage by this database therefore seems reasonably complete, although obviously not 100 per cent.



**Figure 2. Contribution by industries to NTI database by mass**

This has indeed been confirmed, for air emissions at least. According to the NTI database, a total of 3,669,196 tons of HAPs was emitted in the US in 1996, with Manufacturing industries (SIC 20 – SIC 39) and Electricity, sewerage and refuse systems (SIC 49) contributing around 97%, emitting 2,202,304 ton and 1,338,170 ton, respectively. Thus, the major industries generating all but two per cent of HAP emissions are within the scope of the extended TRI database.

However, emission reports for the TRI database are collected only from those facilities employing 10 or more full-time equivalent employees or manufacturing or processing over 25,000 pounds or otherwise using over 10,000 pounds of any listed chemical during the reporting year. Although the emission from each individual facility not meeting these conditions may well be small, together they may be quite substantial.

The completeness of the TRI database has been examined using the NTI database and establishment size distribution data compiled by the Bureau of Census (2001). The NTI

database estimates HAP emissions using reports as well as emission factors and activity rates, regardless of the size of facilities. A comparison between TRI and NTI for overlapping chemicals can therefore provide an indication of the truncation of TRI of facilities below the threshold. This comparison showed that there are indeed significant systematic truncations in TRI showing only 17.2% of HAP emissions, on average, compared to NTI. This strongly suggests that using only TRI may significantly underestimate the potential impacts of toxic releases.<sup>8</sup> One explanation might lie in the size distribution of establishments. Given the wide range of processes involved, each industry has different establishment size distribution characteristics. For instance, North American Industry Classification System (NAICS) 323, Printing and related support activities is dominated by establishments with less than 10 employees, which account for 66% of the total of 42,863 establishments, while the share of these smaller establishments in the Paper manufacturing sector (NAICS 322) is only 20% of the total of 5,868 (US Census Bureau, 2001). The larger the number of smaller establishments in an industry, the less complete the TRI data for that sector will probably be. Besides following from the nature of the threshold, this is also due to emission standards generally being less strict for small-sized establishments and again, although such establishments may generate smaller volumes of toxic emissions individually, their sum total may be substantial.<sup>9</sup>

The regression study was further extended to the level of individual industries in order to reflect the differences in establishment size distribution. The TRI values for each sector represent, on average, 4.4% to 29.4% of the HAPs reported by NTI, depending on the sector involved.<sup>10</sup> These results do not support the argument that TRI can still indicate the relative magnitude of toxic impacts even though their absolute values are misleading due to homogeneous truncation.

In CEDA 3.0, relatively complete data sources such as NTI for HAPs have been utilized as far as available. Otherwise, sectoral toxic emissions have been estimated based on TRI and the relationships between TRI and NTI values derived for each individual sector. In cases where no such sectoral relationships could not be established, owing either to sample size or to poor regression results, more general relationships between TRI and NTI have been used instead.

For mobile and area sources, direct use has been made of the NTI database, with no further adjustments as it is considered to cover most major emissions. Besides point source emissions, the NTI database also includes emissions from natural processes and post-production stages, including wildfire, household product usage, etc., and these emissions have been excluded from subsequent assignment to individual industries.

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<sup>8</sup> These results also support, to some extent, the study by Ayres and Ayres (1998).

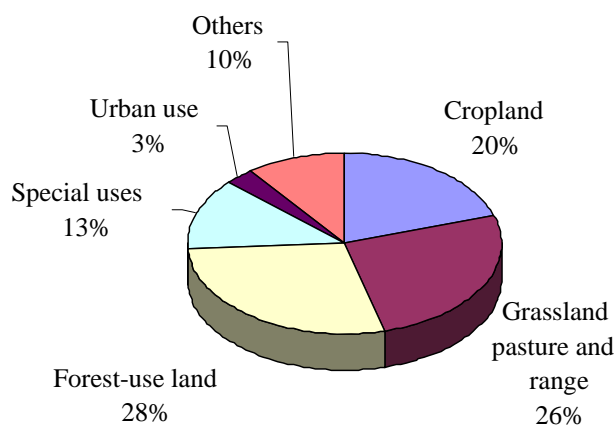
<sup>9</sup> Using the Bureau of Census (2001) data, the relationship between the completeness of TRI and the proportion of small-to-medium sized establishments in each industry was examined. The results show that the two are negatively correlated.

<sup>10</sup> The coefficients of regression lie between 2.1 to 7.1, depending on the sector. Several significant differences between TRI 98 (i.e. for 1998) and NTI for 1996 are observed for SIC 49, Utilities, although there was relatively little change in technology or regulation between the two periods. Formaldehyde and chlorine emissions, for instance, are reported to be 57.7 and 23.0 ton, respectively, by TRI98, while NTI for 1996 reports, for the same chemicals, 15,965.5 and 1,514.0 ton, respectively.

For pesticide emissions, direct use has been made of the NCFAP database. This database compiles and maintains volume records of 235 pesticides applied to 88 types of crop. On the assumption that the amount of pesticide applied equals emission, pesticide emission data have been assigned directly to a BEA industry code based on crop type.

### 3.2.5. Land use

In this part of the CEDA database, only uses of land by major land-covering activities are accounted for (in square meters). In addition, mere occupation of land is all that is considered, with differences in neither land-use intensity nor land transformation being accounted for. Figure 2 shows the major forms of land use in the U.S.



**Figure 3. Major uses of land in the US (USDA, 2002)**

: Total area of land in use: 2.3billion acres (1997).

The Special uses cited in figure 3 include parks, wilderness, wildlife and related uses, transportation and national defense areas, while Others covers deserts, wetlands and barren land. Land uses that can be related to industrial production are croplands, grassland, part of Special uses (recreation, transportation and defense) and part of Urban use (for industrial installations). Urban use here includes industrial complexes and service areas other than agricultural uses, as well as urban residential areas. Most US industrial activities take place in urban areas, accounting for around 3% of land use in this category. The average land coverage of each BEA sector is thus less than 0.006% at most, and these figures have therefore not been included in the CEDA database.<sup>11</sup> Among Special uses, natural parks are the largest category;

<sup>11</sup> Furthermore, no statistics on land use were found that could be allocated to the detailed 6-digit BEA industry level. As land use intensity in urban areas is considered relatively high, however, it is desirable to extend data coverage on Urban use further, especially as impact assessment methods that can properly account for land use intensity become available.

however, these are not considered to be an environmental intervention and have therefore not been included in the CEDA database either. The remaining industrial uses of land have all been allocated directly to BEA codes.

**Table 4. Industrial uses of land in the US**

	Detailed use	Area (million square meter)	Share of total industrial use (%)
Cropland	Soybeans	408777.4	10.68%
	Corn for grain	397729.3	10.39%
	All wheat	303821	7.94%
	Cotton	75494.92	1.97%
	Sorghum for grain	47874.83	1.25%
	Corn silage	34985.45	0.91%
	Barley	27620.09	0.72%
	Rice	20254.73	0.53%
	Sunflower	20254.73	0.53%
	Oats	14730.72	0.38%
	Dry edible beans	11048.04	0.29%
	Sugarbeets	9206.698	0.24%
	Peanuts for nuts	7365.358	0.19%
	Potatoes	7365.358	0.19%
	Canola	5524.019	0.14%
	Sugarcane	5524.019	0.14%
	Tobacco	3682.679	0.10%
	Millet	3682.679	0.10%
	Rye	1841.34	0.05%
	Sorghum silage	1841.34	0.05%
	Noncitrus fruits	11048.04	0.29%
	Fresh market vegetables	11048.04	0.29%
	Processing vegetables	9206.698	0.24%
Citrus fruits	5524.019	0.14%	
Tree nuts	3682.679	0.10%	
Other crops	40509.47	1.06%	
Grassland pasture and range	Grassland pasture and range	2339108	61.09%
Special uses	Transportation	101172.5	2.64%
	National defense	60703.5	1.59%

Land use data for the year 1998 were not available in the data sources considered, and 1997 data were used instead (USDA, 2002). According to trend analyses by USDA (2002), however, the pattern of land use for different activities has remained fairly stable and no readjustments were therefore made to estimate values for 1998. Several land use activities needed to be allocated to appropriate industries. As both industrial and household activities contribute to land use for transportation, the share of the former was estimated based on the CO<sub>2</sub> emissions of passenger cars and other road vehicles such as trucks and buses. According to EPA (2002a) passenger cars are responsible for 36% of total CO<sub>2</sub> emissions by road vehicles. Thus, only 64% of total land use for transportation has been allocated to the transportation sector, based

on respective total production values.<sup>12</sup> Grassland pasture and range has been allocated to livestock industries, again based on total production value.

### 3.2.6. Nitrification

Nitrification is due principally to emissions of nitrogenous and phosphorus compounds to air, freshwater and soil. The main emission sources include combustion gases (for NO<sub>x</sub> to air) and application of fertilizer and manure (for emissions of nitrogenous and phosphorus compounds to freshwater). NO<sub>x</sub> and NH<sub>3</sub> emissions from these sources are fully accounted for in the NET database. Although some nitrogenous emissions from manure application may subsequently undergo a series of biological processes known as nitrification and denitrification, forming nitrite (NO<sub>2</sub><sup>-</sup>), nitrate (NO<sub>3</sub><sup>-</sup>) and nitrogen gas (N<sub>2</sub>), most are in the form of NH<sub>3</sub> or NH<sub>4</sub><sup>+</sup>, depending on the ambient pH (or in the form of organic nitrogen), at the time of initial manure application to agricultural soils. For nitrogenous emissions, direct use has therefore been made of the NH<sub>3</sub> inventory of the NET database

Emissions of phosphorus compounds are not readily available in any of the major statistical archives and these have therefore been estimated in terms of phosphorus equivalents, using a several databases. The CEDA inventory covers phosphorus emissions due to manure application and phosphorus run-off from phosphate fertilizer application.

**Table 5. Major phosphorus emissions from livestock\***

	Number (thousand)	g of P excreted / yr per head	Estimated loss (%)	Annual emission (kg / yr)
Beef cattle	33885	18.23	15	92648.88
Dairy cattle	9199	9.9426	15	13719.3
Chicken	425045	53.0272	15	3380842
Swine	62206	26.5136	15	247395.8
Turkey	5549	46.3988	15	38618.66
Total				3773225

\* Own calculation based on Natural Resources Conservation Service (NRCS) (2000) and National Agricultural Statistics Service (NASS) (2003).

NRCS (2000) provides data on the average mass excreted daily by each type of livestock, its P content and the average run-off ratio. These data have been employed together with the NASS (2003) statistics on US 1998 livestock numbers to estimate annual P emissions to freshwater due to manure application.

Over half the phosphate fertilizer applied in the US is in the form of ammonium phosphate (NH<sub>4</sub>HPO<sub>4</sub>), containing 88-90% of active ingredient. The phosphorus content of ammonium phosphate fertilizer is thus around 22% by mass. NASS (1998, 1999, 2000, 2003) provides data on the amount of phosphate fertilizer applied to each type of crop (including fruits, vegetables and nuts). By applying the average phosphorus run-off rate to soil estimated by NRCS (2000), the level of phosphorus loss to soil was then estimated for use in CEDA 3.0.

<sup>12</sup> There are several “within-industry” uses of transportation that are not visible in the input-output table. However, it has been assumed that utilization of transportation industry services reflects the relative magnitude of the transportation activities of each industry.

**Table 6. Phosphorus emissions due to fertilizer application\*\***

	Phosphate fertilizer applied (million pounds)	P content (kg)	P run-off (kg)	Share of total (%)
Corn	3236.50	3.23E+08	4.85E+07	51.07
Wheat	1326.40	1.32E+08	1.99E+07	20.93
Soybean	763.60	7.63E+07	1.14E+07	12.05
Cotton	378.20	3.78E+07	5.67E+06	5.97
Grapes	306.04	3.06E+07	4.59E+06	4.83
Sorghum	54.50	5.44E+06	8.17E+05	0.86
Oranges	35.94	3.59E+06	5.38E+05	0.57
Lettuce	35.41	3.54E+06	5.31E+05	0.56
Tomatoes	35.25	3.52E+06	5.28E+05	0.56
Melons	25.72	2.57E+06	3.85E+05	0.41
Onions	14.91	1.49E+06	2.23E+05	0.24
Corn	13.06	1.30E+06	1.96E+05	0.21
Carrots	12.38	1.24E+06	1.85E+05	0.20
Almonds	11.77	1.18E+06	1.76E+05	0.19
Beans, Samp, Proc.	8.93	8.92E+05	1.34E+05	0.14
Cabbage	8.91	8.90E+05	1.33E+05	0.14
Peas	8.84	8.82E+05	1.32E+05	0.14
Broccoli	8.13	8.12E+05	1.22E+05	0.13
Beans, Samp, Fresh	6.91	6.90E+05	1.03E+05	0.11
Celery	4.71	4.71E+05	7.06E+04	0.07
Peppers	4.65	4.65E+05	6.97E+04	0.07
Grapefruit	4.57	4.56E+05	6.85E+04	0.07
Apples	3.88	3.88E+05	5.82E+04	0.06
Cucumbers	3.17	3.17E+05	4.75E+04	0.05
Spinach	3.00	3.00E+05	4.50E+04	0.05
Strawberries	3.00	2.99E+05	4.49E+04	0.05

\*\* Own calculation based on NASS (1998; 1999; 2000; 2003) and NRCS (2000).

### 3.2.7. Resource depletion

The only resources considered in CEDA are fossil fuels, iron ore, copper ore, and sand and gravel. Given the homogeneity assumption and the level of aggregation of the current IO table, there was felt to be little point in compiling data on other mineral resources. Thus, any purchase from the 'inorganic chemicals' sector, for instance, will be regarded by CEDA as a blend of all kinds of mineral resources from gold to silicon, regardless of the specific material actually purchased. Compared with other industries using natural resources, however, the energy sector and the iron and steel industry are reasonably homogeneous.

Figures for natural gas extraction have been taken from EIA (2003a), data on crude oil consumption from EIA (2000) and data on coal from EIA (2003b). Statistics for iron ore, copper ore and sand and gravel extraction are from USGS (2000).

## 4. Getting Started with CEDA 3.0

### 4.1. Starting CEDA 3.0 - Workspace

CEDA 3.0 is designed to accommodate an easy retrieval of the most detailed information that the CEDA 3.0 database contains. Starting up the program will open the window shown below.

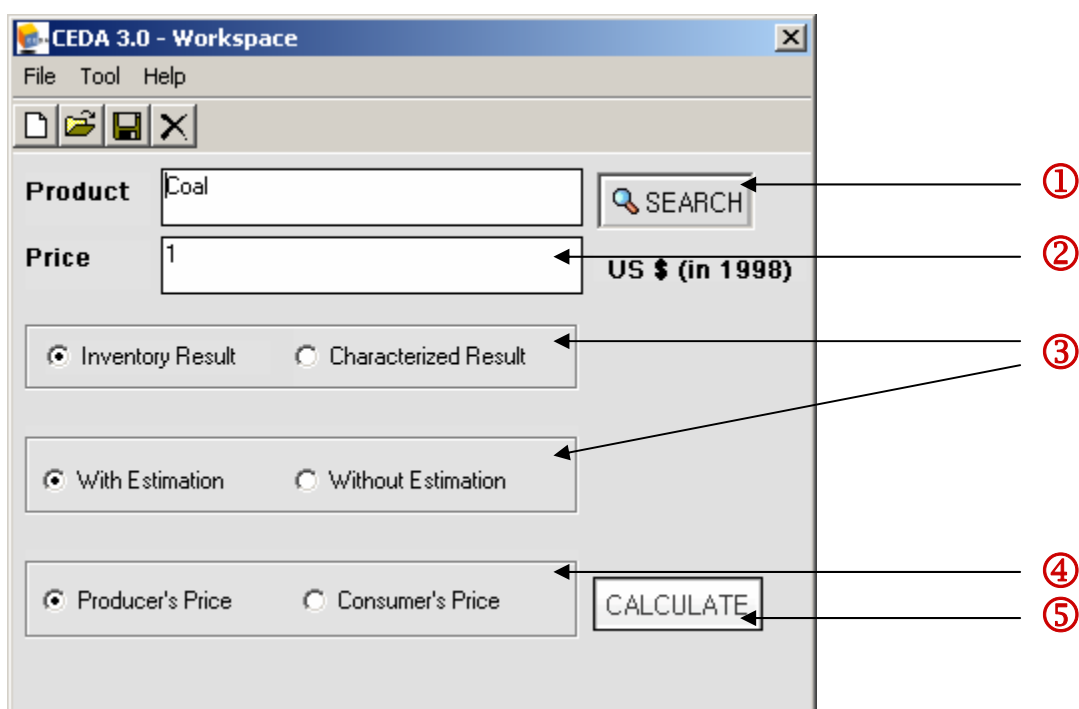


Figure 4. CEDA 3.0 Workspace

Users need to select a commodity for which detailed environmental information is to be retrieved. This is done by clicking the search button (①). Users can perform either keyword searching or browsing to find out the commodity to be analyzed.

