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Identification of significant environmental aspects and their indicators

Bengt Steen, CPM, Centre of Environmental Assessment of Products and Material Systems, and Dept. of Environmental Systems Analysis, Chalmers University of Technology, Gothenburg, Sweden

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CHALMERS TEKNISKA HÖGSKOLA
SE- 412 96 Göteborg

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Content

Summary

An assessment of environmental impacts and selection of performance indicators includes many elements. Knowledge on emissions and resource flows of the technical system studied as well as of environmental mechanisms and cause-effect chains is needed. One of the basic questions that must be answered before any impact assessment can be made is “how do we define the environment and how do we see if it improves or degrades?”

Our conceptual understanding of ‘the environment’ and its values can be described through answering three questions:

1. What is included in our care for the environment? Which safeguard subjects, in which areas and for how long?
2. How do we make trade-off between different impacts?
3. How do we handle uncertainty?

Different individuals include different things in their conceptual understanding of the ‘environment’. From a historic perspective, mans concern has expanded from his or

hers immediate survival to concern for family, tribe, community, society and various parts of the environment. Depending on which environmental concept that is anticipated, different indicators and technical solutions may be found optimal.

On a company level, environmental goal and scope must therefore be made clear at an early stage. It is not necessary that goal and scope be the same for all company activities. It may be that separate indicators are needed for short time survival with respect to critics from environmentalists and for a long-term for brand image building. Indicators may serve different purposes for a market in the Nordic countries than for one in Southeast Asia.

The requirement of a clear idea of which environment our efforts are aiming for is only one of ten requirements that were formulated by an international group of measurement practitioners and scientists at Hardy and Zdan (1997). They are formulated as follows:

1. Guiding visions and Goals
2. Holistic perspective
3. Essential elements
4. Adequate scope
5. Practical focus
6. Openness
7. Effective communication
8. Broad participation
9. Ongoing assessment
10. Institutional capacity

Given the conceptual definition of the environment through its state indicators any impact on their values from a company's activities can be derived from knowledge of prevalent environmental mechanisms expressed in the form of quantitative models. This may be done using LCA methodology.

1. Introduction

The NORDEPE report by Thoreson et.al (2001) describes a framework and management procedures to find various types of EPIs. This report is more similar to a cookbook and presents ways of identifying significant environmental aspects in the process of selecting various indicators.

As in the case of cooking, there are needs for different dishes to meet different needs and wants. A Company's environmental policy may identify different types of needs. To some extent there may be need for a defence against criticism. To some extent there may be a need to avoid cost increases from environmental issues. There may also be a need for brand image building. Different needs may also exist for different markets.

From an environmental ethics aspect, these different needs may be structured as being more or less comprehensive. In a defensive situation, only such environmental aspects being regulated by law or authorities may be of interest for consideration by EPIs. In a cost-avoiding situation, typically a five-year perspective including company plans and

claims from authorities is a base for reasonable choices of EPIs. For brand image building, there is a need to show excellency with regard to environmental issues. It can of course be discussed what excellency means, but normally this means that long-term global issues are included in the environmental concern. Some of these issues are not subject to laws and regulations yet, but may be addressed in the scientific literature and environmental debate.

Having identified the needs or goals, various optional methods to describe significant aspects may be considered and selected for use. This process involves the following steps

1. Goal and scope formulation
2. Inventory of environmental interventions from the product or process system
3. Evaluation of the environmental significance of various interventions
4. Selection of a set of indicators for these interventions
5. Checking the performance of these indicators and eventually modify the selection

This process is very similar to the standardised LCA procedure (ISO 14040). LCA is therefore chosen as a tool for identifying significant aspects. The selection and checking of indicators may be made according to criteria put forward by the Bellagio conference 1996. (Hardy and Zdan 1997)

2. Goal formulation

Three ethical aspects need to be considered when formulating an environmental goal:

1. What should be included in the company's environmental concern?
2. How shall trade-off be handled?
3. How shall uncertainty be handled?

2.1 What should be included

When discussing environmental concerns the terms 'safe guard subject' or 'areas of protection' are often used. They represent the things we want to safeguard or protect from being degraded by environmental impact. ISO 14040 mention Human Health, Ecosystem Health and Natural Resources as a bottom line. Other safeguard subjects suggested are Man Made Resources, Welfare and Environmental Equity.

Human health in itself is a broad concept. In the definition given by WHO, Human Health is not only the absence of disease and disability it is also a state of physical and psychological wellbeing. If we know how all impacts on the environment would affect human health, most people would think that we would not need any more safeguard subjects. Health could then be used as an ultimate goal for the environment. But our knowledge on how different changes in the environment affect human health is limited and we need to have several "defence lines" or safeguard subjects.

One way of looking at the "system borders" for environmental concern is by following its historical development. In prehistoric times, the struggle for survival limited human concern for environment to the resources which in short terms was important for the individual and closest family. Later it was extended, first to the tribe and yearly cycles and then to the village and country. The biblical story of seven fat and seven poor years is evidence of an extended planning horizon. In modern time,

globalisation and increased knowledge on environmental issues has further extended the system borders and introduced the sustainability term. Although unclear in it's definition the sustainability concept shows a clear ambition of very long term planning.

Today all these views exist on the same time in different cultures and individuals, the very narrow perspective and the very extended one including animal and even plant welfare. Furthermore, the perspectives are not static in an individual; it varies in different situations.

When looking at different impact assessments methods at use today, it is sometimes unclear, what the safe guard subjects are. Some methods define their indicators at an early stage in the cause-effect chain (table 1) and do not explicitly say which safe guard subjects they include. In a way one could say that the indicator level is what is safeguarded. If so, the temporal and spatial system borders are narrow. Following ISO 14042 however, the environmental mechanisms and endpoints for any indicator has to be identified and reported.

There are 4 "dimensions" that may be used to characterise items included in the concern for environment:

1) The qualitative dimension, which defines what is included.
2) The position in the cause-effect chain
3) The spatial dimension
4) The temporal dimension

In table 1, existing impact assessment methods are characterised in these dimensions.

2.2. Handling trade-offs

Immediately when determining what to include in the environmental concern, there has to be an idea of what is important or not. A kind of intuitive trade-off is made between alternative issues. If this trade-off is made in a conscious way, the transparency increases and it will be easier to make individual methods consistent with respect to general environmental goals.