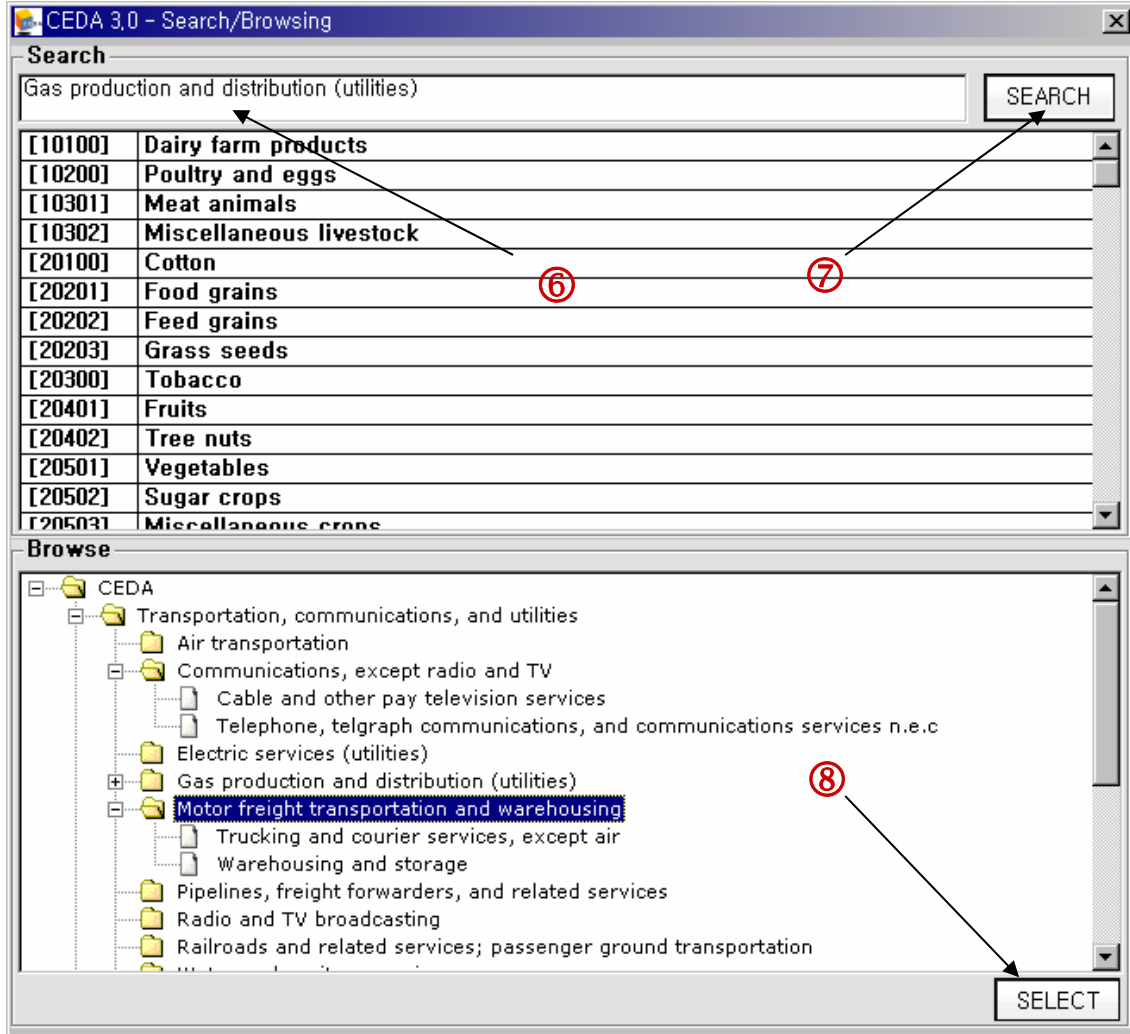


Figure 5. CEDA 3.0 Search/Browsing window

Enter a keyword in the search window (⑥) and press enter or click search button (⑦), or expand the folders shown in the lower half of the window to find the commodity that are to be selected by clicking relevant commodity categories. Then, press select (⑧). This will close the search/browsing window and activate the workspace again.

Type the price of the commodity selected in 1998 U.S. \$ in the price window (②). Then, specify the types of information that you would like to retrieve by checking either of the two radio buttons located beneath the price window (③). The option 'Inventory Result' will retrieve information on individual environmental intervention and their amount generated to produce specified value of the commodity, and 'Characterized Result' will do it on environmental impact categories such as global warming, ozone layer depletion and toxic impacts. A detailed description on each individual characterization method used in CEDA



3.0 can be found in Guinée et al., (2002). CEDA 3.0 uses two sets of environmental intervention database: one with estimation and the other without estimation (see section 3.2.4. of this guide). Checking 'With Estimation' will use the environmental intervention database module that includes estimated toxic pollutants emissions in addition to self-reported data, where checking 'Without Estimation' will use the other one that is purely based on self-reporting.

Finally, users need to specify whether the price is in producer's price or consumer's price (④). When finished selecting all the options above, press 'Calculate' (⑤).

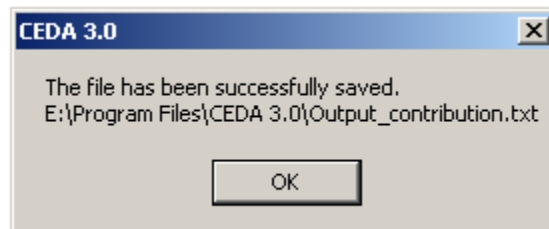
Impact category	Characterization methods	Unit	[70000]
abiotic depletion	ADP (Guinee et al, 2001)	kg antimony eq.	6.73E-01
Landuse increase of land competition	LUC (Guinee et al, 2001)	m2+yr	4.7E-02
global warming	GWP100 (Houghton et al.,	kg CO2 eq.	4.85E+00
global warming	net GWP100 min(Houghton et	kg CO2 eq.	4.86E+00
global warming	net GWP100 max(Houghton et	kg CO2 eq.	4.88E+00
global warming	GWP20 (Houghton et al.,	kg CO2 eq.	1.12E+01
global warming	GWP500 (Houghton et al.,	kg CO2 eq.	2.25E+00
ozone layer depletion	ODP steady state (WMO,	kg CFC-11 eq.	1.6E-06
ozone layer depletion	ODP5 (Solomon & Albritton,	kg CFC-11 eq.	1.99E-05
ozone layer depletion	ODP10 (Solomon & Albritton,	kg CFC-11 eq.	9.11E-06
ozone layer depletion	ODP15 (Solomon & Albritton,	kg CFC-11 eq.	6.05E-06
ozone layer depletion	ODP20 (Solomon & Albritton,	kg CFC-11 eq.	4.79E-06
ozone layer depletion	ODP25 (Solomon & Albritton,	kg CFC-11 eq.	4.02E-06
ozone layer depletion	ODP30 (Solomon & Albritton,	kg CFC-11 eq.	3.49E-06
ozone layer depletion	ODP40 (Solomon & Albritton,	kg CFC-11 eq.	2.9E-06
human toxicity	HTP inf. (Huijbregts, 1999 &	kg 1,4-dichlorobenzene eq.	2.72E+00
Freshwater aquatic ecotoxicity	FAETP inf. (Huijbregts, 1999	kg 1,4-dichlorobenzene eq.	2.42E-02
Marine aquatic ecotoxicity	MAETP inf. (Huijbregts, 1999	kg 1,4-dichlorobenzene eq.	3.59E+04
Freshwater sedimental ecotoxicity	FSETP inf. (Huijbregts, 1999	kg 1,4-dichlorobenzene eq.	2.49E-02
Marine sedimental ecotoxicity	MSETP inf. (Huijbregts, 1999	kg 1,4-dichlorobenzene eq.	1.14E+04
Terrestrial ecotoxicity	TETP inf. (Huijbregts, 1999 &	kg 1,4-dichlorobenzene eq.	2.05E-02
human toxicity	HTP 20 (Huijbregts, 1999 &	kg 1,4-dichlorobenzene eq.	2.55E-01
Freshwater aquatic ecotoxicity	FAETP 20 (Huijbregts, 1999 &	kg 1,4-dichlorobenzene eq.	2.14E-02
Marine aquatic ecotoxicity	MAETP 20 (Huijbregts, 1999	kg 1,4-dichlorobenzene eq.	2.49E-02
Freshwater sedimental ecotoxicity	FSETP 20 (Huijbregts, 1999 &	kg 1,4-dichlorobenzene eq.	1.82E-02
Marine sedimental ecotoxicity	MSETP 20 (Huijbregts, 1999	kg 1,4-dichlorobenzene eq.	1.11E-02
Terrestrial ecotoxicity	TETP 20 (Huijbregts, 1999 &	kg 1,4-dichlorobenzene eq.	1.32E-03
human toxicity	HTP 100 (Huijbregts, 1999 &	kg 1,4-dichlorobenzene eq.	2.55E-01
Freshwater aquatic ecotoxicity	FAETP 100 (Huijbregts, 1999	kg 1,4-dichlorobenzene eq.	2.16E-02
Marine aquatic ecotoxicity	MAETP 100 (Huijbregts, 1999	kg 1,4-dichlorobenzene eq.	6.62E-02
Freshwater sedimental ecotoxicity	FSETP 100 (Huijbregts, 1999	kg 1,4-dichlorobenzene eq.	1.87E-02
Marine sedimental ecotoxicity	MSETP 100 (Huijbregts, 1999	kg 1,4-dichlorobenzene eq.	2.76E-02
Terrestrial ecotoxicity	TETP 100 (Huijbregts, 1999 &	kg 1,4-dichlorobenzene eq.	1.5E-03
human toxicity	HTP 500 (Huijbregts, 1999 &	kg 1,4-dichlorobenzene eq.	2.55E-01
Freshwater aquatic ecotoxicity	FAETP 500 (Huijbregts, 1999	kg 1,4-dichlorobenzene eq.	2.22E-02
Marine aquatic ecotoxicity	MAETP 500 (Huijbregts, 1999	kg 1,4-dichlorobenzene eq.	2.78E-01
Freshwater sedimental ecotoxicity	FSETP 500 (Huijbregts, 1999	kg 1,4-dichlorobenzene eq.	2.01E-02
Marine sedimental ecotoxicity	MSETP 500 (Huijbregts, 1999	kg 1,4-dichlorobenzene eq.	1.15E-01
Terrestrial ecotoxicity	TETP 500 (Huijbregts, 1999 &	kg 1,4-dichlorobenzene eq.	2.33E-03
photochemical oxidation	POCP (Jenkin & Hayman,	kg ethylene eq.	1.74E-03
photochemical oxidation	POCP (Andersson-Skold et	kg ethylene eq.	1.76E-03

Export:  Output contribution  Input contribution  Current Result

EXCEL EXPORT TEXT EXPORT

Figure 6. Result window (an example)

CEDA 3.0 provides two types of contribution analysis; output contribution and input contribution analysis (see section 2.3 of this guide). As the size of the results from such analyses is rather large (1334×480 or 86×480), visualizing the results is not very useful. Thus CEDA 3.0 facilitates export functions for further analyses using more sophisticated software tools such as Matlab and Mathematica. Users can choose either one of the two contribution analyses or the result appeared in the current window by checking one of the radio buttons shown at the bottom (Ⓒ). Users can store the exported file either as a Microsoft Excel spreadsheet or as a text file (comma separated) (Ⓓ).



**Figure 7. Message after a successful export (an example)**

If the export was performed successfully, a message like the one shown above will appear.

## References

- Aspelin, Arnold L., and Arthur H. Grube (1999): *Pesticide Industry Sales and Usage: 1996 and 1997 Market Estimates*, Environmental Protection Agency, US government, available on internet: <http://www.epa.gov/oppbead1/pesticides/>
- Ayres R. U. and Ayres L. W. (1998): *Accounting for resources, 1*. Edward Elgar, Cheltenham, UK.
- Bullard, C.W., P.S. Penner, D.A. Pilati (1978): Net energy analysis: Handbook for combining process and input-output analysis, *Resource and Energy*, 1(3) 267-313.
- Bureau of Economic Analysis (1995a): *Benchmark survey for 1992*, Department of Commerce, US government, USA.
- Bureau of Economic Analysis (2002): Annual input-output table – make and use matrices for 1998 (unpublished), Department of Commerce, US government, USA.
- Bureau of Economic Analysis (1995b): *Benchmark survey for 1992 – make and use matrices*, Department of Commerce, US government, USA. Bureau of Economic Analysis (2002): Annual input-output table – make and use matrices for 1998 (unpublished), Department of Commerce, US government, USA.
- Bureau of Economic Analysis (1995c): *Benchmark survey for 1992 – capital flow matrix* (unpublished), Department of Commerce, US government, USA.
- Bureau of Economic Analysis (2002): Annual input-output table – make and use matrices for 1998 (unpublished), Department of Commerce, US government, USA.
- Census Bureau (2001): *1997 Economic Census – Manufacturing Series*, Department of Commerce, US government, USA.
- Environmental Protection Agency (2002a): *Inventory for U.S. greenhouse gases emissions and sink: 1990 – 2000*. US government. USA
- Environmental Protection Agency (2002b): *Toxic Releases Inventory (TRI) 98*, CD-Rom database, US government. USA
- Environmental Protection Agency (2002c): *National Toxics Inventory (NTI) 96* database, (unpublished) US government. USA
- Environmental Protection Agency (2002d): *National Emission Trends (NET) 98* database, US government. USA
- Energy Information Administration (2002): *Emissions of Greenhouse Gases in the United States 2001*, Department of Energy, US government, USA.
- Energy Information Administration (2003a): *Natural Gas Annual 2001*, US DOE, US government, USA.
- Energy Information Administration (2000): *Accelerated deposition: Its impacts on domestic oil and natural gas prices and production*, US DOE, US government, USA.
- Energy Information Administration (2003b): *U.S. Coal Supply and Demand: 2002 Review*, US DOE, US government, USA.