Trade-off issues are common in society and not only an environmental problem. Two extremes may be identified in the way of making trade-offs. One is the utilitarian. In that, every part is judged with respect to its contribution to a total value. The other is a kind of justice approach. In that each part is judged separately in relation to some acceptable state.

When looking at existing life cycle impact assessment methods, that use a systematic weighting of all its indicators, you find that the Ecoindicator 99 and the EPS 2000 method are utilitarian in character and the Ecoscarcity and Environmental Themes are "justice approaches" (table 2).

Method name	What is included	Position in cause-effect chain	Spatial extension	Temporal extension
Ecoindicator 99 (Goedkoop and Spriensmaa, 1999)	1. Human health defined as lack of illness (i.e. disability adjusted life years) 2. Ecosystem health, defined as Potentially Affected Fraction of species 3. Resources defined as induced impacts on Human and Ecosystem health.	Endpoint	Europe	About 200 years
Ecoscarcity (BUWAL, 1998)	Emissions contributing to an exceeding of national targets	Early	National, e.g Switzerland	Infinite
EDIP (Hauschild, M. & Wenzel, H. , 1998)	Relative contribution to environmental threats (relative to per capita contribution) for radiative forcing, ozone depletion potential, acidification potential, eutrofication potential, toxicity and land use.(?)	Midpoint	National (Denmark) and global	1 year
Environmental Themes- Short (Lindfors et.al 1995)	Relative contribution to environmental threats (relative to national emission goals) for radiative forcing, ozone depletion potential, acidification potential, eutrofication potential and toxicity	Midpoint	National	infinite
Environmental Themes- Long (Lindfors et.al 1995)	Relative contribution to environmental threats (relative to national critical loads) for radiative forcing, ozone depletion potential, acidification potential, eutrofication potential and toxicity	Midpoint	National	infinite
EPS v 2000 (Steen 1999a, and 1999b)	1. Human health, defined in a broad sense, as by WHO, 2. Ecosystem production capacity, including agricultural ecosystems and forestry 3. Biodiversity 4. Abiotic resources 5. Recreational values	Endpoint	Global	Infinite
Tellus (Lindfors et.al 1995)	Regulated emissions	Early	USA	Based on history

Table 1 Characteristics of some impact assessment methods

Method name	Weighting method	Trade-off principle
Ecoindicator 99	Panel rating	utilitarian
Ecoscarcity	Distance to target	justice approaches
Environmental Themes- Short	Distance to target	justice approaches
Environmental Themes- Long	Distance to target	justice approaches
EPS v 2000	WTP (Willingness To Pay) for environmental effects	utilitarian
Tellus	WTP for emission reduction	utilitarian

Table 2 Principle approach of various impact assessment methods

2.3. Handling uncertainty

In most environmental work, the precautionary principle is used. It is common in the setting of standards, and it was included in the Rio agreement 1992. It works well together with the justice approach on trade-offs, but when using the utilitarian approach there may be problems. Too large a marginal on one impact category may increase the impact on another and result in an overall increasing impact value.

The same reasoning as for the trade-off aspect may be used for handling of uncertainty:
Immediately when determining what to include in the environmental concern, there has to be an idea of how certain you want to be about an impact issue. A kind of intuitive trade-off is made between alternative issues. If this trade-off with respect to uncertainty is made in a conscious way, the transparency increases and it will be easier to make individual methods consistent with respect to general environmental goals.
Besides being an important aspect when selecting system borders, methods and data, uncertainty may be included in the analysis in different ways. A general classifying of data uncertainty may be made, as in the ExternE project. (ExternE, 1995) or a quantitative estimation of uncertainties and use of statistical methods may be made as in the EPS 2000 method. Although a standard requirement in the ISO 14040 series on LCA, few methods and studies have yet have a transparent methodological handling of uncertainty.

3. Inventory

ISO standard 14041 describes how life cycle inventories are made. The aim of the inventory is to find which emission, and resource flows there are. For the sake of selecting EPIs it is more of value to find all interventions, their relative size and the precision by which they can be measured than their exact quantitative value. Interventions like land use and noise may be forgotten if only material flows are considered.

4. Impact assessment

The life cycle impact assessment procedure is described in the ISO standard 14042. In order to facilitate this step, ready made weighting indices for some LCIA methods are compiled in appendix A. The significance of the inventory results may then be found

directly through multiplication with these indices. An aggregation of weighted impacts may be done on any activity in the company, where emissions and resource flows are known, finding out how much this activity contributes to the total.

Three weighting methods are chosen in appendix A, although there are a number of others presented. Lindeier (1996). The reason for choosing these three is that they are being maintained and updated, that they represent different environmental goals and that they include a relative large amount of different emissions and resources.

5. Holistic perspective

What is holistic for a company? On a societal level, companies are exchangeable but on a company level not. The survival of the company must be possible to include in a holistic company perspective.
For companies survival the basic business idea is essential. The rational for the existence of a company is that it contributes with some added value and gets paid by those who receive the added value. Environmental issues arise, when there is a third party not receiving the added value, but still have to pay with some of his or her assets. In early industrial history there was no way of considering the interest of third parties, but today various ways have been explored. The polluter pays principle is generally accepted. This means that values of environmental impacts should be considered when determining the added value of by company's activities.

A good starting point for a company is to include those areas of protection mentioned by the ISO 14040 standard, i.e. human health, ecosystem health and resources. Another base for establishing a holistic approach is the protocol from the Earth Summit conference at Rio 1992, which also specified the issue of biodiversity and indicated an anthropocentric approach to evaluation of impacts. The Rio conference also agreed about future generations equal rights to a good environment. This means a long-term thinking.

The requirement for a holistic perspective means that the indicators cover all aspects. It also could mean that they are able to compare to the whole, i.e. that their relative weight may be estimated compared to others. A monetary measure of the impact would fulfil this requirement for many companies as it allows comparison with the utility of the companies economic activities, i.e the environmental damage cost may be compared to the added value from the company's normal activity.

6. Essential elements

This issue can also be discussed on different levels. On a society level, the essential elements may be found in the environmental literature, for instance UNEP's yearly review of the global environment (WRI 2000) or policy declarations like Swedish Department of Environment "Framtidens miljö" (SoU 2000:52).

On a company level the contribution to the impact recognised by UNEP etc. may be regarded as essential elements, but local specific elements may also be of interest.

The different LCA weighting methods (table 2) can be used to select "essential elements" in a structured way.

Emissions and resources included in three impact assessment methods and their weighting factors are shown in appendix A. These impact assessment methods have been chosen because they are well documented and maintained by research groups.