- Frischknecht, R. (2000): Allocation in life cycle inventory analysis for joint production, *Int. J. LCA* 5 (2), 85-95.
- Gianessi L. P. and Marcelli M. B. (2000): *Pesticide use in U.S. crop production: 1997*,
- Guinée, J.B. (Ed.), M. Gorrée, R. Heijungs, G. Huppes, R. Kleijn, L. van Oers, A. W. Sleeswijk, S. Suh, H. Udo de Haes, H. de Bruijn, R. van Duin, M. A.J. Huijbregts (2002): *Handbook on life cycle assessment. Operational guide to the ISO standards*, Kluwer Academic Publisher, Dordrecht, the Netherlands.
- Hayami, H., A. Ikeda, M. Suga, K. Yoshioka (1993): Estimation of a pollutions and evaluating CO2 emissions from production activities: Using Japan's 1985 input-output tables, *J. Appl. Input-Output Anal.*, I(2), 29-45.
- Heijungs R, Suh S (2002): *The Computational Structure of Life Cycle Assessment*, Kluwer Academic Publisher, Amsterdam, the Netherlands
- Hendrickson, C.T., Horvath, A., Joshi, S. and Lave, L.B. (1998): Economic Input-Output Models for Environmental Life-Cycle Assessment. *Environmental Science & Technology*, 32, 184A-191A.
- Hunt, R.G., T.K.Boguski, K.Weitz, A.Sharma (1998): Case studies examining LCA streamlining techniques, *Int. J. LCA* 3 (1) 36-42.
- Huppes, G., Schneider, F.(Ed.) (1994): *Proceedings of the European Workshop on Allocation in LCA*. CML, Leiden University, The Netherlands.
- ISO (1998): ISO 14041, *Environmental management - Life cycle assessment - Goal and scope definition and inventory analysis*, Geneve, Switzerland.
- ISO (1999): ISO 14042, *Environmental management-Life cycle assessment-Life cycle impact assessment*, Geneve, Switzerland.
- Konjin, P.J.A. (1994): *The make and use of commodities by industries-On the compilation of input-output data from the national accounts*, Ph.D. thesis, University of Twente, the Netherlands.
- Lave, L., E. Cobas-Flores, C. Hendricksion, F. McMichael (1995): Using input-output analysis to estimate economy wide discharges, *Environmental Science & Technology*, 29 (9), 420-426.
- Leontief, W. (1970): Environmental repercussions and the economic structure: An input-output approach, *Rev. Econ. Stat*, LII(3), 261-71.
- Miller, R., Blair, P. (1985): *Input-Output Analysis: Foundations and Extensions*, Prentice-Hall, Englewood Cliffs.
- National Agricultural Statistics Service (1998): *Agricultural Chemical Usage*, USDA, US government, USA.
- National Agricultural Statistics Service (1999): *Agricultural Chemical Usage*, USDA, US government, USA.
- National Agricultural Statistics Service (2000): *Agricultural Chemical Usage*, USDA, US government, USA.

- National Agricultural Statistics Service (2003): *Agricultural Statistics 2003*, USDA, US. government, USA.
- National Center for Food and Agricultural Policy (2000): *Pesticide use in the U.S. crop production*, Washington D.C., US.
- Natural Resources Conservation Service (2000): *Agricultural Waste Management Field Handbook*, National Engineering Handbook (NEH) Part 651, USDA, US. government, USA.
- Raynolds, M., R. Fraser, and D. Checkel (2000a): The relative mass-energy-economic (RMEE) method for system boundary selection, Part I: A means to systematically and quantitatively select LCA boundaries, *Int. J. LCA* 5 (1) 37-46.
- Raynolds, M., R. Fraser, and D. Checkel (2000b): The relative mass-energy-economic (RMEE) method for system boundary selection, Part II: Selecting the boundary cut-off parameter ( $Z_{RMEE}$ ) and its relationship to overall uncertainty, *Int. J. LCA* 5 (2) 96-104.
- Steenge, A.E. (1990): The commodity technology revisited-Theoretical basis and an application to error location in the make-use framework, *Economic modeling*, Vol. 7, 376-387
- Stone, R., Bacharach, M. & Bates, J. (1963): *Input-Output Relationships, 1951-1966*, Programme for Growth, Volume 3, London, Chapman and Hall.
- Suh, S. (2001): Missing Inventory Estimation Tool (MIET) 2.0., On-line database, CML, Leiden University, the Netherlands.
- Suh, S. (2003a): *Accumulative structural path analysis for life cycle assessment*. CML Working Paper, CML, Leiden University, the Netherlands.
- Suh, S. (2003b): Structural Path Analysis for Danish Environmental Prioritization Project. Presented at LCA 2-0 Consultants, Copenhagen, Denmark.
- Suh, S. (2004): Functions, commodities and environmental impacts in an ecological economic model, *Ecological Economics*, 48 (4), 451 – 467.
- Suh S., Huppel G. (2002): Missing Inventory Estimation Tool using extended Input-Output Analysis. *International Journal of Life Cycle Assessment*. 7 (3): 134-140.
- Suh, S., Huppel, H. (2005): Methods in Life Cycle Inventory (LCI) of a product, *Journal of Cleaner Production*, 13 (7), 687 – 697.
- Suh, S., M. Lenzen, G. Treloar, H. Hondo, A. Horvath, G. Huppel, O. Jolliet, U. Klann, W. Krewitt, Y. Moriguchi, J. Munksgaard, G. Norris (2004): System Boundary Selection for Life Cycle Inventories, *Environmental Science & Technology*. 38 (3), 657 – 664.
- ten Raa, T., D. Chakraborty, J.A. Small (1984): An alternative treatment of secondary products in input-output analysis, *Review of Economics and Statistics*. 66(1) 88-97.
- ten Raa, T. (1988): An alternative treatment of secondary products in input-output analysis: Frustration, *Review of Economics and Statistics*, 70(3) 535-538
- United Nations (1968): *A System of National Accounts Studies in Methods*, Series F, No. 2 Rev. 3, United Nations, New York.

United States Department of Agriculture (2001): Agricultural Resources and Environmental Indicators, US government, USA.

United States Geological Survey (2000): Mineral commodity summaries, US DOI, US government, USA.



# Appendix A

## List of BEA commodities in the economic Input-Output database module

IO code	Name		
10100	Day farm products	130200	vehicles
10200	Poultry and eggs		Ammunition, except for small arms, n.e.c.
10301	Meat animals	130300	Tanks and tank components
10302	Miscellaneous livestock	130500	Small arms
20100	Cotton	130600	Small arms ammunition
20201	Food grains	130700	Ordnance and accessories, n.e.c.
20202	Feed grains	140101	Meat packing plants
20203	Grass seeds	140102	Sausages and other prepared meat products
20300	Tobacco		Poultry slaughtering and processing
20401	Fruits	140200	Creamery butter
20402	Tree nuts	140300	Natural, processed, and imitation cheese
20501	Vegetables	140400	Dry, condensed, and evaporated day products
20502	Sugar crops	140500	Ice cream and frozen desserts
20503	Miscellaneous crops	140600	Fluid milk
20600	Oil bearing crops	140700	Canned and cured fish and seafoods
20702	Greenhouse and nursery products	140800	Canned specialties
30001	Forestry products	140900	Canned fruits, vegetables, preserves, jams, and jellies
30002	Commercial fishing	141000	Dehydrated fruits, vegetables, and soups
40001	Agricultural, forestry, and fishery services	141100	Pickles, sauces, and salad dressings
40002	Landscape and horticultural services	141200	Prepared fresh or frozen fish and seafoods
50001	Iron and ferroalloy ores, and miscellaneous metal ores, n.e.c.	141301	Frozen fruits, fruit juices, and vegetables
60100	Copper ore	141302	Frozen specialties, n.e.c.
60200	Nonferrous metal ores, except copper	141401	Flour and other grain mill products
70000	Coal	141402	Cereal breakfast foods
80001	Crude petroleum and natural gas	141403	Prepared flour mixes and doughs
90001	Dimension, crushed and broken stone	141501	Dog and cat food
90002	Sand and gravel	141502	Prepared feeds, n.e.c.
90003	Clay, ceramic, and refractory minerals	141600	Rice milling
90004	Nonmetallic mineral services and miscellaneous	141700	Wet corn milling
100000	Chemical and fertilizer minerals	141801	Bread, cake, and related products
110101	New residential 1 unit structures, nonfarm	141802	Cookies and crackers
110102	New residential 2-4 unit structures, nonfarm	141803	Frozen bakery products, except bread
110105	New additions & alterations, nonfarm, construction	141900	Sugar
110108	New residential garden and high-rise apartments construction	142002	Chocolate and cocoa products
110400	New highways, bridges, and other horizontal construction	142004	Salted and roasted nuts and seeds
110501	New farm residential construction	142005	Candy and other confectionery products
110601	Petroleum and natural gas well drilling	142101	Malt beverages
110602	Petroleum, natural gas, and solid mineral exploration	142102	Malt
110603	Access structures for solid mineral development	142103	Wines, brandy, and brandy spirits
110800	New office, industrial and commercial buildings construction	142104	Distilled and blended liquors
110900	Other new construction	142200	Bottled and canned soft drinks
120101	Maintenance and repair of farm and nonfarm residential structures	142300	Flavoring extracts and flavoring syrups, n.e.c.
120214	Maintenance and repair of highways & streets	142400	Cottonseed oil mills
120215	Maintenance and repair of petroleum and natural gas wells	142500	Soybean oil mills
120300	Other repair and maintenance construction	142600	Vegetable oil mills, n.e.c.
130100	Guided missiles and space	142700	Animal and marine fats and oils
		142800	Roasted coffee
		142900	Edible fats and oils, n.e.c.
		143000	Manufactured ice
		143100	Macaroni, spaghetti, vermicelli, and noodles
		143201	Potato chips and similar snacks
		143202	Food preparations, n.e.c.
150101	Cigarettes	150101	Cigarettes
150102	Cigars	150102	Cigars
150103	Chewing and smoking tobacco and snuff	150103	Chewing and smoking tobacco and snuff
150200	Tobacco stemming and redrying	150200	Tobacco stemming and redrying
160100	Broadwoven fabric mills and fabric finishing plants	160100	Broadwoven fabric mills and fabric finishing plants
160200	Narrow fabric mills	160200	Narrow fabric mills
160300	Yarn mills and finishing of textiles, n.e.c.	160300	Yarn mills and finishing of textiles, n.e.c.
160400	Thread mills	160400	Thread mills
170100	Carpets and rugs	170100	Carpets and rugs
170600	Coated fabrics, not rubberized	170600	Coated fabrics, not rubberized
170700	Tire cord and fabrics	170700	Tire cord and fabrics
170900	Cordage and twine	170900	Cordage and twine
171001	Nonwoven fabrics	171001	Nonwoven fabrics
171100	Textile goods, n.e.c.	171100	Textile goods, n.e.c.
180101	Women's hosiery, except socks	180101	Women's hosiery, except socks
180102	Hosiery, n.e.c.	180102	Hosiery, n.e.c.
180300	Knit fabric mills	180300	Knit fabric mills
180400	Apparel made from purchased materials	180400	Apparel made from purchased materials
190100	Curtains and draperies	190100	Curtains and draperies
190200	House furnishings, n.e.c.	190200	House furnishings, n.e.c.
190301	Textile bags	190301	Textile bags
190302	Canvas and related products	190302	Canvas and related products
190303	Pleating and stitching	190303	Pleating and stitching
190304	Automotive and apparel trimmings	190304	Automotive and apparel trimmings
190305	Schiffli machine embroideries	190305	Schiffli machine embroideries
190306	Fabricated textile products, n.e.c.	190306	Fabricated textile products, n.e.c.
200100	Logging	200100	Logging
200200	Sawmills and planing mills, general	200200	Sawmills and planing mills, general
200300	Hardwood dimension and flooring mills	200300	Hardwood dimension and flooring mills
200400	Special product sawmills, n.e.c.	200400	Special product sawmills, n.e.c.
200501	Millwork	200501	Millwork
200502	Wood kitchen cabinets	200502	Wood kitchen cabinets
200600	Veneer and plywood	200600	Veneer and plywood
200701	Structural wood members, n.e.c.	200701	Structural wood members, n.e.c.
200702	Prefabricated wood buildings and components	200702	Prefabricated wood buildings and components
200703	Mobile homes	200703	Mobile homes
200800	Wood preserving	200800	Wood preserving
200901	Wood pallets and skids	200901	Wood pallets and skids
200903	Wood products, n.e.c.	200903	Wood products, n.e.c.
200904	Reconstituted wood products	200904	Reconstituted wood products
210000	Wood containers, n.e.c.	210000	Wood containers, n.e.c.
220101	Wood household furniture, except upholstered	220101	Wood household furniture, except upholstered
220102	Household furniture, n.e.c.	220102	Household furniture, n.e.c.
220103	Wood television and radio cabinets	220103	Wood television and radio cabinets
220200	Upholstered household furniture	220200	Upholstered household furniture
220300	Metal household furniture	220300	Metal household furniture
220400	Mattresses and bedsprings	220400	Mattresses and bedsprings
230100	Wood office furniture	230100	Wood office furniture
230200	Office furniture, except wood	230200	Office furniture, except wood
230300	Public building and related furniture	230300	Public building and related furniture
230400	Wood partitions and fixtures	230400	Wood partitions and fixtures
230500	Partitions and fixtures, except wood	230500	Partitions and fixtures, except wood
230600	Drapery hardware and window blinds and shades	230600	Drapery hardware and window blinds and shades
230700	Furniture and fixtures, n.e.c.	230700	Furniture and fixtures, n.e.c.
240100	Pulp mills	240100	Pulp mills

240400	Envelopes	350200	Glass containers	420202	machine tools and handsaws
240500	Sanitary paper products	360100	Cement, hydraulic	420300	Saw blades and handsaws
240701	Paper coating and glazing	360200	Brick and structural clay tile	420300	Hardware, n.e.c.
240702	Bags, except textile	360300	Ceramic wall and floor tile	420401	Plating and polishing
240703	Die-cut paper and paperboard and cardboard	360400	Clay refractories	420402	Coating, engraving, and allied services, n.e.c.
240705	Stationery, tablets, and related products	360500	Structural clay products, n.e.c.	420500	Miscellaneous fabricated wire products
240706	Converted paper products, n.e.c.	360600	Vitreous china plumbing fixtures	420700	Steel springs, except wire
240800	Paper and paperboard mills	360701	Vitreous china table and kitchenware	420800	Pipe, valves, and pipe fittings
250000	Paperboard containers and boxes	360702	Fine earthenware table and kitchenware	421000	Metal foil and leaf
260100	Newspapers	360800	Porcelain electrical supplies	421100	Fabricated metal products, n.e.c.
260200	Periodicals	360900	Pottery products, n.e.c.	430100	Turbines and turbine generator sets
260301	Book publishing	361000	Concrete block and brick	430200	Internal combustion engines, n.e.c.
260302	Book printing	361100	Concrete products, except block and brick	440001	Farm machinery and equipment
260400	Miscellaneous publishing	361200	Ready-mixed concrete	440002	Lawn and garden equipment
260501	Commercial printing	361300	Lime	450100	Construction machinery and equipment
260601	Manifold business forms	361400	Gypsum products	450200	Mining machinery, except oil field
260602	Blankbooks, looseleaf binders and devices	361500	Cut stone and stone products	450300	Oil and gas field machinery and equipment
260700	Greeting cards	361600	Abrasive products	460100	Elevators and moving stairways
260802	Bookbinding and related work	361700	Asbestos products	460200	Conveyors and conveying equipment
260803	Typesetting	361900	Minerals, ground or treated	460300	Hoists, cranes, and monorails
260806	Platemaking and related services	362000	Mineral wool	460400	Industrial trucks and tractors
270100	Industrial inorganic and organic chemicals	362100	Nonclay refractories	470100	Machine tools, metal cutting types
270201	Nitrogenous and phosphatic fertilizers	362200	Nonmetallic mineral products, n.e.c.	470200	Machine tools, metal forming types
270300	Pesticides and agricultural chemicals, n.e.c.	370101	Blast furnaces and steel mills	470300	Special dies and tools and machine tool accessories
270401	Gum and wood chemicals	370102	Electrometallurgical products, except steel	470401	Power-driven handtools
270402	Adhesives and sealants	370103	Steel wiredrawing and steel nails and spikes	470402	Rolling mill machinery and equipment
270403	Explosives	370200	Iron and steel foundries	470404	Electric and gas welding and soldering equipment
270404	Printing ink	370300	Iron and steel forgings	470405	Industrial patterns
270405	Carbon black	370401	Metal heat treating	470500	Metalworking machinery, n.e.c.
270406	Chemicals and chemical preparations, n.e.c.	370402	Primary metal products, n.e.c.	480100	Food products machinery
280100	Plastics materials and resins	380100	Primary smelting and refining of copper	480200	Textile machinery
280200	Synthetic rubber	380400	Primary aluminum	480300	Woodworking machinery
280300	Cellulosic manmade fibers	380501	Primary nonferrous metals, n.e.c.	480400	Paper industries machinery
280400	Manmade organic fibers, except cellulosic	380700	Rolling, drawing, and extruding of copper	480500	Printing trades machinery and equipment
290100	Drugs	380800	Aluminum rolling and drawing	480600	Special industry machinery, n.e.c.
290201	Soap and other detergents	380900	Nonferrous rolling and drawing, n.e.c.	490100	Pumps and compressors
290202	Polishes and sanitation goods	381000	Nonferrous wiredrawing and insulating	490200	Ball and roller bearings
290203	Surface active agents	381100	Aluminum castings	490300	Blowers and fans
290300	Toilet preparations	381400	Nonferrous forgings	490500	Mechanical power transmission equipment
300000	Paints and allied products	390100	Metal cans	490600	Industrial process furnaces and ovens
310101	Petroleum refining	390200	Metal shipping barrels, drums, kegs, and pails	490700	General industrial machinery and equipment, n.e.c.
310102	Lubricating oils and greases	400100	Enameled iron and metal sanitary ware	490800	Packaging machinery
310103	Products of petroleum and coal, n.e.c.	400200	Plumbing fixture fittings and trim	500100	Carburetors, pistons, rings, and valves
310200	Asphalt paving mixtures and blocks	400300	Heating equipment, except electric and warm air furnaces	500200	Fluid power equipment
310300	Asphalt felts and coatings	400400	Fabricated structural metal	500300	Scales and balances, except laboratory
320100	Tires and inner tubes	400500	Metal doors, sash, frames, molding, and trim	500400	Industrial and commercial machinery and equipment, n.e.c.
320200	Rubber and plastics footwear	400600	Fabricated plate work (boiler shops)	510102	Calculating and accounting machines
320300	Fabricated rubber products, n.e.c.	400700	Sheet metal work	510103	Electronic computers
320400	Miscellaneous plastics products, n.e.c.	400800	Architectural and ornamental metal work	510104	Computer peripheral equipment
320500	Rubber and plastics hose and belting	400901	Prefabricated metal buildings and components	510400	Office machines, n.e.c.
320600	Gaskets, packing, and sealing devices	400902	Miscellaneous structural metal work	520100	Automatic vending machines
330001	Leather tanning and finishing	410100	Screw machine products, bolts, etc.	520200	Commercial laundry equipment
340100	Boot and shoe cut stock and findings	410201	Automotive stampings	520300	Refrigeration and heating equipment
340201	Shoes, except rubber	410202	Crowns and closures	520400	Measuring and dispensing pumps
340202	House slippers	410203	Metal stampings, n.e.c.	520500	Service industry machinery, n.e.c.
340301	Leather gloves and mittens	420100	Cutlery	530200	Power, distribution, and specialty
340302	Luggage	420201	Hand and edge tools, except		
340303	Women's handbags and purses				
340304	Personal leather goods, n.e.c.				
340305	Leather goods, n.e.c.				
350100	Glass and glass products, except containers				



	transformers		work	730103	Personnel supply services
530300	Switchgear and switchboard apparatus	640104	Silverware and plated ware	730104	Computer and data processing services; including own-account software
530400	Motors and generators	640105	Costume jewelry		
530500	Relays and industrial controls	640200	Musical instruments	730106	Detective and protective services
530700	Carbon and graphite products	640301	Games, toys, and children's vehicles	730107	Miscellaneous equipment rental and leasing
530800	Electrical industrial apparatus, n.e.c.	640302	Dolls and stuffed toys	730108	Photofinishing labs and commercial photography
540100	Household cooking equipment	640400	Sporting and athletic goods, n.e.c.	730109	Other business services
540200	Household refrigerators and freezers	640501	Pens, mechanical pencils, and parts	730111	Management and public relations services
540300	Household laundry equipment	640502	Lead pencils and art goods	730112	Research, development, and testing services, except noncommercial
540400	Electric housewares and fans	640503	Marking devices	730200	Advertising
540500	Household vacuum cleaners	640504	Carbon paper and inked ribbons	730301	Legal services
540700	Household appliances, n.e.c.	640700	Fasteners, buttons, needles, and pins	730302	Engineering, architectural, and surveying services
550100	Electric lamp bulbs and tubes	640800	Brooms and brushes	730303	Accounting, auditing and bookkeeping, and miscellaneous services, n.e.c.
550200	Lighting fixtures and equipment	640900	Hard surface floor coverings, n.e.c.	740000	Eating and drinking places
550300	Wiring devices	641000	Burial caskets	750001	Automotive rental and leasing, without drivers
560100	Household audio and video equipment	641100	Signs and advertising specialties	750002	Automotive repair shops and services
560200	Prerecorded records and tapes	641200	Manufacturing industries, n.e.c.	750003	Automobile parking and car washes
560300	Telephone and telegraph apparatus	650100	Railroads and related services	760101	Motion picture services and theaters
560500	Communication equipment	650200	Local and suburban transit and interurban highway passenger transportation	760102	Video tape rental
570100	Electron tubes	650301	Trucking and courier services, except air	760201	Theatrical producers (except motion picture), bands, orchestras and entertainers
570200	Semiconductors and related devices	650302	Warehousing and storage	760202	Bowling centers
570300	Other electronic components	650400	Water transportation	760203	Professional sports clubs and promoters
580100	Storage batteries	650500	Air transportation	760204	Racing, including track operation
580200	Primary batteries, dry and wet	650600	Pipelines, except natural gas	760205	Physical fitness facilities and membership sports and recreation clubs
580400	Electrical equipment for internal combustion engines	650701	Freight forwarders and other transportation services	760206	Other amusement and recreation services
580600	Magnetic and optical recording media	650702	Arrangement of passenger transportation	770100	Doctors and dentists
580700	Electrical machinery, equipment, and supplies, n.e.c.	660100	Telephone, telegraph communications, and communications services n.e.c.	770200	Hospitals
590100	Truck and bus bodies	660200	Cable and other pay television services	770301	Nursing and personal care facilities
590200	Truck trailers	670000	Radio and TV broadcasting	770303	Other medical and health services
590301	Motor vehicles and passenger car bodies	680100	Electric services (utilities)	770304	Veterinary services
590302	Motor vehicle parts and accessories	680201	Natural gas transportation	770401	Elementary and secondary schools
600100	Aircraft	680202	Natural gas distribution	770402	Colleges, universities, and professional schools
600200	Aircraft and missile engines and engine parts	680301	Water supply and sewerage systems	770403	Private libraries, vocational schools, and educational services, n.e.c.
600400	Aircraft and missile equipment, n.e.c.	680302	Sanitary services, steam supply, and irrigation systems	770501	Business associations and professional membership organizations
610100	Ship building and repairing	690100	Wholesale trade	770502	Labor organizations, civic, social, and fraternal associations
610200	Boat building and repairing	690200	Retail trade, except eating and drinking	770503	Religious organizations
610300	Railroad equipment	700100	Banking	770504	Other membership organizations
610500	Motorcycles, bicycles, and parts	700200	Credit agencies other than banks	770600	Job training and related services
610601	Travel trailers and campers	700300	Security and commodity brokers	770700	Child day care services
610603	Motor homes	700400	Insurance carriers	770800	Residential care
610700	Transportation equipment, n.e.c.	700500	Insurance agents, brokers, and services	770900	Social services, n.e.c.
620101	Search and navigation equipment	710100	Owner-occupied dwellings	780100	U.S. Postal Service
620102	Laboratory apparatus and furniture	710201	Real estate agents, managers, operators, and lessors	780500	Other Federal Government enterprises
620200	Mechanical measuring devices	710202	Royalties	790300	Other State and local government enterprises
620300	Environmental controls	720101	Hotels	810001	Scrap
620400	Surgical and medical instruments and apparatus	720102	Other lodging places	820000	General government industry
620500	Surgical appliances and supplies	720201	Laundry, cleaning, garment services, and shoe repair		
620600	Dental equipment and supplies	720202	Funeral service and crematories		
620700	Watches, clocks, watchcases, and parts	720203	Portrait photographic studios, and other miscellaneous personal services		
620800	X-ray apparatus and tubes	720204	Electrical repair shops		
620900	Electromedical and electrotherapeutic apparatus	720205	Watch, clock, jewelry, and furniture repair		
621000	Laboratory and optical instruments	720300	Beauty and barber shops		
621100	Instruments to measure electricity	730101	Miscellaneous repair shops		
630200	Ophthalmic goods	730102	Services to dwellings and other buildings		
630300	Photographic equipment and supplies				
640101	Jewelry, precious metal				
640102	Jewelers' materials and lapidary				

# Appendix B

## List of environmental interventions in the environmental database module

Substance	cas no.	init. emissn						
Coal	coal hard	r	ALUMINUM (FUME OR DUST)	7429905	is	DICHLOROMETHANE	75092	is
Copper ore	7440508(o)	r	ALUMINUM OXIDE (FIBROUS FORMS)	1344281	is	DICYCLOPENTADIENE	77736	is
Crude oil	8012951	r	AMMONIA	7664417	is	DIETHANOLAMINE	111422	is
Iron ore	7439896(o)	r	ANILINE	62533	is	DIISOCYANATES	N120	is
Natural gas	nat. gas	r	ANTHRACENE	120127	is	DIMETHYL PHTHALATE	131113	is
Sand and gravel	N/A	r	ANTIMONY	7440360	is	DIMETHYLAMINE	124403	is
Land use	N/A	l	ANTIMONY COMPOUNDS	N010	is	DINITROBUTYL PHENOL	88857	is
1-(3-CHLOROALLYL)-3,5,7-TRIAZA-1-AZONIAADAMANTANE CHLORIDE	4080313	is	ARSENIC	7440382	is	DIPHENYLAMINE	122394	is
1,1,1-TRICHLOROETHANE	71556	is	ARSENIC COMPOUNDS	N020	is	EPICHLOROHYDRIN	106898	is
1,1,2,2-TETRACHLOROETHANE	79345	is	ASBESTOS (FRIABLE)	1332214	is	ETHOPROP	13194484	is
1,1,2-TRICHLOROETHANE	79005	is	ATRAZINE	1912249	is	ETHYL ACRYLATE	140885	is
1,1-DICHLORO-1-FLUOROETHANE	1717006	is	BARIUM	7440393	is	ETHYL	541413	is
1,2,3-TRICHLOROPROPANE	96184	is	BARIUM COMPOUNDS	N040	is	CHLOROFORMATE		
1,2,4-TRICHLOROETHANE	120821	is	BENZENE	71432	is	ETHYLBENZENE	100414	is
1,2,4-TRIMETHYLBENZENE	106934	is	BENZOYL PEROXIDE	94360	is	ETHYLENE	74851	is
1,2-DIBROMOETHANE	95501	is	BENZYL CHLORIDE	100447	is	ETHYLENE GLYCOL	107211	is
1,2-DICHLOROETHANE	107062	is	BERYLLIUM	7440417	is	ETHYLENE OXIDE	75218	is
1,2-DICHLOROPROPANE	78875	is	BERYLLIUM COMPOUNDS	N050	is	ETHYLIDENE	75343	is
1,2-PHENYLENEDIAMINE	95545	is	BIPHENYL	92524	is	DICHLORIDE		
1,3-BUTADIENE	106990	is	BIS(2-CHLORO-1-METHYLETHYL) ETHER	108601	is	FLUORINE	7782414	is
1,3-PHENYLENEDIAMINE	108452	is	BIS(TRIBUTYLTIN) OXIDE	56359	is	FLUOROURACIL	51218	is
1,4-DICHLOROBENZENE	106467	is	BROMINE	7726956	is	FORMALDEHYDE	50000	is
1,4-DIOXANE	123911	is	BROMOMETHANE	74839	is	FORMIC ACID	64186	is
2,4,5-TRICHLOROPHENOL	95954	is	BUTYL ACRYLATE	141322	is	FREON 113	76131	is
2,4,6-TRICHLOROPHENOL	88062	is	BUTYRALDEHYDE	123728	is	HEXACHLORO-1,3-BUTADIENE	87683	is
2,4-D	94757	is	CADMIUM	7440439	is	HEXACHLOROBENZENE	118741	is
2,4-DICHLOROPHENOL	120832	is	CADMIUM COMPOUNDS	N078	is	HEXACHLOROETHANE	67721	is
2,4-DINITROPHENOL	51285	is	CARBARYL	63252	is	HYDRAMETHYLNON	67485294	is
2,4-DINITROTOLUENE	121142	is	CARBON DISULFIDE	75150	is	HYDRAZINE	302012	is
2,6-DINITROTOLUENE	606202	is	CARBON	56235	is	HYDROCHLORIC ACID (1995 AND AFTER "ACID AEROSOLS" ONLY)	7647010	is
2-ACETYLAMINOFLOURENE	53963	is	TETRACHLORIDE			HYDROGEN CYANIDE	74908	is
2-ETHOXYETHANOL	110805	is	CATECHOL	120809	is	HYDROGEN FLUORIDE	7664393	is
2-MERCAPTOBENZOTHIASZOLE	149304	is	CERTAIN GLYCOL ETHERS	N230	is	HYDROQUINONE	123319	is
2-METHOXYETHANOL	109864	is	CHLORINE	7782505	is	ISOPROPYL ALCOHOL (MANUFACTURING, STRONG-ACID PROCESS ONLY, NO SUPPLIE	67630	is
2-PHENYLPHENOL	90437	is	CHLORINE DIOXIDE	10049044	is	LEAD	7439921	is
3-iodo-2-propynyl butylcarbamate	55406536	is	CHLOROBENZENE	108907	is	LEAD COMPOUNDS	N420	is
4,4"-isopropylidenediphenol	80057	is	CHLORODIFLUOROMETHANE	75456	is	LITHIUM CARBONATE	554132	is
4,4"-methylenebis(2-chloroaniline)	101144	is	CHLOROFORM	67663	is	MALEIC ANHYDRIDE	108316	is
4,4"-methylenedianiline	101779	is	CHLOROMETHANE	74873	is	MALONONITRILE	109773	is
4,6-dinitro-o-cresol	534521	is	CHLOROPHENOLS	N084	is	MANGANESE	7439965	is
4-nitrophenol	100027	is	CHROMIUM	7440473	is	MANGANESE COMPOUNDS	N450	is
5-nitro-o-toluidine	99558	is	CHROMIUM COMPOUNDS	N090	is	M-CRESOL	108394	is
acetaldehyde	75070	is	COBALT	7440484	is	M-DINITROBENZENE	99650	is
acetonitrile	75058	is	COBALT COMPOUNDS	N096	is	MECOPROP	7085190	is
acrolein	107028	is	COPPER	7440508	is	MERCURY	7439976	is
acrylamide	79061	is	COPPER COMPOUNDS	N100	is	MERCURY COMPOUNDS	N458	is
acrylic acid	79107	is	CREOSOTE	8001589	is	METHACRYLONITRILE	126987	is
acrylonitrile	107131	is	CRESOL (MIXED ISOMERS)	1319773	is	METHAM SODIUM	137428	is
aldicarb	116063	is	CUMENE	98828	is	METHANOL	67561	is
allyl alcohol	107186	is	CUMENE HYDROPEROXIDE	80159	is	METHOXONE	94746	is
allyl chloride	107051	is	CYANAZINE	21725462	is	METHYL ACRYLATE	96333	is
			CYANIDE COMPOUNDS	N106	is	METHYL CHLOROCARBONATE	79221	is
			CYCLOHEXANE	110827	is	METHYL ETHYL	78933	is
			DAZOMET	533744	is	KETONE		
			DECABROMODIPHENYL OXIDE	1163195	is	METHYL IODIDE	74884	is
			DI(2-ETHYLHEXYL) PHTHALATE	117817	is	METHYL ISOBUTYL	108101	is
			DIAMINOTOLUENE (MIXED ISOMERS)	25376458	is	KETONE		
			DIBENZOFURAN	132649	is	METHYL ISOCYANATE	624839	is
			DIBUTYL PHTHALATE	84742	is	METHYL	80626	is
			DICHLOROBROMOMETHANE	75274	is	METHACRYLATE		
			DICHLOROFLUOROMETHANE	75434	is	METHYL TERT-BUTYL ETHER	1634044	is
						METTRIBUZIN	21087649	is
						MIXTURE	N/A	is
						MOLYBDENUM	1313275	is
						TRIOXIDE		
						M-XYLENE	108383	is
						N,N-DIMETHYLFORMAMIDE	68122	is