7. Adequate scope

An EPI can include more or less of activities in a technical system or more or less interventions in the environment. Depending on whether the EPI is going to be used by financial analysts or in plant operation, the aspects covered by the EPI may vary from many to few.

In system analysis, the terms 'background system' and 'foreground system' are used to denote the system that is more or less given and the system one can influence. Weighting of impacts may help to make a balanced choice of indicators from the foreground system versus the background system and to draw system boundaries in general. If this weighting is made in a transparent way as prescribed by ISO 14042 for an LCA, the scope formulation may be discussed in a group in a structured way and agreed upon.

An optimal EPI is an entity that is as independent as possible from others and may explain as much as possible of the variance in the impact value caused by activities in the foreground system analysed.

8. Practical focus

To some extent the requirement of practical focus and adequate scope overlap. But besides delivering useful information, the extra efforts necessary for determining the indicators need to be minimised. Otherwise an EPI will be unpractical to work with. Therefore, as a first option, EPIs should be based on data, which are already monitored or may be monitored at a low extra cost.

9. Openness

As environmental issues are 3rd party issues, an indicator that can be published is to prefer. EPIs that may reveal secret or confidential information from the company should be avoided.

10. Effective communication

Indicators that can be understood by the stakeholders are to prefer. Investigations show (Fallenius et al., 1997) that ordinary consumers have a very limited ability of understanding complex environmental information.

In ISO 14042 there is a requirement that an impact category indicator shall have a descriptive name. Indicators are often reported in columns of tables and shortly referred to in texts. It is therefore somewhat of a challenge to find good names for the indicators. The value of finding indicators with good names should not be underestimated.

11. Broad participation

It is important to assure that all stakeholders accept the EPIs, which are chosen. The procedure for this is discussed in Thoresen et al. (2001).

12. Ongoing assessment

This point overlap the requirement of *a practical focus*, where it was recommended that EPIs should be based on data, which are already monitored or may be monitored at a low extra cost.

13. Institutional capacity

This requirement is mainly relevant for environmental state indicators, but may also be checked for companies with respect to the nearest future. Is there backup competence to take over if the present experts leave for other tasks?

14. Discussion

Some of the models, which are used to determine the relative weight of various alternative EPIs, are often questioned from a traditional scientific point of view. The models as such are not rigid enough to withstand a critical evaluation in the scientific society. However, one has to bear in mind that when used for management purposes, the purpose of including the models is primarily to improve the quality of a decision and not to test the model per se. This means that we are more interested of the model being useful than being true. Mostly the usefulness increases if the models become more accurate, but there are situations when there is a conflict, such as when the model requires too much input data to be practical and when the knowledge is not good enough to create a scientific consensus. In the approaches described in this report, the goal is more to find out what the present knowledge tells us or indicate than to make an exact forecast.

15. Tables of combined characterisation and weighting factors for emissions and resource depletion (weighting indices)

Below, combined characterisation and weighting factors are summarised for 3 different impact assessment methods, Ecoindicator 99 (Goedkoop & Spriensmaa, 1999), Ecoscarcity 97 (BUWAL, 1998) and EPS 2000 (Steen 1999a and b). The combined characterisation and weighting factors are here called weighting indices. The weighting indices shown in the tables below may be used for ranking of environmental impacts from emissions and use of natural resources. Results from inventories (elementary flows) may simply be multiplied with the indices given. If a certain elementary flow, e.g. an emission of SO_2 is 4.5 kg, then its weight using the EPS2000 method is 3.27(ELU/kg)*4.5(kg) = 14.7 ELU.

In the tables all weighting indices are expressed per kg of an emission or resource, but when calculating the relative significance of an elementary flow, this unit or the unit of the index is of no importance as far as they are used consistently. The relative significance (S) is found from the expression

$$S = I_j * F_j / \Sigma I_j * F_j, \text{ where}$$

I_j = the inventory result, i.e. the elementary flow of type j
F_j = the weighting index for the elementary flow type j

It must be remembered that there are large uncertainties involved in determining weighting indices. As a rule of thumb, difference in magnitudes rather than decimals is needed for a safe ranking.

When an index is missing in one of the methods, it sometimes means that the index is zero and sometimes that is not considered. When an index is missing it is recommended that as a first alternative, a group index is used, like NMVOC for a specific hydrocarbon which is emitted to air. As a second alternative is to try to find a similar substance. If it turns out to be significant contribution to the overall impact, it is recommended to consult the basic method descriptions and documentation.

The Ecoindicator 99 method has several different weighting indices, reflecting different cultural groups. Here, the default index is shown.

The Ecoscarcity 97 method is a distance to target method and reflects conformity with emission reduction goals.

The EPS method reflects the ‘willingness to pay’ to restore the changes in the environment caused by an emission or resource flow, by those who are affected by the changes.

Table 3 Emission of organic substances to air (For Ecoscarcity 99 use the value for NMVOC in table 7)

Substance	EI99(H,A)	EPS2000
1,1,1,2-tetrachlorethane	0.00E+00	
1,1,1-trichloroethane	2.08E-04	
1,1,2,2-tetrachlorethane	0.00E+00	
1,1,2-trichlorethane	0.00E+00	
1,1-dichloroethene	0.00E+00	
1,2,3-trichlorobenzene	2.74E-03	
1,2,3-trimethyl benzene	2.89E-02	2.41E+00
1,2,4-trichlorobenzene	1.98E-03	
1,2,4-trimethyl benzene	2.89E-02	2.38E+00
1,2-dibromoethane	2.76E+00	
1,2-dichloroethane	3.16E-01	
1,3,5-trichlorobenzene	1.01E-02	
1,3,5-trimethyl benzene	3.16E-02	2.40E+00
1,3-butadiene	1.88E-01	1.07E+01
1,4-dioxane	1.47E-03	
1-butene	2.44E-02	2.59E+00
1-butoxy propanol	9.93E-03	
1-hexene	1.98E-02	
1-methoxy 2-propanol	8.39E-03	
1-pentene	2.26E-02	2.46E+00
2,2-dimethyl butane	5.51E-03	
2,3,7,8-TCDD Dioxin	1.91E+06	
2,3-dimethyl butane	1.26E-02	
2,4,6-trichlorophenol	2.18E-02	
2,4-Dichlorophenoxyacetic acid (2,4-D)	1.14E-01	
2-butene		2.57E+00
2-butoxy ethanol	9.93E-03	
2-ethoxy ethanol	8.85E-03	
2-hexanone	1.26E-02	
2-methoxy ethanol	6.86E-03	
2-methyl 1-butanol	9.03E-03	
2-methyl 1-butene	1.80E-02	2.40E+00
2-methyl 2-butanol	3.25E-03	
2-methyl 2-butene	1.90E-02	2.84E+00
2-methyl hexane	9.03E-03	
2-methyl pentane	9.93E-03	2.43E+00
2-metylheptane		2.40E+00
2-metyloktane		2.36E+00
2-methylnonane		2.45E+00
2-pentanone	1.26E-02	
2-pentene		2.54E+00
3,5-diethyl toluene	2.98E-02	
3,5-dimethyl ethyl benzene	2.98E-02	
3-hexanone	1.36E-02	
3-methyl 1-butanol	9.03E-03	
3-methyl 1-butene	1.54E-02	
3-methyl 2-butanol	8.39E-03	
3-methyl hexane	8.31E-03	
3-methyl pentane	1.08E-02	2.32E+00
3-methylcholanthrene	0.00E+00	
3-pentanol	9.93E-03	