NAPHTHALENE	91203	is	VINYLDENE CHLORIDE	75354	is	3,3"-	612839	fw
N-BUTYL ALCOHOL	71363	is	XYLENE (MIXED	1330207	is	DICHLOROBENZIDINE		
N-HEXANE	110543	is	ISOMERS)			DIHYDROCHLORIDE		
NICKEL	7440020	is	ZINC (FUME OR DUST)	7440666	is	3,3"-	119904	fw
NICKEL COMPOUNDS	N7440020	is	ZINC COMPOUNDS	N982	is	DIMETHOXYBENZIDINE		
NITRATE COMPOUNDS	N511	is	1-(3-CHLOROALLYL)-3,5,7-	4080313	fw	3,3"-	20325400	fw
NITRIC ACID	7697372	is	TRIAZA-1-			DIMETHOXYBENZIDINE		
NITROBENZENE	98953	is	AZONIAADAMANTANE			DIHYDROCHLORIDE		
N-METHYL-2-	872504	is	CHLORIDE			3,3"-	119937	fw
PYRROLIDONE			1,1,1,2-	630206	fw	DIMETHYLBENZIDINE		
N-	924425	is	TETRACHLOROETHANE			3-iodo-2-propynyl	55406536	fw
METHYLOLACRYLAMIDE			1,1,1-	71556	fw	BUTYL CARBAMATE		
N-	55185	is	TRICHLOROETHANE			4,4"-DIAMINODIPHENYL	101804	fw
NITROSODIETHYLAMIN			1,1,2,2-	79345	fw	ETHER		
E			TETRACHLOROETHANE			4,4"-	80057	fw
N-NITROSOPIPERIDINE	100754	is	1,1,2-	79005	fw	ISOPROPYLDENEDIPHE		
NORFLURAZON	27314132	is	TRICHLOROETHANE			NOL		
O-CRESOL	95487	is	1,1-DICHLORO-1-	1717006	fw	4,4"-METHYLENEBIS(2-	101144	fw
OXYFLUORFEN	42874033	is	FLUOROETHANE			CHLOROANILINE)		
O-XYLENE	95476	is	1,1-DIMETHYL	57147	fw	4,4"-	101779	fw
OZONE	10028156	is	HYDRAZINE			METHYLENEDIANILINE		
P-CRESOL	106445	is	1,2,3-	96184	fw	4-NITROPHENOL	100027	fw
PENDIMETHALIN	40487421	is	TRICHLOROPROPANE			5-NITRO-O-ANISIDINE	99592	fw
PENTACHLOROPHENOL	87865	is	1,2,4-	120821	fw	ABAMECTIN	71751412	fw
PERACETIC ACID	79210	is	TRICHLOROETHANE			ACETALDEHYDE	75070	fw
PERMETHRIN	52645531	is	1,2,4-	95636	fw	ACETAMIDE	60355	fw
PHENANTHRENE	85018	is	TRIMETHYLBENZENE			ACETONITRILE	75058	fw
PHENOL	108952	is	1,2-BUTYLENE OXIDE	106887	fw	ACETOPHENONE	98862	fw
PHOSPHORUS (YELLOW	7723140	is	1,2-DIBROMOETHANE	106934	fw	ACIFLUORFEN, SODIUM	62476599	fw
OR WHITE)			1,2-DICHLORO-1,1,2-	354234	fw	SALT		
PHTHALIC ANHYDRIDE	85449	is	TRIFLUOROETHANE			ACROLEIN	107028	fw
P-NITROANILINE	100016	is	1,2-DICHLORO-1,1-	1649087	fw	ACRYLAMIDE	79061	fw
POLYCHLORINATED	N583	is	DIFLUOROETHANE			ACRYLIC ACID	79107	fw
ALKANES			1,2-DICHLOROETHANE	95501	fw	ACRYLONITRILE	107131	fw
POLYCHLORINATED	1336363	is	1,2-	107062	fw	ALACHLOR	15972608	fw
BIPHENYLS			DICHLOROETHYLENE	540590	fw	ALLYL ALCOHOL	107186	fw
POLYCYCLIC AROMATIC	N590	is	1,2-DICHLOROPROPANE			ALLYL CHLORIDE	107051	fw
COMPOUNDS			1,2-	78875	fw	ALLYLAMINE	107119	fw
POTASSIUM	128030	is	DIPHENYLHYDRAZINE	122667	fw	ALPHA-	134327	fw
DIMETHYLDITHIOCARB			1,2-			NAPHTHYLAMINE		
AMATE			PHENYLENEDIAMINE	95545	fw	ALUMINUM (FUME OR	7429905	fw
P-PHENYLENEDIAMINE	106503	is	1,3-BUTADIENE	106990	fw	DUST)		
PROPACHLOR	1918167	is	1,3-DICHLOROBENZENE	541731	fw	ALUMINUM OXIDE	1344281	fw
PROPYLENE	115071	is	1,3-	542756	fw	(FIBROUS FORMS)		
PROPYLENE OXIDE	75569	is	DICHLOROPROPYLENE			AMETRYN	834128	fw
P-XYLENE	106423	is	1,3-	108452	fw	AMITROLE	61825	fw
QUINOLINE	91225	is	PHENYLENEDIAMINE			AMMONIA	7664417	fw
SAFROLE	94597	is	1,4-DICHLORO-2-BUTENE	764410	fw	ANILINE	62533	fw
SEC-BUTYL ALCOHOL	78922	is	1,4-DICHLOROBENZENE	106467	fw	ANTHRACENE	120127	fw
SELENIUM	7782492	is	1,4-DIOXANE	123911	fw	ANTIMONY	7440360	fw
SELENIUM COMPOUNDS	N725	is	1-CHLORO-1,1-	75683	fw	ANTIMONY	N010	fw
SILVER	7440224	is	DIFLUOROETHANE			COMPOUNDS		
SILVER COMPOUNDS	N740	is	2,2-DICHLORO-1,1,1-	306832	fw	ARSENIC	7440382	fw
SODIUM AZIDE	26628228	is	TRIFLUOROETHANE			ARSENIC COMPOUNDS	N020	fw
SODIUM	128041	is	2,3-DICHLOROPROPENE	78886	fw	ATRAZINE	1912249	fw
DIMETHYLDITHIOCARB			2,4,5-	95954	fw	BARIUM	7440393	fw
AMATE			TRICHLOROPHENOL			BARIUM COMPOUNDS	N040	fw
SODIUM NITRITE	7632000	is	2,4,6-	88062	fw	BENZENE	71432	fw
STYRENE	100425	is	TRICHLOROPHENOL			BENZOYL PEROXIDE	94360	fw
SULFURIC ACID (1994	7664939	is	2,4-D	94757	fw	BENZYL CHLORIDE	100447	fw
AND AFTER "ACID			2,4-D 2-ETHYLHEXYL	1928434	fw	BERYLLIUM	7440417	fw
AEROSOLS" ONLY)			ESTER			BERYLLIUM	N050	fw
TERT-BUTYL ALCOHOL	75650	is	2,4-D BUTYL ESTER	94804	fw	COMPOUNDS		
TETRACHLOROETHYLE	127184	is	2,4-D SODIUM SALT	2702729	fw	BETA-NAPHTHYLAMINE	91598	fw
NE			2,4-DICHLOROPHENOL	120832	fw	BIPHENYL	92524	fw
THALLIUM	7440280	is	2,4-DIMETHYLPHENOL	105679	fw	BIS(2-CHLORO-1-	108601	fw
THALLIUM COMPOUNDS	N760	is	2,4-DINITROPHENOL	51285	fw	METHYLETHYL) ETHER		
THIODICARB	59669260	is	2,4-DINITROTOLUENE	121142	fw	BIS(2-	111911	fw
THIOUREA	62566	is	2,6-DINITROTOLUENE	606202	fw	CHLOROETHOXY)METH		
THIRAM	137268	is	2-	53963	fw	ANE		
TOLUENE	108883	is	ACETYLAMINOFLUOREN			BIS(2-CHLOROETHYL)	111444	fw
TOLUENE	26471625	is	E			ETHER		
DIISOCYANATE (MIXED			2-CHLORO-1,1,1,2-	2837890	fw	BIS(TRIBUTYL TIN)	56359	fw
ISOMERS)			TETRAFLUROETHANE			OXIDE		
TOLUENE-2,4-	584849	is	2-CHLORO-1,1,1-	75887	fw	BROMINE	7726956	fw
DIISOCYANATE			TRIFLUOROETHANE			BROMOFORM	75252	fw
TRICHLORFON	52686	is	2-ETHOXYETHANOL	110805	fw	BROMOMETHANE	74839	fw
TRICHLOROETHYLENE	79016	is	2-	149304	fw	BUTYL ACRYLATE	141322	fw
TRICHLOROFLUOROMET	75694	is	MERCAPTOBENZOTHIAZ			BUTYRALDEHYDE	123728	fw
HANE			OLE			C.I. DIRECT BLUE 218	28407376	fw
TRIETHYLAMINE	121448	is	2-METHOXYETHANOL	109864	fw	C.I. DISPERSE YELLOW 3	2832408	fw
URETHANE	51796	is	2-METHYLPYRIDINE	109068	fw	CADMIUM	7440439	fw
VANADIUM (FUME OR	7440622	is	2-NITROPHENOL	88755	fw	CADMIUM COMPOUNDS	N078	fw
DUST)			2-NITROPROPANE	79469	fw	CAPTAN	133062	fw
VINYL ACETATE	108054	is	2-PHENYLPHENOL	90437	fw	CARBARYL	63252	fw
VINYL CHLORIDE	75014	is				CARBOFURAN	1563662	fw

CARBON DISULFIDE	75150	fw	ETHYLENE OXIDE	75218	fw	PYRROLIDONE		
CARBON	56235	fw	ETHYLENE THIOUREA	96457	fw	N-	924425	fw
TETRACHLORIDE			ETHYLIDENE	75343	fw	METHYLOLACRYLAMIDE		
CATECHOL	120809	fw	DICHLORIDE			N-	55185	fw
CERTAIN GLYCOL	N230	fw	FLUORINE	7782414	fw	NITROSODIETHYLAMIN		
ETHERS			FOLPET	133073	fw	E		
CHLORDANE	57749	fw	FOMESAFEN	72178020	fw	N-NITROSODI-N-	924163	fw
CHLORINE	7782505	fw	FORMALDEHYDE	50000	fw	BUTYLAMINE		
CHLORINE DIOXIDE	10049044	fw	FORMIC ACID	64186	fw	N-NITROSO-N-	759739	fw
CHLOROACETIC ACID	79118	fw	FREON 113	76131	fw	ETHYLUREA		
CHLORO BENZENE	108907	fw	HEPTACHLOR	76448	fw	N-NITROSO-N-	684935	fw
CHLORO BENZILATE	510156	fw	HEXACHLORO-1,3-	87683	fw	METHYLUREA		
CHLORODIFLUOROMET	75456	fw	BUTADIENE			N-NITROSOPIPERIDINE	100754	fw
HANE			HEXACHLOROBENZENE	118741	fw	NORFLURAZON	27314132	fw
CHLOROETHANE	75003	fw	HEXACHLOROCYCLOPE	77474	fw	O-ANISIDINE	90040	fw
CHLOROFORM	67663	fw	NTADIENE			O-CRESOL	95487	fw
CHLOROMETHANE	74873	fw	HEXACHLOROETHANE	67721	fw	O-DINITROBENZENE	528290	fw
CHLOROMETHYL	107302	fw	HEXACHLOROPHENE	70304	fw	O-TOLUIDINE	95534	fw
METHYL ETHER			HEXAZINONE	51235042	fw	O-TOLUIDINE	636215	fw
CHLOROPHENOLS	N084	fw	HYDRAZINE	302012	fw	HYDROCHLORIDE		
CHLOROTHALONIL	1897456	fw	HYDROCHLORIC ACID	7647010	fw	O-XYLENE	95476	fw
CHLOROTRIFLUOROMET	75729	fw	(1995 AND AFTER "ACID			PARALDEHYDE	123637	fw
HANE			AEROSOLS" ONLY)			P-CHLOROANILINE	106478	fw
CHROMIUM	7440473	fw	HYDROGEN CYANIDE	74908	fw	P-CRESIDINE	120718	fw
CHROMIUM	N090	fw	HYDROGEN FLUORIDE	7664393	fw	P-CRESOL	106445	fw
COMPOUNDS			HYDROQUINONE	123319	fw	P-DINITROBENZENE	100254	fw
COBALT	7440484	fw	ISOBUTYRALDEHYDE	78842	fw	PENDIMETHALIN	40487421	fw
COBALT COMPOUNDS	N096	fw	ISOPROPYL ALCOHOL	67630	fw	PENTACHLOROETHANE	76017	fw
COPPER	7440508	fw	(MANUFACTURING,			PENTACHLOROPHENOL	87865	fw
COPPER COMPOUNDS	N100	fw	STRONG-ACID PROCESS			PERACETIC ACID	79210	fw
CRESOTE	8001589	fw	ONLY, NO SUPPLIE			PHENANTHRENE	85018	fw
CRESOL (MIXED	1319773	fw	ISOSAFROLE	120581	fw	PHENOL	108952	fw
ISOMERS)			LEAD	7439921	fw	PHOSPHORUS (YELLOW	7723140	fw
CROTONALDEHYDE	123739	fw	LEAD COMPOUNDS	N420	fw	OR WHITE)		
CUMENE	98828	fw	LINDANE	58899	fw	Phosphorus	7723140	fw
CUMENE	80159	fw	LINURON	330552	fw	PHTHALIC ANHYDRIDE	85449	fw
HYDROPEROXIDE			LITHIUM CARBONATE	554132	fw	PICLORAM	1918021	fw
CYANIDE COMPOUNDS	N106	fw	MALATHION	121755	fw	PICRIC ACID	88891	fw
CYCLOATE	1134232	fw	MALEIC ANHYDRIDE	108316	fw	POLYCHLORINATED	N583	fw
CYCLOHEXANE	110827	fw	MALONONITRILE	109773	fw	ALKANES		
CYCLOHEXANOL	108930	fw	MANGANESE	7439965	fw	POLYCHLORINATED	1336363	fw
CYFLUTHRIN	68359375	fw	MANGANESE	N450	fw	BIPHENYLS		
DAZOMET	533744	fw	COMPOUNDS			POLYCYCLIC AROMATIC	N590	fw
DECABROMODIPHENYL	1163195	fw	M-CRESOL	108394	fw	COMPOUNDS		
OXIDE			M-DINITROBENZENE	99650	fw	POTASSIUM	128030	fw
DI(2-ETHYLHEXYL)	117817	fw	MERCURY	7439976	fw	DIMETHYLDITHIOCARB		
PHTHALATE			MERCURY COMPOUNDS	N458	fw	AMATE		
DIALATE	2303164	fw	MERPHOS	150505	fw	POTASSIUM N-	137417	fw
DIAMINOTOLUENE	25376458	fw	METHACRYLONITRILE	126987	fw	METHYLDITHIOCARBAM		
(MIXED ISOMERS)			METHAM SODIUM	137428	fw	ATE		
DIAZINON	333415	fw	METHANOL	67561	fw	P-PHENYLENEDIAMINE	106503	fw
DIBENZOFURAN	132649	fw	METHYL ACRYLATE	96333	fw	PROMETRYN	7287196	fw
DIBUTYL PHTHALATE	84742	fw	METHYL	79221	fw	PRONAMIDE	23950585	fw
DICAMBA	1918009	fw	CHLOROCARBONATE			PROPANIL	709988	fw
DICHLORODIFLUOROME	75718	fw	METHYL ETHYL	78933	fw	PROPIONALDEHYDE	123386	fw
THANE			KETONE			PROPYLENE	115071	fw
DICHLOROMETHANE	75092	fw	METHYL IODIDE	74884	fw	PROPYLENE OXIDE	75569	fw
DICHLOROTETRAFLUOR	76142	fw	METHYL ISOBUTYL	108101	fw	P-XYLENE	106423	fw
OETHANE (CFC-114)			KETONE			PYRIDINE	110861	fw
DICHLORVOS	62737	fw	METHYL	80626	fw	QUINOLINE	91225	fw
DICYCLOPENTADIENE	77736	fw	METHACRYLATE			QUINONE	106514	fw
DIETHANOLAMINE	111422	fw	METHYL TERT-BUTYL	1634044	fw	QUINTOZENE	82688	fw
DIISOCYANATES	N120	fw	ETHER			S,S,S-	78488	fw
DIMETHOATE	60515	fw	METHYLENE BROMIDE	74953	fw	TRIBUTYLTRITHIOPHOS		
DIMETHYL	2524030	fw	METTRIBUZIN	21087649	fw	PHATE		
CHLOROTHIOPHOSPHAT			MOLINATE	2212671	fw	SEC-BUTYL ALCOHOL	78922	fw
E			MOLYBDENUM	1313275	fw	SELENIUM	7782492	fw
DIMETHYL PHTHALATE	131113	fw	TRIOXIDE			SELENIUM COMPOUNDS	N725	fw
DIMETHYL SULFATE	77781	fw	MONOCHLOROPENTAFL	76153	fw	SILVER	7440224	fw
DIMETHYLAMINE	124403	fw	UOROETHANE			SILVER COMPOUNDS	N740	fw
DIMETHYLCARBAMYL	79447	fw	M-XYLENE	108383	fw	SIMAZINE	122349	fw
CHLORIDE			N,N-DIMETHYLANILINE	121697	fw	SODIUM AZIDE	26628228	fw
DINITROTOLUENE	25321146	fw	N,N-	68122	fw	SODIUM	128041	fw
(MIXED ISOMERS)			DIMETHYLFORMAMIDE			DIMETHYLDITHIOCARB		
DIPHENYLAMINE	122394	fw	NAPHTHALENE	91203	fw	AMATE		
DIURON	330541	fw	N-BUTYL ALCOHOL	71363	fw	SODIUM NITRITE	7632000	fw
EPICHLOROHYDRIN	106898	fw	N-HEXANE	110543	fw	STYRENE	100425	fw
ETHYL ACRYLATE	140885	fw	NICKEL	7440020	fw	SULFURIC ACID (1994	7664939	fw
ETHYL	541413	fw	NICKEL COMPOUNDS	N7440020	fw	AND AFTER "ACID		
CHLOROFORMATE			NICOTINE AND SALTS	N503	fw	AEROSOLS" ONLY)		
ETHYL	759944	fw	NITRATE COMPOUNDS	N511	fw	TERT-BUTYL ALCOHOL	75650	fw
DIPROPYLTHIOCARBAM			NITRIC ACID	7697372	fw	TETRACHLOROETHYLE	127184	fw
ATE			NITRILOTRIACETIC ACID	139139	fw	NE		
ETHYLBENZENE	100414	fw	NITROBENZENE	98953	fw	TETRACHLORVINPHOS	961115	fw
ETHYLENE	74851	fw	NTROGLYCERIN	55630	fw	THALLIUM	7440280	fw
ETHYLENE GLYCOL	107211	fw	N-METHYL-2-	872504	fw	THALLIUM COMPOUNDS	N760	fw

THIOACETAMIDE	62555	fw	TETRAFLUOROETHANE			(Including Salts)		
THIOUREA	62566	fw	1-CHLORO-1,1-	75683	a	4-Aminobiphenyl	92671	a
THIRAM	137268	fw	DIFLUOROETHANE			4-Dimethylaminoazobenzene	60117	a
TOLUENE	108883	fw	2,2,4-Trimethylpentane	540841	a	4-Nitrobiphenyl	92933	a
TOLUENE	26471625	fw	2,2-DICHLORO-1,1,1-	306832	a	4-Nitrophenol	100027	a
DIISOCYANATE (MIXED			TRIFLUOROETHANE			5-NITRO-O-ANISIDINE	99592	a
ISOMERS)			2,3-DICHLOROPROPENE	78886	a	5-NITRO-O-TOLUIDINE	99558	a
TOLUENE-2,4-	584849	fw	2,4,5-Trichlorophenol	95954	a	ABAMECTIN	71751412	a
DIISOCYANATE			2,4,6-Trichlorophenol	88062	a	ACEPHATE	30560191	a
TOXAPHENE	8001352	fw	2,4-D	H94757	a	Acetaldehyde	75070	a
TRICHLOROETHYLENE	79016	fw	2,4-D (2,4-	94757	a	Acetamide	60355	a
TRICHLOROFLUOROMET	75694	fw	Dichlorophenoxyacetic			ACETONE	67641	a
HANE			Acid)(Including Salts And			Acetonitrile	75058	a
TRIEETHYLAMINE	121448	fw	Esters)			Acetophenone	98862	a
TRIS(2,3-	126727	fw	2,4-D 2-ETHYLHEXYL	1928434	a	ACIFLUORFEN, SODIUM	62476599	a
DIBROMOPROPYL)			ESTER			SALT		
PHOSPHATE			2,4-D BUTOXYETHYL	1929733	a	Acrolein	107028	a
URETHANE	51796	fw	ESTER			Acrylamide	79061	a
VANADIUM (FUME OR	7440622	fw	2,4-DB	94826	a	Acrylic Acid	79107	a
DUST)			2,4-DIAMINOTOLUENE	95807	a	Acrylonitrile	107131	a
VINYL ACETATE	108054	fw	2,4-DICHLOROPHENOL	120832	a	ALACHLOR	15972608	a
VINYL CHLORIDE	75014	fw	2,4-DIMETHYLPHENOL	105679	a	ALDICARB	116063	a
VINYLDIENE CHLORIDE	75354	fw	2,4-Dinitrophenol	51285	a	ALLYL ALCOHOL	107186	a
XYLENE (MIXED	1330207	fw	2,4-Dimitrotoluene	121142	a	Allyl Chloride	107051	a
ISOMERS)			2,4-DITHIOBIURET	541537	a	ALLYLAMINE	107119	a
ZINC (FUME OR DUST)	7440666	fw	2,4-DP	120365	a	ALPHA-	134327	a
ZINC COMPOUNDS	N982	fw	2,4-Toluene Diisocyanate	584849	a	NAPHTHYLAMINE		
1-(3-CHLOROALLYL)-3,5,7-	4080313	a	2,6-DINITROTOLUENE	606202	a	ALUMINUM (FUME OR	7429905	a
TRIAZA-1-			2,6-XYLIDINE	87627	a	DUST)		
AZONIAADAMANTANE			2-Acetylamino fluorene	53963	a	ALUMINUM OXIDE	1344281	a
CHLORIDE			2-CHLORO-1,1,1,2-	2837890	a	(FIBROUS FORMS)		
1,1,1,2-	630206	a	TETRAFLUOROETHANE			ALUMINUM PHOSPHIDE	20859738	a
TETRACHLOROETHANE			2-CHLORO-1,1,1-	75887	a	AMETRYN	834128	a
1,1,1-	H71556	a	TRIFLUOROETHANE			AMITROLE	61825	a
TRICHLOROETHANE			2-Chloroacetophenone	98862	a	AMMONIA	7664417	a
1,1,2,2-TETRACHLORO-1-	354143	a	2-ETHOXYETHANOL	110805	a	AMMONIA	H7664417	a
FLUOROETHANE			2-	149304	a	Aniline	62533	a
1,1,2,2-Tetrachloroethane	79345	a	MERCAPTOBENZOTHIAZ			ANTHRACENE	120127	a
1,1,2-Trichloroethane	79005	a	OLE			ANTIMONY	7440360	a
1,1-DICHLORO-1-	1717006	a	2-METHOXYETHANOL	109864	a	Antimony Compounds	N7440360	a
FLUOROETHANE			2-	75865	a	ARSENIC	7440382	a
1,1-DIMETHYL	57147	a	METHYLLACTONITRILE			ARSENIC COMPOUNDS	N7784421	a
HYDRAZINE			2-METHYLPYRIDINE	109068	a	Arsenic	N7784421	a
1,1-Dimethylhydrazine	57147	a	2-NITROPHENOL	88755	a	Compounds(Inorganic		
1,2,3,4,5,6-	58899	a	2-Nitropropane	79469	a	Including Arsenic)		
Hexachlorocyclohexane (All			2-PHENYLPHENOL	90437	a	Asbestos	1332214	a
Stereo Isomers, Including			3,3"-	91941	a	ASBESTOS (FRIABLE)	1332214	a
Lindane)			DICHLOROBENZIDINE			ATRAZINE	1912249	a
1,2,3-	96184	a	3,3"-	612839	a	BARIUM	7440393	a
TRICHLOROPROPANE			DICHLOROBENZIDINE			BARIUM COMPOUNDS	N/A	a
1,2,4-Trichlorobenzene	120821	a	DIHYDROCHLORIDE			BENDIOCARB	22781233	a
1,2,4-	95636	a	3,3"-	119904	a	BENFLURALIN	1861401	a
TRIMETHYLBENZENE			DIMETHOXYBENZIDINE			BENOMYL	17804352	a
1,2-BUTYLENE OXIDE	106887	a	3,3"-	20325400	a	BENZAL CHLORIDE	98873	a
1,2-Dibromo-3-	96128	a	DIMETHOXYBENZIDINE			BENZENE	H71432	a
Chloropropane			DIHYDROCHLORIDE			Benzene (Including Benzene	71432	a
1,2-DIBROMOETHANE	J106934	a	3,3"-	119937	a	From Gasoline)		
1,2-DICHLORO-1,1,2-	354234	a	DIMETHYLBENZIDINE			Benzidine	92875	a
TRIFLUOROETHANE			3,3-DICHLORO-1,1,1,2,2-	422560	a	BENZOIC TRICHLORIDE	H98077	a
1,2-DICHLORO-1,1-	1649087	a	PENTAFLUOROPROPAN			Benzotrichloride	98077	a
E						BENZOYL CHLORIDE	98884	a
DIFLUOROETHANE			3,3'-Dichlorobenzidene	91941	a	BENZOYL PEROXIDE	94360	a
1,2-DICHLOROENZENE	95501	a	3,3'-Dimethoxybenzidine	119904	a	Benzyl Chloride	100447	a
1,2-DICHLOROETHANE	H107062	a	3,3'-Dimethylbenzidine	119937	a	BERYLLIUM	7440417	a
1,2-	540590	a	3-CHLORO-2-METHYL-1-	563473	a	Beryllium Compounds	N7440417	a
DICHLOROETHYLENE			PROPENE			BETA-NAPHTHYLAMINE	91598	a
1,2-DICHLOROPROPANE	H78875	a	3-	542767	a	Beta-Propiolactone	57578	a
1,2-Diphenylhydrazine	122667	a	CHLOROPROPIONITRILE			BIFENTHRIN	82657043	a
1,2-Epoxybutane	106887	a	3-IODO-2-PROPYNYL	55406536	a	Biphenyl	92524	a
1,2-	95545	a	BUTYL CARBAMATE			BIS(2-CHLORO-1-	108601	a
PHENYLENEDIAMINE			4,4"-DIAMINODIPHENYL	101804	a	METHYLETHYL) ETHER		
1,2-Propylenimine (2-	75558	a	ETHER			BIS(2-	111911	a
Methylazindine)			4,4"-	80057	a	CHLOROETHOXY)METH		
1,3-Butadiene	106990	a	ISOPROPYLDENEDIPHE			ANE		
1,3-DICHLORO-1,1,2,2,3-	507551	a	NOL			BIS(2-CHLOROETHYL)	H111444	a
PENTAFLUOROPROPAN			4,4"-METHYLENEBIS(2-	101144	a	ETHER		
E			CHLOROANILINE)			Bis(2-Ethylhexyl)Phthalate	117817	a
1,3-DICHLOROENZENE	541731	a	4,4"-	101779	a	(Dehp)		
1,3-Dichloropropene	542736	a	METHYLENEDIANILINE			Bis(Chloromethyl) Ether	542881	a
1,3-	542736	a	4,4'-Methylenebis(2-	101144	a	BIS(TRIBUTYL)TIN	56359	a
DICHLOROPROPYLENE			Chloroaniline)			OXIDE		
1,3-	108452	a	4,4'-Methylenedianiline	101779	a	BORON TRICHLORIDE	10294345	a
PHENYLENEDIAMINE			4,4'-Methylenediphenyl	101688	a	BORON TRIFLUORIDE	7637072	a
1,4-DICHLORO-2-BUTENE	764410	a	Diisocyanate (MDI)			BROMACIL	314409	a
1,4-Dichlorobenzene	106467	a	4,6-DINITRO-O-CRESOL	H534521	a	BROMINE	7726956	a
1,4-DIOXANE	H123911	a	4,6-Dinitro-o-Cresol	534521	a	BROMOCHLORODIFLUO	353593	a
1-CHLORO-1,1,2,2-	354256	a						