Table 3 Emission of organic substances to air (continued)

3-pentanone	9.03E-03	
acetaldehyde	1.67E-02	2.11E+00
acetic acid	2.26E-03	
acetone	2.16E-03	1.46E+00
acetylene	1.98E-03	1.64E+00
acrolein		3.32E+00
acrylonitrile	1.79E-01	
alcohols	8.06E-03	
aldehydes	1.49E-02	
Aldrin	0.00E+00	
alkanes	7.96E-03	
alkenes	2.23E-02	
allyl chloride		2.16E+00
alpha-hexachlorocyclohexan	3.18E+00	
Atrazine	1.63E+01	
Azinphos-methyl	8.58E+02	
Bentazon	5.72E-01	
benzene	3.17E-02	3.65E+00
benzo(a)anthracene	6.22E+02	
benzo(a)pyrene	5.33E+01	
benzotrichloride	7.00E+01	
benzylchloride	1.10E-01	
beta-chlorocyclohexan	1.06E+00	
bis(2-chlorethyl)ether	0.00E+00	
bis(chloromethyl)ether	7.94E+01	
bromodichloromethane	9.29E-02	
butane	8.03E-03	2.15E+00
butanol	1.44E-02	2.33E+00
butene	2.62E-02	2.58E+00
butyraldehyde		2.30E+00
Carbendazim	1.87E+02	
carbontetrachloride	8.89E+00	
chloroform	2.80E-01	
cis 1,2-dichloroethene	9.93E-03	
cis 2-butene	2.62E-02	
cis 2-hexene	2.44E-02	
cis 2-pentene	2.53E-02	
cyclohexane	6.59E-03	
cyclohexanol	9.93E-03	
cyclohexanone	6.86E-03	
decane	8.76E-03	2.45E+00
di(2-ethylhexyl)phthalate	3.59E-01	
diacetone alcohol	5.96E-03	
dibenz(a)anthracene	3.29E+05	
dibutylphthalate	8.81E-03	
dichloromethane	6.17E-03	
Dichlorvos (DDVP)	4.60E-01	7.13E+00
Dieldrin	0.00E+00	7.13E+01
diethyl ether	1.08E-02	
di-i-propyl ether	1.08E-02	
dimethyl ether	3.97E-03	1.66E+00
Diquat-dibromide	1.86E+02	
Diuron	3.45E+02	
DNOC	6.39E-01	
dodecane	8.13E-03	2.19E+00

Table 3 Emission of organic substances to air (continued)

epichlorohydrin	3.20E-03	
ethane	2.80E-03	1.46E+00
ethane diol	8.76E-03	
ethanol	8.85E-03	1.95E+00
ethene	2.26E-02	3.45E+00
ethyl t-butyl ether	4.88E-03	
ethylacetate	4.88E-03	1.68E+00
ethylbenzene	1.62E-02	2.11E+00
ethylene oxide	1.94E+00	
fentin acetate	5.28E+01	
fluoranthene	3.41E-03	
formaldehyde	2.23E-02	
formic acid	7.31E-04	
gamma-HCH(Lindane)	3.87E+00	
heptane	1.18E-02	2.58E+00
Hexachlorobenzene	8.78E+02	4.46E+00
hexachlorobutadiene	0.00E+00	
hexachloroethane	0.00E+00	
hexane	1.08E-02	2.57E+00
i-butane	7.05E-03	1.74E+00
i-butanol	8.58E-03	1.85E+00
i-butylacetate		1.66E+00
i-butyraldehyde	1.18E-02	2.20E+00
i-pentane	9.03E-03	1.80E+00
i-propanol	3.16E-03	1.46E+00
i-propyl acetate	4.88E-03	
i-propyl benzene	1.18E-02	2.07E+00
isoprene	2.53E-02	2.11E+00
ketones	9.23E-03	
Malathion	9.12E+00	
Maneb	2.99E+00	
Mecoprop	6.07E-03	
Metabenzthiazuron	2.39E+01	
Metamitron	2.95E+00	
methane	1.36E-04	
methanol	2.98E-03	1.44E+00
methyl acetate	1.08E-03	
methyl chloride	1.18E-04	
methyl chloroform		1.15E+00
metyl-cyclohexane		1.87E+00
methyl ethyl ketone	8.58E-03	1.85E+00
methyl formate	7.59E-04	
methyl i-butyl ketone	1.08E-02	2.37E+00
methyl i-propyl ketone	8.31E-03	
methyl propene	1.44E-02	
methyl t-butyl ether	3.52E-03	
methyl t-butyl ketone	7.41E-03	
m-ethyl toluene	2.34E-02	2.28E+00
Metribuzin	3.84E+01	
Mevinphos	1.66E+02	
Monolinuron	8.27E+00	
m-xylene	2.53E-02	2.20E+00
n-butanol	1.44E-02	
n-butyl acetate	5.51E-03	1.94E+00
n-butyraldehyde	1.80E-02	