ROMETHANE								
Bromofom	75252	a	Dibutyl Phthalate	84742	a	FORMIC ACID	64186	a
BROMOMETHANE	H74839	a	DICAMBA	1918009	a	FREON 113	76131	a
BROMOTRIFLUOROMETHANE	75638	a	DICHLOROENZENE (MIXED ISOMERS)	25321226	a	Glycol Ethers	N111762	a
HANE			DICHLOROBROMOMETHANE	75274	a	Heptachlor	76448	a
BROMOXYNIL	1689845	a	ANE			HEXACHLORO-1,3-BUTADIENE	H87683	a
BROMOXYNIL OCTANOATE	1689992	a	DICHLORODIFLUOROMETHANE	75718	a	Hexachlorobenzene	118741	a
BRUCINE	357573	a	Dichloroethyl Ether (Bis[2-Chloroethyl]Ether)	111444	a	Hexachlorobutadiene	87683	a
BUTYL ACRYLATE	141322	a	DICHLOROFLUOROMETHANE	75434	a	Hexachlorocyclopentadiene	77474	a
BUTYRALDEHYDE	123728	a	HANE			Hexachloroethane	67721	a
C.I. DISPERSE YELLOW 3	2832408	a	DICHLOROMETHANE	H75092	a	HEXACHLOROPHENE	70304	a
C.I. SOLVENT YELLOW 34	492808	a	DICHLOROPENTAFLUOROPROPANE	127564925	a	Hexamethylene Diisocyanate	822060	a
CADMIUM	7440439	a	DICHLOROTETRAFLUOROETHANE (CFC-114)	76142	a	Hexamethylphosphoramide	680319	a
Cadmium Compounds	N7440439	a	DICHLOROTRIFLUOROETHANE	34077877	a	Hexane	110543	a
CALCIUM CYANAMIDE	156627	a	Dichlorvos	62737	a	HEXAZINONE	51235042	a
Captan	133062	a	DICOFOL	115322	a	HYDRAMETHYLLON	67485294	a
Carbaryl	63252	a	DICYCLOPENTADIENE	77736	a	Hydrazine	302012	a
CARBOFURAN	1563662	a	Diethanolamine	111422	a	HYDROCHLORIC ACID (1995 AND AFTER "ACID AEROSOLS" ONLY)	H7647010	a
CARBON DIOXIDE	124389	a	Diethyl Sulfate	64675	a	Hydrochloric Acid (Hydrogen Chloride [Gas Only])	7647010	a
Carbon Disulfide	75150	a	DIGLYCIDYL RESORCINOL ETHER	101906	a	HYDROGEN CYANIDE	74908	a
CARBON MONOOXIDE	630080	a	DIHYDROSAFROLE	94586	a	HYDROGEN FLUORIDE	H7664393	a
Carbon Tetrachloride	56235	a	DIISOCYANATES	N120	a	Hydrogen Fluoride (Hydrofluoric Acid)	123319	a
Carbonyl Sulfide	463581	a	DIMETHOATE	60515	a	Hydroquinone	13463406	a
CARBONIN	5234684	a	DIMETHYL	2524030	a	IRON PENTACARBONYL	78842	a
Catechol	120809	a	CHLOROTHIOPHOSPHATE			ISOBUTYRALDEHYDE	25311711	a
CERTAIN GLYCOL ETHERS	N/A	a	Dimethyl Phthalate	131113	a	ISOFENPHOS	78591	a
Chlordane	57749	a	Dimethyl Sulfate	77781	a	Isophorone	67630	a
CHLORENDIC ACID	115286	a	DIMETHYLAMINE	124403	a	ISOPROPYL ALCOHOL (MANUFACTURING, STRONG-ACID PROCESS ONLY, NO SUPPLIE		
CHLORIMURON ETHYL	90982324	a	DIMETHYLAMINE	2300665	a	ISOSAFROLE	120581	a
Chlorine	7782505	a	DICAMBA			LACTOFEN	77501634	a
CHLORINE DIOXIDE	10049044	a	Dimethylcarbamoyl Chloride	79447	a	LEAD	7439921	a
Chloroacetic Acid	79118	a	DIMETHYL CARBAMYL CHLORIDE	79447	a	Lead Compounds	N7439921	a
Chlorobenzene	108907	a	CHLORIDE			LINDANE	H58899	a
CHLOROBENZILATE	510156	a	DINITROBUTYL PHENOL	88857	a	LINURON	330552	a
CHLORODIFLUOROMETHANE	75456	a	DINITROTOLUENE (MIXED ISOMERS)	25321146	a	LITHIUM CARBONATE	554132	a
CHLOROETHANE	H75003	a	DIPHENYLAMINE	122394	a	MALATHION	121755	a
Chloroform	67663	a	DIPOTASSIUM ENDOTHALL	2164070	a	Maleic Anhydride	108316	a
CHLOROMETHANE	H74873	a	DIURON	330541	a	MALONONITRILE	109773	a
Chloromethyl Methyl Ether	107302	a	EPICHLOROHYDRIN	H106898	a	MANGANESE	7439965	a
CHLOROPHENOLS	N084	a	Epichlorohydrin (1-Chloro-2,3-Epoxypropane)	106898	a	Manganese Compounds	N7439965	a
CHLOROPICRIN	76062	a	ETHOPROP	13194484	a	M-CRESOL	108394	a
Chloroprene	126998	a	Ethyl Acrylate	140885	a	M-DINITROBENZENE	99650	a
CHLOROTETRAFLUOROETHANE	63938103	a	Ethyl Carbamate (Urethane) Chloride (Chloroethane)	51796	a	MECOPROP	7085190	a
CHLOROTHALONIL	1897456	a	Ethyl Chloride	75003	a	MERCURY	7439976	a
CHLOROTRIFLUOROMETHANE	75729	a	ETHYL	541413	a	Mercury Compounds	N7439976	a
CHLOROPYRIFOS METHYL	5598130	a	CHLOROFORMATE			METHACRYLONITRILE	126987	a
CHLORSULFURON	64902723	a	ETHYL	759944	a	METHAM SODIUM	137428	a
CHROMIUM	7440473	a	DIPROPYLTHIOCARBAMATE			METHANE	74828	a
Chromium Compounds	N7440473	a	Ethylbenzene	100414	a	Methanol	67561	a
COBALT	7440484	a	ETHYLENE	74851	a	METHOXONE	94746	a
Cobalt Compounds	N7440484	a	Ethylene Dibromide (Dibromoethane)	106934	a	Methoxychlor	72435	a
Coke Oven Emissions	N/A	a	Ethylene Dichloride (1,2-Dichloroethane)	107062	a	METHYL ACRYLATE	96333	a
COPPER	7440508	a	Ethylene Glycol	107211	a	Methyl Bromide (Bromomethane)	74839	a
COPPER COMPOUNDS	N100	a	Ethylene Oxide	75218	a	Methyl Chloride (Chloromethane)	74873	a
CREOSOTE	8001589	a	Ethylene Thiourea	96457	a	METHYL	79221	a
CRESOL (MIXED ISOMERS)	1319773	a	ETHYLENEBISDITHIOCARBAMIC ACID, SALTS AND ESTERS	N171	a	CHLOROCARBONATE		
Cresol/Cresylic Acid (Mixed Isomers)	N/A	a	ETHYLENEIMINE	151564	a	Methyl Chloroform (1,1,1-Trichloroethane)	71556	a
CROTONALDEHYDE	123739	a	Ethyleneimine (Aziridine)	151564	a	METHYL ETHYL	H78933	a
Cumene	98828	a	ETHYLIDENE	H75343	a	KETONE		
CUMENE	80159	a	DICHLORIDE			Methyl Ethyl Ketone (2-Butanone)	78933	a
HYDROPEROXIDE			Ethylidene Dichloride (1,1-Dichloroethane)	75343	a	METHYL HYDRAZINE	60344	a
CYANAZINE	21725462	a	FAMPHUR	52857	a	METHYL IODIDE	74884	a
Cyanide Compounds	N57125	a	FENBUTATIN OXIDE	13356086	a	Methyl Iodide (Iodomethane)	74884	a
CYCLOATE	1134232	a	Fine Mineral Fibers	N/A	a	METHYL ISOBUTYL KETONE	H108101	a
CYCLOHEXANE	110827	a	FLUOMETURON	2164172	a	KETONE		
CYCLOHEXANOL	108930	a	FLUORINE	7782414	a	Methyl Isobutyl Ketone (Hexone)	108101	a
CYFLUTHRIN	68359375	a	FOLPET	133073	a	Methyl Isocyanate	624839	a
DAZOMET	533744	a	FOMESAFEN	72178020	a	METHYL	556616	a
DECABROMODIPHENYLOXIDE	1163195	a	Formaldehyde	50000	a	ISOTHIOCYANATE		
DESMEDIPHAM	13684565	a				Methyl Methacrylate	80626	a
DI(2-ETHYLHEXYL) PHTHALATE	H117817	a				METHYL PARATHION	298000	a
DIALATE	2303164	a				Methyl Tert-Butyl Ether	1634044	a
DIAMINOTOLUENE (MIXED ISOMERS)	25376458	a				METHYLENE BROMIDE	74953	a
DIAZINON	333415	a				Methylene Chloride	75092	a
DIAZOMETHANE	334883	a						
Dibenzofuran	132649	a						

(Dichloromethane)			PERMETHRIN	52645531	a	FLUOROACETATE		
Methylhydrazine	60344	a	PHENANTHRENE	85018	a	SODIUM NITRITE	7632000	a
METRIBUZIN	21087649	a	Phenol	108952	a	STRYCHNINE AND SALTS	N746	a
MICHLER'S KETONE	90948	a	PHENYTOIN	57410	a	Styrene	100425	a
MIXTURE			Phosgene	75445	a	Styrene Oxide	96093	a
MOLINATE	2212671	a	Phosphine	7803512	a	SULFURIC ACID (1994	7664939	a
MOLYBDENUM	1313275	a	PHOSPHORUS (YELLOW	7723140	a	AND AFTER "ACID		
TRIOXIDE			OR WHITE)			AEROSOLS" ONLY)		
MONOCHLOROPENTAFL	76153	a	Phosphorus Compounds	N7723140	a	SULFURYL FLUORIDE	2699798	a
UOROETHANE			Phthalic Anhydride	85449	a	Sulphur dioxide	7446095	a
M-XYLENE	108383	a	PICLORAM	1918021	a	TEBUTHIURON	34014181	a
MYCLOBUTANIL	88671890	a	PIPERONYL BUTOXIDE	51036	a	TERT-BUTYL ALCOHOL	75650	a
N,N-Dimethylaniline	121697	a	PIRIMIPHOS METHYL	29232937	a	TETRACHLOROETHYLE	H127184	a
N,N-Dimethylformamide	68122	a	P-NITROANILINE	100016	a	NE		
Naphthalene	91203	a	P-	156105	a	Tetrachloroethylene	127184	a
N-BUTYL ALCOHOL	71363	a	NITROSODIPHENYLAMI			(Perchloroethylene)		
N-HEXANE	H110543	a	NE			TETRACHLORVINPHOS	961115	a
NICKEL	7440020	a	POLYCHLORINATED	N583	a	TETRAMETHRIN	7696120	a
Nickel Compounds	N7440020	a	ALKANES			THALLIUM	7440280	a
NICOTINE AND SALTS	N503	a	POLYCHLORINATED	1336363	a	THALLIUM COMPOUNDS	N760	a
NITRAPYRIN	1929824	a	BIPHENYLS			THIABENDAZOLE	148798	a
NITRATE COMPOUNDS	N511	a	Polychlorinated Biphenyls	11141165	a	THIOACETAMIDE	62555	a
NITRIC ACID	7697372	a	(Aroclors)			THIOBENCARB	28249776	a
NITRILOTRIACETIC ACID	139139	a	POLYCYCLIC AROMATIC	N590	a	THIODICARB	59669260	a
COMPOUNDS			COMPOUNDS			THIOPHANATE-METHYL	23564058	a
Nitrobenzene	98953	a	Polycyclic Organic Matter	N/A	a	THIOSEMICARBAZIDE	79196	a
NITROGEN DIOXIDE	10102440	a	Polycyclic Organic Matter as	N/A	a	THIOUREA	62566	a
NITROGLYCERIN	55630	a	15-PAH			THIRAM	137268	a
NITROUS OXIDE	10024972	a	Polycyclic Organic Matter as	N/A	a	Titanium Tetrachloride	7550450	a
N-METHYL-2-	872504	a	7-PAH			Toluene	108883	a
PYRROLIDONE			POTASSIUM BROMATE	7758012	a	TOLUENE	26471625	a
N-	924425	a	POTASSIUM	128030	a	DIISOCYANATE (MIXED		
METHYLOLACRYLAMIDE			DIMETHYLDITHIOCARB			ISOMERS)		
N-	55185	a	AMATE	137417	a	Toluene-2,4-Diamine	95807	a
NITROSODIETHYLAMIN			POTASSIUM N-			TOLUENE-2,4-	584849	a
E			METHYLDITHIOCARBAM			DIISOCYANATE		
N-Nitrosodimethylamine	62759	a	ATE			TOLUENE-2,6-	91087	a
N-NITROSODI-N-	924163	a	p-Phenylenediamine	106503	a	DIISOCYANATE		
BUTYLAMINE			PROFENOFOS	41198087	a	TOXAPHENE	8001352	a
N-NITROSODI-N-	621647	a	PROMETRYN	7287196	a	TRANS-1,3-	10061026	a
PROPYLAMINE			PRONAMIDE	23950585	a	DICHLOROPROPENE		
N-	86306	a	PROPACHLOR	1918167	a	TRANS-1,4-DICHLORO-2-	110576	a
NITROSODIPHENYLAMI			PROPANE SULTONE	1120714	a	BUTENE		
NE			PROPANIL	709988	a	TRIALATE	2303175	a
N-	4549400	a	PROPARGITE	2312358	a	TRIBENURON METHYL	101200480	a
NITROSOMETHYLVINYL			PROPARGYL ALCOHOL	107197	a	TRIBUTYLTIN	2155706	a
AMINE			PROPETAMPHOS	31218834	a	METHACRYLATE		
N-Nitrosomorpholine	59892	a	PROPICONAZOLE	60207901	a	TRICHLORFON	52686	a
N-NITROSO-N-	759739	a	Propionaldehyde	123386	a	TRICHLOROACETYL	76028	a
ETHYLUREA			PROPOXUR	H114261	a	CHLORIDE		
N-NITROSO-N-	684935	a	Propoxur (Baygon)	114261	a	Trichloroethylene	79016	a
METHYLUREA			PROPYLENE	115071	a	TRICHLOROFLUOROMET	75694	a
N-NITROSOPIPERIDINE	100754	a	Propylene Dichloride (1,2-	78875	a	HANE		
Non-Methane Volatile	NMVOC	a	Dichloropropene)			TRICLOPYR	57213691	a
Organic Compounds			Propylene Oxide	75569	a	TRIETHYLAMMONIUM		
(NMVOC)			PROPYLENEIMINE	75558	a	SALT		
NORFLURAZON	27314132	a	P-XYLENE	106423	a	Triethylamine	121448	a
o-Anisidine	90040	a	PYRIDINE	110861	a	Trifluralin	1582098	a
O-CRESOL	95487	a	Quinoline	91225	a	TRIPHENYLTIN	639587	a
O-DINITROBENZENE	528290	a	QUINONE	106514	a	CHLORIDE		
ORYZALIN	19044883	a	Quinone (p-Benzoquinone)	106514	a	TRIPHENYLTIN	76879	a
o-Toluidine	95534	a	QUINTOZENE	82688	a	HYDROXIDE		
O-TOLUIDINE	636215	a	Radionuclides (Including	N/A	a	TRIS(2,3-	126727	a
HYDROCHLORIDE			Radon)			DIBROMOPROPYL)		
OXYDIAZON	19666309	a	RESMETHRIN	10453868	a	PHOSPHATE		
OXYFLUORFEN	42874033	a	S,S,S-	78488	a	TRYPAN BLUE	72571	a
O-XYLENE	95476	a	TRIBUTYLTRITHIOPHOS			URETHANE	51796	a
OZONE	10028156	a	PHATE			VANADIUM (FUME OR	7440622	a
PARALDEHYDE	123637	a	SACCHARIN	81072	a	DUST)		
PARTICULATE MATTER	PM10	a	(MANUFACTURING, NO			Vinyl Acetate	108054	a
(PM10)			SUPPLIER			Vinyl Bromide	593602	a
PARTICULATE MATTER	PM2.5	a	NOTIFICATION)			Vinyl Chloride	75014	a
(PM2.5)			SAFROLE	94597	a	VINYLDIENE CHLORIDE	H75354	a
P-CHLOROANILINE	106478	a	SEC-BUTYL ALCOHOL	78922	a	Vinylidene Chloride (1,1-	75354	a
P-CRESIDINE	120718	a	SELENIUM	7782492	a	Dichloroethylene)		
P-CRESOL	106445	a	Selenium Compounds	N7782492	a	WARFARIN AND SALTS	N874	a
P-DINITROBENZENE	100254	a	SETHOXYDIM	74051802	a	XYLENE (MIXED	1330207	a
p-Dioxane	123911	a	SILVER	7440224	a	ISOMERS)		
PEBULATE	1114712	a	SILVER COMPOUNDS	N740	a	Xylenes (Mixed Isomers)	N108383	a
PENDIMETHALIN	40487421	a	SIMAZINE	122349	a	ZINC (FUME OR DUST)	7440666	a
PENTACHLOROETHANE	76017	a	SODIUM AZIDE	26628228	a	ZINC COMPOUNDS	N982	a
Pentachloronitrobenzene	10642	a	SODIUM DICAMBA	1982690	a	ZINEB	12122677	a
(Quintobenzene)			SODIUM	128041	a	1,3-D	N/A	as
Pentachlorophenol	87865	a	DIMETHYLDITHIOCARB			2,4-D	94757	as
PERACETIC ACID	79210	a	AMATE			2,4-DB	94826	as
PERCHLOROMETHYL	594423	a	SODIUM	62748	a	ABAMECTIN	71751412	as
MERCAPTAN								

ACEPHATE	30560191	as	FERBAM	14484641	as	PYRIDATE	55512339	as
ACETOCHLOR	34256821	as	FLUAZIFOP	69335917	as	PYRIPROXYFEN	95737681	as
ACIFLUORFEN	77207013	as	FLUMETRALIN	62924703	as	PYRITHIOBAC	123342938	as
ALACHLOR	15972608	as	FLUMETSULAM	98967409	as	QUINCLORAC	84087014	as
ALDICARB	116063	as	FLUMICLORAC	87546187	as	QUIZALOFOP	76578148	as
AMETRYN	834128	as	FLUOMETURON	2164172	as	RIMSULFURON	122931480	as
AMITRAZ	33089611	as	FLUTOLANIL	66332965	as	SETHOXYDIM	74051802	as
ASULAM	3337711	as	FOMESAFEN	72178020	as	SIMAZINE	122349	as
ATRAZINE	1912249	as	FONOFOS	944229	as	SODIUM CHLORATE	7775099	as
AZADIRACHTIN	11141176	as	FORMETANATE HCL	22259309	as	SPINOSAD	168316958	as
AZINPHOS-METHYL	86500	as	FOSETYL-AL	39148248	as	STREPTOMYCIN	57921	as
AZOXYSTROBIN	131860338	as	GIBBERELIC ACID	77065	as	SULFENTRAZONE	122836355	as
BENEFIN	1861401	as	GLYPHOSATE	1071836	as	SULFUR	7704349	as
BENOMYL	17804352	as	HALOSULFURON	135397307	as	SULFURIC ACID	7664939	as
BENSULFURON	1897456	as	HEXAZINONE	51235042	as	SULPROFOS	35400432	as
BENSULIDE	741582	as	HEXYTHIAZOX	78587050	as	TEBUCONAZOLE	107534963	as
BENTAZON	25057890	as	IMAZAMETHABENZ	100728845	as	TEBUFENOZIDE	112410238	as
BENZYLADENINE	1214397	as	IMAZAPIC	104098488	as	TEBUPIRIMPHOS	96182535	as
BIFENTHRIN	82657043	as	IMAZAQUIN	81335377	as	TEBUTHIURON	34014181	as
BROMACIL	314409	as	IMAZETHAPYR	81335775	as	TEFLUTHRIN	79538322	as
BROMOXNYL	1689845	as	IMIDACLOPRID	138261413	as	TERBACIL	5902512	as
BUPROFEZIN	69327760	as	IPRODIONE	36734197	as	TERBUFOS	13071799	as
BUTENOIC ACID	3724650	as	LACTOFEN	77501634	as	THIDIAZURON	51707552	as
BUTYLATE	2008415	as	LAMBDA-CYHALOTHRIN	91465086	as	THIFENSULFURON	79277671	as
CACODYLIC ACID	75605	as	LINDANE	58899	as	THIOBENCARB	28249776	as
CAPTAN	133062	as	LINURON	330552	as	THIODICARB	59669260	as
CARBARYL	63252	as	MALATHION	121755	as	THIOPHANATE METHYL	23564058	as
CARBOFURAN	1563662	as	MALEIC HYDRAZIDE	123331	as	THIRAM	137268	as
CHLORETHOXYFOS	54593838	as	MANCOZEB	8018017	as	TRALOMETHRIN	66841256	as
CHLORIMURON	90982324	as	MANEB	12427382	as	TRIADIMEFON	43121433	as
CHLOROPICRIN	76062	as	MCPA	94746	as	TRIALATE	2303175	as
CHLOROTHALONIL	1897456	as	MCPB	94815	as	TRIASULFURON	82097505	as
CHLORPYRIFOS	2921882	as	MCPP	93652	as	TRIBENURON	106040486	as
CHLORSULFURON	64902723	as	MEFENOXAM	70630170	as	TRIBUFOS	78488	as
CLETHODIM	99129212	as	MEPIQUAT CHLORIDE	15302917	as	TRICLOPYR	55335063	as
CLOFENTEZINE	74115245	as	METALAXYL	57837191	as	TRIFLUMIZOLE	99387890	as
CLOMAZONE	81777891	as	METALDEHYDE	108623	as	TRIFLURALIN	1582098	as
CLOPYRALID	1702176	as	METAM SODIUM	137428	as	TRIFLUSULFURON	135990293	as
COPPER	7440508	as	METHAMIDOPHOS	10265926	as	TRIFORINE	26644462	as
CRYOLITE	15096523	as	METHIDATHION	950378	as	TRIPHENYLTIN HYD	76879	as
CYANAZINE	21725462	as	METHOMYL	16752775	as	VERNOLATE	1929777	as
CYCLANILIDE	113136779	as	METHOXYCHLOR	72435	as	VINCLOZOLIN	50471448	as
CYCLOATE	1134232	as	METHYL BROMIDE	74839	as	ZIRAM	137304	as
CYFLUTHRIN	68359375	as	METHYL PARATHION	298000	as			
CYMOXANIL	57966957	as	METIRAM	9006422	as			
CYPERMETHRIN	52315078	as	METOLACHLOR	51218452	as			
CYROMAZINE	66215278	as	METRIBUZIN	21087649	as			
CYTOKININS	308064235	as	METSULFURON	74223646	as			
DCNA	99309	as	MOLINATE	2212671	as			
DCA	1861321	as	MSMA	2163806	as			
DELTAMETHRIN	52918635	as	MYCLOBUTANIL	88671890	as			
DESMEDIPHAM	13684565	as	NAA	86873	as			
DIAZINON	333415	as	NAD	86862	as			
DICAMBA	1918009	as	NALED	300765	as			
DICHLOBENIL	1194656	as	NAPROPAMIDE	15299997	as			
DICLOFOP	40843252	as	NAPTALAM	132661	as			
DICOFOL	115322	as	NICOSULFURON	111991094	as			
DICROTOPHOS	141662	as	NORFLURAZON	27314132	as			
DIFENZOQUAT	43222486	as	OIL	N/A	as			
DIFLUBENZURON	35367385	as	ORYZALIN	19044883	as			
DIMETHENAMID	87674688	as	OXAMYL	23135220	as			
DIMETHIPIIN	55290647	as	OXYDEMETON-METHYL	301122	as			
DIMETHOATE	60515	as	OXYFLUORFEN	42874033	as			
DIMETHOMORPH	110488705	as	OXYTETRACYCLINE	79572	as			
DIQUAT	85007	as	OXYTHIOQUINOX	2439012	as			
DISULFOTON	298044	as	PARAQUAT	1910425	as			
DIURON	330541	as	PCNB	82688	as			
DODINE	2439103	as	PEBULATE	1114712	as			
DSMA	144218	as	PENDIMETHALIN	40487421	as			
ENDOSULFAN	115297	as	PERMETHRIN	52645531	as			
ENDOTHALL	145733	as	PHENMEDIPHAM	13684634	as			
EPTC	759944	as	PHORATE	29802	as			
ESFENVALERATE	66230044	as	PHOSMET	732116	as			
ETHALFLURALIN	55283686	as	PICLORAM	1918021	as			
ETHEPHON	16672870	as	PRIMISULFURON	113036876	as			
ETHION	563122	as	PROFENOFOS	41198087	as			
ETHOFUMESATE	26225796	as	PROMETRYN	7287196	as			
ETHOPROP	13194484	as	PRONAMIDE	23950585	as			
ETHYL PARATHION	56382	as	PROPACHLOR	1918167	as			
ETRIDIAZOLE	2593159	as	PROPAMOCARB	25606411	as			
FENAMIPHOS	22224926	as	PROPANIL	709988	as			
FENARIMOL	60168889	as	PROPARGITE	2312358	as			
FENBUCONAZOLE	114369436	as	PROPICONAZOLE	60207901	as			
FENBUTATIN OXIDE	13356086	as	PROSULFURON	94125345	as			
FENOXAPROP	73519558	as	PYRAZON	1702176	as			
FENPROPATHRIN	39515418	as	PYRIDABEN	96489713	as			

- cas no. = Chemical Abstract Service number,  
 - init. emisn. = initial emission,  
 - r = resources,  
 - l = land use,  
 - is = industrial soil,  
 - fw = freshwater,  
 - a = air,  
 - as = agricultural soil.



# Appendix C

## List of characterization methods in characterization factor database module

Approach	Impact category	Reference	Units
Problem oriented approach (CML)	Abiotic depletion	ADP (Guinee et al. 2001)	kg antimony eq.
	Land use (increased land competition)	LUC (Guinee et al. 2001)	m <sup>2</sup> *yr
	Global warming	GWP100 (Houghton et al., 2001)	kg CO2 eq.
	Global warming	net GWP100 min(Houghton et al., 2001)	kg CO2 eq.
	Global warming	net GWP100 max(Houghton et al., 2001)	kg CO2 eq.
	Global warming	GWP20 (Houghton et al., 2001)	kg CO2 eq.
	Global warming	GWP500 (Houghton et al., 2001)	kg CO2 eq.
	Ozone layer depletion	ODP steady state (WMO, 1992 & 1995 & 1999)	kg CFC-11 eq.
	Ozone layer depletion	ODP5 (Solomon & Albritton, 1992))	kg CFC-11 eq.
	Ozone layer depletion	ODP10 (Solomon & Albritton, 1992))	kg CFC-11 eq.
	Ozone layer depletion	ODP15 (Solomon & Albritton, 1992))	kg CFC-11 eq.
	Ozone layer depletion	ODP20 (Solomon & Albritton, 1992))	kg CFC-11 eq.
	Ozone layer depletion	ODP25 (Solomon & Albritton, 1992))	kg CFC-11 eq.
	Ozone layer depletion	ODP30 (Solomon & Albritton, 1992))	kg CFC-11 eq.
	Ozone layer depletion	ODP40 (Solomon & Albritton, 1992))	kg CFC-11 eq.
	Human toxicity	HTP inf. (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Freshwater aquatic ecotoxicity	FAETP inf. (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Marine aquatic ecotoxicity	MAETP inf. (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Freshwater sedimental ecotoxicity	FSETP inf. (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Marine sedimental ecotoxicity	MSETP inf. (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Terrestrial ecotoxicity	TETP inf.(Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Human toxicity	HTP 20 (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Freshwater aquatic ecotoxicity	FAETP 20 (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Marine aquatic ecotoxicity	MAETP 20 (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Freshwater sedimental ecotoxicity	FSETP 20 (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Marine sedimental ecotoxicity	MSETP 20 (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Terrestrial ecotoxicity	TETP 20 (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Human toxicity	HTP 100 (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Freshwater aquatic ecotoxicity	FAETP 100 (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Marine aquatic ecotoxicity	MAETP 100 (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Freshwater sedimental ecotoxicity	FSETP 100 (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Marine sedimental ecotoxicity	MSETP 100 (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Terrestrial ecotoxicity	TETP 100 (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Human toxicity	HTP 500 (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Freshwater aquatic ecotoxicity	FAETP 500 (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Marine aquatic ecotoxicity	MAETP 500 (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Freshwater sedimental ecotoxicity	FSETP 500 (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Marine sedimental ecotoxicity	MSETP 500 (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Terrestrial ecotoxicity	TETP 500 (Huijbregts, 1999 & 2000)	kg 1,4-dichlorobenzene eq.
	Photochemical oxidation	POCP (Jenkin & Hayman, 1999; Derwent et al. 1998; high NOx)	kg ethylene eq.
	Photochemical oxidation	POCP (Andersson-Skold et al. 1992; low NOx)	kg ethylene eq.
	Photochemical oxidation	MIR 1997; very high NOx (Carter, 1994, 1997, 1998;Carter, Pierce, Luo & Malkina, 1995 )	kg formed ozone
	Photochemical oxidation	MOIR; high NOx (Carter, 1994, 1997, 1998;Carter, Pierce, Luo & Malkina, 1995 )	kg formed ozone
	Photochemical oxidation	EBIR; low NOx (Carter, 1994, 1997, 1998;Carter, Pierce, Luo & Malkina, 1995 )	kg formed ozone
	Acidification	AP ( Huijbregts, 1999; average Europe total, A&B)	kg SO2 eq.
	Acidification	AP (Hauschild & Wenzel (1998).	kg SO2 eq.
	Eutrophication	EP (Heijungs et al. 1992))	kg PO4--- eq.
Eutrophication	EP ( Huijbregts, 1999; average Europe total, A&B)	kg NOx eq.	
Radiation	(Frischknecht et al., 1999)	DALYs (Egalitarian, Hierarchist)	
	Odor	1/OTV	m3
Damage Approach	EPS (Steen, 1999))	EPS (Steen, 1999))	elu
ECOINDICATOR 99	Carcinogenic effects on humans (H.A)	Carcinogenic effects on humans (H.A)	DALY
	Respiratory effects on humans caused by organic substances (H.A)	Respiratory effects on humans caused by organic substances (H.A)	DALY
	Respiratory effects on humans caused by inorganic substances (H.A)	Respiratory effects on humans caused by inorganic substances (H.A)	DALY
	Damages to human health caused by climate change (H.A)	Damages to human health caused by climate change (H.A)	DALY
	Human health effects caused by ionizing radiation (H.A)	Human health effects caused by ionizing radiation (H.A)	DALY

Human health effects caused by ozone layer depletion (H.A)	Human health effects caused by ozone layer depletion (H.A)	DALY
Damage to Ecosystem Quality caused by ecotoxic emissions (H.A)	Damage to Ecosystem Quality caused by ecotoxic emissions (H.A)	PDF*m2*yr
Damage to Ecosystem Quality caused by the combined effect of acidification and eutrophication (H.A)	Damage to Ecosystem Quality caused by the combined effect of acidification and eutrophication (H.A)	PDF*m2*yr
Damage to Ecosystem Quality caused by land occupation (H.A)	Damage to Ecosystem Quality caused by land occupation (H.A)	PDF*m2*yr
Damage to Ecosystem Quality caused by land conversion (H.A)	Damage to Ecosystem Quality caused by land conversion (H.A)	PDF*m2
Damage to Resources caused by extraction of minerals (H.A)	Damage to Resources caused by extraction of minerals (H.A)	MJ surplus energy
Damage to Resources caused by extraction of fossil fuels (H.A)	Damage to Resources caused by extraction of fossil fuels (H.A)	MJ surplus energy
Carcinogenic effects on humans (E.E)	Carcinogenic effects on humans (E.E)	DALY
Respiratory effects on humans caused by organic substances (E.E)	Respiratory effects on humans caused by organic substances (E.E)	DALY
Respiratory effects on humans caused by inorganic substances (E.E)	Respiratory effects on humans caused by inorganic substances (E.E)	DALY
Damages to human health caused by climate change (E.E)	Damages to human health caused by climate change (E.E)	DALY
Human health effects caused by ionizing radiation (E.E)	Human health effects caused by ionizing radiation (E.E)	DALY
Human health effects caused by ozone layer depletion (E.E)	Human health effects caused by ozone layer depletion (E.E)	DALY
Damage to Ecosystem Quality caused by ecotoxic emissions (E.E)	Damage to Ecosystem Quality caused by ecotoxic emissions (E.E)	PDF*m2*yr
Damage to Ecosystem Quality caused by the combined effect of acidification and eutrophication (E.E)	Damage to Ecosystem Quality caused by the combined effect of acidification and eutrophication (E.E)	PDF*m2*yr
Damage to Ecosystem Quality caused by land occupation (E.E)	Damage to Ecosystem Quality caused by land occupation (E.E)	PDF*m2*yr
Damage to Ecosystem Quality caused by land conversion (E.E)	Damage to Ecosystem Quality caused by land conversion (E.E)	PDF*m2
Damage to Resources caused by extraction of minerals (E.E)	Damage to Resources caused by extraction of minerals (E.E)	MJ surplus energy
Damage to Resources caused by extraction of fossil fuels (E.E)	Damage to Resources caused by extraction of fossil fuels (E.E)	MJ surplus energy
Carcinogenic effects on humans (I.I)	Carcinogenic effects on humans (I.I)	DALY
Respiratory effects on humans caused by organic substances (I.I)	Respiratory effects on humans caused by organic substances (I.I)	DALY
Respiratory effects on humans caused by inorganic substances (I.I)	Respiratory effects on humans caused by inorganic substances (I.I)	DALY
Damages to human health caused by climate change (I.I)	Damages to human health caused by climate change (I.I)	DALY
Human health effects caused by ionizing radiation (I.I)	Human health effects caused by ionizing radiation (I.I)	DALY
Human health effects caused by ozone layer depletion (I.I)	Human health effects caused by ozone layer depletion (I.I)	DALY
Damage to Ecosystem Quality caused by ecotoxic emissions (I.I)	Damage to Ecosystem Quality caused by ecotoxic emissions (I.I)	PDF*m2*yr
Damage to Ecosystem Quality caused by the combined effect of acidification and eutrophication (I.I)	Damage to Ecosystem Quality caused by the combined effect of acidification and eutrophication (I.I)	PDF*m2*yr
Damage to Ecosystem Quality caused by land occupation (I.I)	Damage to Ecosystem Quality caused by land occupation (I.I)	PDF*m2*yr
Damage to Ecosystem Quality caused by land conversion (I.I)	Damage to Ecosystem Quality caused by land conversion (I.I)	PDF*m2
Damage to Resources caused by extraction of minerals (I.I)	Damage to Resources caused by extraction of minerals (I.I)	MJ surplus energy