Table 3 Emission of organic substances to air (continued)

neopentane	3.97E-03	
NMVOC	1.36E-02	
nonane	9.03E-03	2.29E+00
n-propanol	1.26E-02	
n-propyl acetate	6.59E-03	
n-propyl benzene	1.44E-02	2.07E+00
octane	9.93E-03	2.41E+00
o-ethyl toluene	2.08E-02	2.23E+00
o-xylene	2.44E-02	1.91E+00
Parathion	4.72E+00	
pentachlorophenol	7.75E+01	
pentanal	1.72E-02	
pentane	9.03E-03	2.25E+00
perchloroethylene	5.77E-03	
p-ethyl toluene	2.08E-02	2.28E+00
propane	4.06E-03	2.24E+00
propane diol	1.08E-02	
propanoic acide	3.43E-03	
propene	2.53E-02	2.64E+00
propionaldehyde	1.80E-02	2.33E+00
propylene glycol methyl ether		2.54E+00
propylene glycol methyl ether acetate		1.70E+00
propyleneoxide	1.24E-01	
p-xylene	2.34E-02	2.25E+00
s-butanol	9.03E-03	
s-butyl acetate	6.14E-03	
Simazine	1.12E+02	
Sodium fluoracetate		
styrene	2.59E-04	
t-butanol	2.80E-03	
t-butyl acetate	1.44E-03	
Thallium sulfate		
Thiram	1.76E+01	
toluene	1.44E-02	1.95E+00
trans 1,2-dichloroethene	8.94E-03	
trans 2-butene	2.62E-02	
trans 2-hexene	2.44E-02	
trans 2-pentene	2.53E-02	
trichloroethylene	7.41E-03	
Trifluralin	8.50E-02	
undecane	8.76E-03	2.34E+00
Valeraldehyde		2.26E+00
vinyl chloride	2.22E-03	
xylene	2.34E-02	

Table 4 Weighting indices for emission of freons and similar substances

Substance	EI99(H,A)	EPS2000	Ecoscarcity97
1,1,1-trichloroethane	1.34E+00		
carbon dioxide	2.97E-02		
carbontetrachloride	-2.27E+01		2.20E+06
CF4		6.97E+02	
C2F6		1.38E+03	
c-C4F8		1.01E+03	
C6F14		7.52E+02	
CFC-11		5.41E+02	2.00E+06
			2.00E+06
			2.00E+06
CFC-113	9.92E+01	6.59E+02	1.60E+06
CFC-114	9.50E+00	1.11E+03	2.00E+06
CFC-115	4.47E+00	1.08E+03	1.20E+06
CFC-12	1.95E+02	1.04E+03	2.00E+06
CFC-13		1.39E+03	2.00E+06
CFC- 211			2.00E+06
CFC- 212			2.00E+06
CFC- 213			2.00E+06
CFC- 214			2.00E+06
CFC- 215			2.00E+06
CFC- 216			2.00E+06
CFC- 217			2.00E+06
chloroform	8.81E-03		
HALON-1201	1.56E+01		
HALON-1202	1.40E+01		
HALON-1211	5.70E+01		6.00E+06
HALON-1301	-9.63E+02	2.20E+03	2.00E+07
HALON-2311	1.56E+00		
HALON-2401	2.79E+00		
HALON-2402	7.82E+01		1.20E+07
HCFC-123	7.83E+01	1.23E+01	4.00E+04
HCFC-124	1.06E+00	5.53E+01	9.40E+04
HCFC-141b	8.87E-01	8.06E+01	2.20E+05
HCFC-142b	4.72E+00	2.28E+02	3.60E+05
HCFC-22	3.53E+00	1.94E+02	3.00E+05
HCFC-225ca	2.24E-01	2.13E+01	
HCFC-225cb	2.24E-01	6.19E+01	
HFC-125	8.17E+01	3.54E+02	5.60E+05
HFC-134	2.23E+00	1.33E+02	2.00E+05
HFC-134a	2.86E+00	1.44E+02	2.60E+05
HFC-143	6.68E-01	3.21E+01	6.00E+04
HFC-143a	1.06E+02	4.87E+02	7.60E+05
HFC-152a	3.08E-01	1.55E+01	2.80E+04
HFC-227ea	8.49E+01	3.65E+02	5.80E+05
HFC-23	2.76E+01	1.34E+03	2.30E+06
HFC-236fa	1.49E+01	8.85E+02	1.30E+06
HFC-245ca	1.27E+00	6.75E+01	1.10E+05
HFC-32	1.49E+00	6.42E+01	1.30E+05
HFC-41	3.29E-01		3.00E+04
HFC-43-10mee	2.86E+00	1.77E+02	2.60E+05
methyl bromide	7.15E+00	1.40E+06	
methyl chloride	2.24E-01		
methyl chloroform	-4.56E-01	2.00E+05	

Table 4 Weighting indices for emission of freons and similar substances(continued)

methylenechloride	2.02E-02	
perfluorbutane	1.59E+01	1.40E+06
perfluorcyclobutane	2.02E+01	1.70E+06
perfluorethane	2.12E+01	1.80E+06
perfluorhexane	1.70E+01	1.50E+06
perfluormethane	1.49E+01	1.30E+06
perfluorpentane	1.80E+01	1.50E+06
perfluorpropane	1.59E+01	1.40E+06
trifluoroiodomethane	2.23E-03	

Table 5 Weighting indices for emissions of inorganic substances to air

Substance	EI99(H,A)	EPS2000	Ecoscarcity 97
ammonia	2.11E+00	2.90E+00	6.30E+04
arsenic	3.07E+02	9.53E+01	
cadmium	2.18E+03	1.02E+01	1.20E+08
carbon dioxide	2.97E-02	1.08E-01	2.00E+02
chromium	3.22E+02	2.00E+01	
chromium(VI)	1.86E+04		
CO	0.00E+00	3.31E-01	
copper	1.14E+02	0.00E+00	
HCl		2.13E+00	4.70E+04
HF		2.07E+00	8.50E+04
H2S		6.89E+00	
lead	1.98E+02	2.91E+03	2.90E+06
mercury	6.46E+01	6.14E+01	1.20E+08
methane	4.67E-02	2.72E+00	4.20E+03
nickel	8.03E+02	0.00E+00	
nickel-refinery-dust	5.03E+02		
nickel-subsulfide	1.01E+03		
nitrous oxide	7.32E-01	3.83E+01	6.20E+04
NO	2.14E+00	1.39E+00	
NO2	1.39E+00	2.13E+00	
NOx	1.39E+00	2.13E+00	6.70E+04
SO2	6.60E-01	3.27E+00	5.30E+04
SO3	5.29E-01	2.62E+00	
SOx(as SO2)	6.60E-01	3.27E+00	
sulphur hexafluoride	5.62E+01	2.76E+03	4.80E+06
zinc	2.25E+02	0.00E+00	5.20E+05

Table 6 Weighting indices for emissions of radionuclides to air. For EPS2000, see table 7.

Radionuclide (Bequerel)	EI99(H,A)
C-14	2.02E-07
Co-58	4.56E-09
Co-60	1.80E-07
Cs-134	1.27E-07
Cs-137	1.49E-07
H-3	1.49E-10
I-129	3.08E-06
I-131	1.70E-09
I-133	9.97E-11
Kr-85	1.49E-12
Pb-210	1.59E-08
Po-210	1.59E-08
Pu alpha	8.81E-07
Pu-238	7.11E-07
Ra-226	9.66E-09
Rn-222	2.55E-10
Th-230	4.77E-07
U-234	1.03E-06
U-235	2.23E-07
U-238	8.70E-08
Xe-133	1.49E-12

Table 7 Weighting indices for emissions of substance groups to air

Substance group	EI99(H,A)	EPS2000	Ecoscarcity 97
particles diesel soot	1.04E-01		
metals	7.55E+01		
CxHy aromatic	2.23E-02		
CxHy chloro	3.71E-03		
CxHy halogenated	3.71E-03		
esters	3.93E-03		
ethers	7.85E-03		
PAH's	1.80E+00	6.43E+04	
Polychlorobiphenyls	2.72E+01		
TSP	1.17E+00		
NMVOC	6.85E-03	2.14E+00	3.20E+04
Radionuclides/MJ electricity from nuclear power *)		2.96E+03	
dust(PM10)	3.98E+00	3.60E+01	1.10E+05
dust(PM2.5)	7.43E+00	7.20E+01	

*) Includes also emissions to water and soil, but air emissions are dominating.

Table 8 Emissions of inorganic substances to water

Substance	EI99(H,A)	EPS2000	Ecoscarcity 97
NH4+			5.40E+01
Arsenic	6.98E+02		
Cadmium	7.92E+02		1.10E+04
Chromium	5.36E+00		6.60E+02
Chromium(VI)	3.64E+03		
Nickel	3.41E+02		1.90E+02
Nickel-subsulfide	5.33E+01		
Nickel-refinery-dust	1.06E+02		
Copper	1.15E+01		1.20E+03
Mercury	1.54E+01	1.80E+02	2.40E+05
NO3-			1.60E+01
Lead	5.76E-01		1.50E+02
Zinc	1.27E+00		2.10E+02

Table 9 Emissions of organic substances to water. For EPS2000 and Ecoscarcity 97 see table 10.

Substance	EI99(H,A)
1,1,1,2-tetrachlorethane	0.00E+00
1,1,2,2-tetrachlorethane	0.00E+00
1,1,2-trichlorethane	0.00E+00
1,1-dichloroethene	0.00E+00
1,2,3-trichlorobenzene	1.22E-02
1,2,4-trichlorobenzene	1.08E-02
1,2-dibromoethane	1.32E+01
1,2-dichloroethane	3.16E-01
1,3,5-trichlorobenzene	2.13E-02
1,3-butadiene	3.58E+00
1,4-dioxane	9.77E-03
2,4,6-trichlorophenol	1.11E-01
2,4-D	5.89E-03
3-methylcholanthrene	0.00E+00
acetaldehyde	9.79E-03
acrylonitrile	4.41E-01
Aldrin	0.00E+00
alpha-hexachlorocyclohexan	7.27E+01
Atrazine	3.95E+00
Azinphos-methyl	6.92E+01
Bentazon	4.53E-03
benzene	4.74E-02
benzo(a)anthracene	6.98E+03
benzo(a)pyrene	3.17E+04
benzotrichloride	1.00E+02
benzylchloride	2.10E-01
beta-chlorocyclohexan	6.10E+01
bis(2-chlorethyl)ether	0.00E+00
Bis(chloromethyl)ether	1.63E+02
bromodichloromethane	9.93E-02
Carbendazim	1.27E+01
carbontetrachloride	8.80E+00
chloroform	2.76E-01
di(2-ethylhexyl)phthalate	7.10E+00

dibenz(a)anthracene	4.32E+05
dibutylphthalate	1.26E-01
dichloromethane	5.27E-03
Dichlorvos	1.38E-01
Dieldrin	0.00E+00
dioxins (TEQ)	2.14E+07
Diquat-dibromide	9.20E+00
Diuron	1.80E+01
DNOC	5.25E-02
epichloorhydrin	1.05E-02
ethylene oxide	1.47E+00
fentin acetate	6.12E+01
fluoranthene	3.09E-01
formaldehyde	5.27E-02
gamma-HCH(Lindane)	4.49E+01
hexachlorobenzene	1.33E+03
hexachlorobutadiene	0.00E+00
hexachloroethane	0.00E+00
Malathion	1.28E+01
Maneb	4.86E-02
Mecoprop	1.05E-03
Metabenzthiazuron	1.12E+00
Metamitron	2.94E-02
methyl chloride	0.00E+00
Metribuzin	2.48E-01
Mevinphos	5.25E+00
Monolinuron	8.11E-01
PAH's	2.76E+01
Parathion	1.93E+01
pentachlorophenol	2.45E+02
perchloroethylene	5.01E-03
Polychlorobiphenyls	4.35E+02
propylene oxide	1.85E-01
Simazine	4.70E+00
styrene	1.29E-02
Thiram	6.81E+01
toluene	1.35E-02
trichloroethylene	0.00E+00
Trifluralin	6.08E+00
vinyl chloride	3.01E-03

Table 10 Weighting indices for emissions of substance groups to water

Substance group	EPS 2000	Ecoscarcity97
BOD	2.01E-03	5.90E+03
COD	1.01E-03	1.80E+04
N-tot	-3.81E-01	6.90E+01
P-tot	5.50E-02	2.00E+03
TOC		1.80E+04
AOX		3.30E+05

Table 11 Emissions of radionuclides to water. For EPS2000 see table 7.

Radionuclide (Bequerel)	EI99(H,A)
Ag-110m	5.41E-09
Co-58	4.35E-10
Co-60	4.67E-07
Cs-134	1.49E-06
Cs-137	1.80E-06
H-3	4.77E-12
I-131	5.41E-09
Mn-54	3.29E-09
Ra-226	1.38E-09
Sb-124	8.70E-09
U-234	2.55E-08
U-235	2.44E-08
U-238	2.44E-08

Table 12 Weighting indices for emissions of organic substances to soil

Substance	EI99(H,A)	EPS2000	Ecoscarcity 97
1,1,1,2-tetrachlorethane(ind.)	0.00E+00		
1,1,2,2-tetrachlorethane(ind.)	0.00E+00		
1,1,2-trichlorethane(ind.)	0.00E+00		
1,1-dichloroethene(ind.)	0.00E+00		
1,2,3-trichlorobenzene(ind.)	1.88E-01		
1,2,4-trichlorobenzene(ind.)	1.76E-01		
1,2-dibromoethane(ind.)	4.04E+01		
1,2-dichloroethane(ind.)	4.86E+00		
1,3,5-trichlorobenzene(ind.)	9.28E-02		
1,3-butadiene(ind.)	1.27E-01		
1,4-dioxane(ind.)	3.29E-03		
2,3,7,8-TCDD Dioxin(ind.)	9.12E+04		
2,4,5, Trichlorophenoxyacetic acid (2,4,5-T)		3.57E-01	
2,4,6-trichlorophenol(ind.)	2.93E-02		
2,4-Dichlorophenoxyacetic acid (2,4-D)	9.90E-06	3.57E-01	
3-methylcholanthrene(ind.)	0.00E+00		
acetaldehyde(ind.)	5.06E-03		
acrylonitrile(ind.)	7.44E-01		
Alachlor		3.57E-01	
Aldicarb		3.57E+00	
Aldrin(agr.)	0.00E+00	1.19E+02	
alpha-hexachlorocyclohexan(agr.)	2.46E+02		
Arsenic(ind.)	1.88E+02		
Atrazine(agr.)	1.16E-02	1.02E-01	
Azinphos-methyl(agr.)	2.77E-02		
Benomyl		7.13E-02	
Bentazon(agr.)	1.29E-03		
benzene(ind.)	1.80E-01		
benzo(a)anthracene(ind.)	1.70E+03		
benzo(a)pyrene(ind.)	5.87E+02		
benzotrichloride(ind.)	1.40E+03		
benzylchloride(ind.)	4.41E-01		
beta-chlorocyclohexan(agr.)	7.81E+01		
bis(2-chloretyl)ether(ind.)	0.00E+00		

Table 12 Weighting indices for emissions of organic substances to soil (continued)

Bis(chloromethyl)ether(ind.)	1.78E+02		
bromodichloromethane(ind.)	7.82E-05		
Cadmium(agr.)	2.35E+00	5.00E+00	1.20E+08
Cadmium(ind.)	8.17E+02	5.00E+00	1.20E+08
Captan		2.74E-02	
Carbaryl		3.57E-02	
Carbendazim(agr.)	1.82E-01		
Carbofuran		7.13E-01	
carbontetrachloride(ind.)	4.23E+02		
Chlordane		7.13E+00	
chloroform(ind.)	4.37E-02		
Chlorpyrifos		1.19E+00	
Chromium(ind.)	3.21E+03		
Cr			1.30E+06
Copper(ind.)	1.17E+02		
Co			3.80E+06
Cu			1.90E+06
Cypermethrin		3.57E-01	
Demeton		8.92E+01	
di(2-ethylhexyl)phthalate(ind)	5.45E-03		
dibenz(a)anthracene(ind.)	2.59E+05		
dibutylphthalate(ind.)	8.89E-02		
dichloromethane(ind.)	6.36E-02		
Dichlorvos(agr.)	2.39E-01	7.13E+00	
Dieldrin(agr.)	0.00E+00	7.13E+01	
Diflubenzuron		1.78E-01	
Dimethoate		8.92E+00	
Diquat		1.62E+00	
Diquat-dibromide(agr.)	5.33E-03		
Disulfoton		8.92E+01	
Diuron(agr.)	3.17E-03		
DNOC(agr.)	4.81E-04		
Endosulfan		5.94E-01	
Endrin		1.19E+01	
epichloorhydrin(ind.)	1.38E-02		
ethyleenoxide(ind.)	2.53E+01		
Fenamiphos		1.43E+01	
fentin acetate(agr.)	2.99E-02		
fluoranthene(ind.)	6.24E-01		
formaldehyde(ind.)	1.94E-02		
gamma-HCH(Lindane)(agr.)	9.18E+01		
Glyphosate		3.57E-02	
Heptachlor		7.13E+00	
hexachlorobenzene(ind.)	1.57E+03	4.46E+00	
hexachlorobutadiene(ind.)	0.00E+00		
hexachloroethane(ind.)	0.00E+00		
Pb			2.90E+06
Lead(ind.)	1.01E+00		
Lindane		1.19E+01	
Malathion(agr.)	2.18E-03	1.78E-01	
Maneb(agr.)	2.04E-02		
Mecoprop(agr.)	2.18E-07		
Mercury(ind.)	1.31E+02		
Hg		1.80E+02	1.20E+08
Metabenzthiazuron(agr.)	2.46E-02		

Table 12 Weighting indices for emissions of organic substances to soil (continued)

Metamitron(agr.)	1.58E-05		
Methomyl		1.43E-01	
Methoxychlor		7.13E-01	
methylchloride(ind.)	0.00E+00		
Metribuzin(agr.)	3.83E-03		
Mevinphos(agr.)	1.63E-02		
Mo			1.90E+07
Monolinuron(agr.)	3.42E-02		
Naled		1.78E+00	
Nickel(ind.)	6.13E+02		
Ni			1.90E+06
Nickel-refinery-dust(ind.)	6.76E+01		
Nickel-subsulfide(ind.)	1.35E+02		
NO3-			2.70E+04
Oxamyl		1.43E-01	
Paraquat		7.93E-01	
Parathion(agr.)	2.53E-03		
PCBs(ind.)	2.81E+02		
pentachloorfenol(ind.)	2.09E+00		
perchloroethylene(ind.)	6.37E-02		
Permethrin		7.13E-02	
Phosphine		1.19E+01	
Pirimifos-methyl		3.57E-01	
Propachlor		2.74E-01	
propyleenoxide(ind.)	1.49E+00		
Resmethrin		1.19E-01	
Simazine(agr.)	3.02E-02		
Sodium fluoracetate		1.78E+02	
styrene(ind.)	2.22E-04		
Thallium sulfate		4.46E+01	
Thiram(agr.)	7.77E-02	7.13E-01	
toluene(ind.)	5.29E-03		
trichlorethene(ind.)	0.00E+00		
Trifluralin(agr.)	0.00E+00		
Trifluralin(agr.)	1.61E-03		
Warfarin		1.19E+01	
vinylchloride(ind.)	8.14E-03		
Zn			5.20E+05
Zinc(ind.)	2.32E+02		
Zinc phosphide		1.19E+01	
Waste to landfill for inertmaterial			5.00E+02
Risk waste			2.40E+04
Low radioactivity waste (m3)			3.30E+09
High radioactive waste (m3)			4.60E+10

Table 13 Weighting indices for land use types.

Land use type	EI99(H,A)	EPS2000
Littering, m2		1.39E+01
Occupation as Contin. urban land (m2year)	8.97E-02	4.55E-02
Occupation as Convent arable land	8.97E-02	1.56E-03
Occupation as Discont. urban land	7.49E-02	4.55E-02
Occupation as Forest land	8.58E-03	5.50E-04
Forestry, m3		6.25E+00
Occupation as Green urban land	6.55E-02	
Occupation as Industrial area	6.55E-02	
Occupation as Intens. meadow land	8.81E-02	
Occupation as Organic arable land	8.50E-02	
Occupation as organic meadow land	7.95E-02	
Occupation as rail/road area	6.55E-02	
Occupation as Integrated arable land	8.97E-02	
Occupation as less intens.meadow land	7.95E-02	
Conversion to Continuous urban land	2.69E+00	
Conversion to Convent. arable land	2.68E+00	
Conversion to Discontinuous urban	2.24E+00	
Conversion to Green urban	1.96E+00	
Conversion to Industrial area	1.96E+00	
Conversion to Integr. arable land	2.68E+00	
Conversion to Intensive meadow	2.65E+00	
Conversion to Less intensive meadow	2.39E+00	
Conversion to Organic arable land	2.55E+00	
Conversion to Organic meadow	2.39E+00	
Conversion to rail/road area	1.96E+00	

Table 14. Weighting indices for depletion of ore and other inorganic mineral resources.

Substance	EI99(H,A)	EPS2000
Aluminium (in ore)	5.66E-02	4.39E-01
Ag (in ore)		5.40E+04
Ar (in ore)		0.00E+00
As (in ore)		1.49E+03
Au (in ore)		1.19E+06
B (in ore)		5.00E-02
Ba (in ore)		4.45E+00
bauxite	1.19E-02	
Bi (in ore)		2.41E+04
Be (in ore)		9.58E+02
Br (in ore)		0.00E+00
Cd (in ore)		2.91E+04
Ce (in ore)		4.52E+01
Chromium (in ore)	2.18E-02	8.49E+01
Chromium (ore)	6.54E-03	
Cl (in ore)		0.00E+00
Co (in ore)		2.56E+02
Copper (in ore)	8.73E-01	2.08E+02
Copper (ore)	9.87E-03	

Cs (in ore)		5.12E+02
Dy (in ore)		1.02E+03
Er (in ore)		1.41E+03
Eu (in ore)		3.13E+03
F (in ore)		4.86E+00
Ga (in ore)		2.12E+02
Gd (in ore)		1.06E+03
Ge (in ore)		2.12E+03
H (in ore)		0.00E+00
He (in ore)		0.00E+00
Hf (in ore)		5.12E+02
Hg (in ore)		5.30E+04
Ho (in ore)		4.79E+03
I (in ore)		0.00E+00
In (in ore)		4.87E+04
Ir (in ore)		5.94E+07
Iron (in ore)	1.21E-03	9.61E-01
Iron (ore)	6.90E-04	
K (in ore)		1.00E-02
La (in ore)		9.20E+01
Lead (in ore)	1.75E-01	1.75E+02
Lead (ore)	8.75E-03	
Li (in ore)		1.00E-01
Lu (in ore)		1.10E+04
Manganese (in ore)	7.44E-03	5.64E+00
Manganese (ore)	3.35E-03	
Mercury (in ore)	3.94E+00	
Mg (in ore)		0.00E+00
Molybdene (in ore)	9.75E-01	2.12E+03
Molybdenum (ore)	9.75E-04	
N (in ore)		0.00E+00
Na (in ore)		0.00E+00
Nb (in ore)		1.14E+02
Nd (in ore)		1.15E+02
Ne (in ore)		0.00E+00
Nickel (in ore)	3.88E-01	1.60E+02
Nickel (ore)	5.83E-03	
Pd (in ore)		7.43E+06
Pr (in ore)		4.71E+02
Pt (in ore)		7.43E+06
Rb (in ore)		2.70E+01
Re (in ore)		7.43E+06
Rh (in ore)		4.95E+07
Ru (in ore)		2.97E+07
S (in ore)		1.00E-01
Sb (in ore)		9.58E+03
Sc (in ore)		4.24E+02
Se (in ore)		3.58E+04
Sm (in ore)		6.32E+02
Sr (in ore)		9.40E+00
Ta (in ore)		1.98E+03
Tb (in ore)		5.94E+03
Te (in ore)		5.94E+05
Th (in ore)		2.88E+02
Ti (in ore)		9.53E-01
Tl (in ore)		3.96E+03

Tm (in ore)		9.90E+03
U (in ore)		1.19E+03
V (in ore)		5.60E+01
W (in ore)		2.12E+03
Y (in ore)		1.43E+02
Yb (in ore)		1.98E+03
Tin (in ore)	1.43E+01	1.19E+03
Tin (ore)	1.43E-03	
Tungsten (ore)	7.68E-03	
Zinc (in ore)	4.48E-02	5.71E+01
Zinc (ore)	1.78E-03	
Zr (in ore)		1.25E+01

Table 15 Weighting indices for fossil resource depletion

Substance		EI99(H,A)	EPS2000	Ecoscarcity97
coal (kg)	kg	5.99E-03	4.98E-02	3.00E+01
crude oil (kg)	kg	1.40E-01	5.06E-01	4.00E+01
crude oil (MJ)	MJ	3.42E-03	1.27E-02	1.00E+00
hard coal (MJ)	MJ	2.04E-04	1.66E-03	1.00E+00
lignite (kg)	kg			
lignite (MJ)	MJ			1.00E+00
natural gas (kg)	kg	1.08E-01	1.10E+00	5.00E+01
natural gas (m3)	m3	1.25E-01	7.81E-01	
natural gas (MJ)	MJ	3.57E-03	2.20E-02	1.00E+00

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