TECHNICAL REPORT

ISO/TR 14047

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Environmental management — Life cycle impact assessment — Examples of application of ISO 14042

Management environnemental — Évaluation de l'impact du cycle de vie — Exemples d'application de l'ISO 14042

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Foreword

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In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TR 14047 was prepared by Technical Committee ISO/TC 207, *Environmental management*, Subcommittee SC 5, *Life cycle assessment*.

Introduction

The heightened awareness of the importance of environmental protection, and the possible environmental significance of a product system[1)], has increased the interest in development of methods to better understand this significance. One of the techniques being developed for this purpose is Life Cycle Assessment (LCA).

Life cycle impact assessment (LCIA) is the third phase of life cycle assessment, and its purpose is to assess a product system's life cycle inventory analysis (LCI) results to better understand its environmental significance. It models selected environmental issues called impact categories and, through the use of category indicators which help condense and explain the LCI results, portrays the aggregate emissions or resources used for each impact category to reflect their potential environment impacts.

This Technical Report provides examples to illustrate the application of ISO 14042, *Environmental management – Life cycle assessment — Life cycle impact assessment*. It uses several examples concerning key areas of ISO 14042 in order to enhance the understanding of its requirements.

1) In this Technical Report the term “product system” also includes service systems.

Environmental management — Life cycle impact assessment — Examples of application of ISO 14042

1 Scope

This Technical Report provides examples to illustrate current practice in carrying out a life cycle impact assessment in accordance with ISO 14042. These are only examples of the total possible "ways" to satisfy the provisions of ISO 14042. They reflect the key elements of the life cycle impact assessment (LCIA) phase of the LCA.

NOTE The examples presented in this Technical Report are not exclusive; other examples exist to illustrate the methodological issues described.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 14040:1997, *Environmental management — Life cycle assessment — Principles and framework*

ISO 14042:2000, *Environmental management — Life cycle assessment — Life cycle impact assessment*

3 Abbreviated terms

The following is a non-exhaustive list of abbreviated terms found in this Technical Report.

ADI allowable dose intake

AP acidification potential

CFC chlorofluorocarbon

CML Centre of Environmental Science, Leiden University

COD chemical oxygen demand

DALY disability-affected life years

DLY disability life years

E exponent

EBIR equal benefit incremental reactivity

EDIP environmental design of industrial products

EL	environmental load
ELU	environmental load unit
EPS	environmental priorities strategy
ETP	eco-toxicity potential
FU	functional unit
GWP	global warming potential
IIASA	International Institute for Applied Systems Analysis
IPPC	integrated pollution prevention and control
IPCC	Intergovernmental Panel on Climate Change
LCA	life cycle assessment
LCI	life cycle inventory analysis
LCIA	life cycle impact assessment
MDF	medium density fibreroad
MIR	maximum incremental reactivity
MOIR	maximum ozone incremental reactivity
NP	nutrification potential
ODP	ozone depletion potential
OSB	oriented standard board
PAH	polycyclic aromatic hydrocarbon
PDF	potentially disappeared fraction
PEC	predicted environmental concentration
PNEC	predicted no-effect concentration
POCP	photochemical ozone creation potential
RIVM	National Institute of Public Heath and the Environment
SE	sensitive ecosystem category indicator
USES	uniform system for the evaluation of substances
VOC	volatile organic compound
WMO	World Meteorological Organization
YLL	years of life lost

4 Organization of examples in ISO/TR 14047

4.1 Mandatory and optional elements

The general framework of the LCIA phase is composed of several mandatory elements that convert Life Cycle Inventory (LCI) results to indicator results. In addition, there are optional elements for normalizing, grouping or weighting of the indicator results and data quality analysis techniques for assisting in the interpretation of the results.

4.2 Scope of examples

The examples provided within this Technical Report illustrate and support the methodology specified in Clauses 5, 6, 7 and 10 of ISO 14042:2000. The coverage is indicated in Table 1.

Table 1 — Elements or clauses of ISO 14042:2000 illustrated with examples

ISO 14042:2000 reference	IS0 14042 clause	Example coverage in this Technical Report
Clauses 1 to 4	Foreword, Scope, Normative references, Terms and definitions, General description of LCIA	Examples of impact categories
Clause 5	Mandatory elements	Example 1, Example 2, Example 3, Example 4, Example 5
5.1	General	
5.2	Concept of category indicators	
5.3	Selection of impact categories, category indicators and characterization models	
5.4	Assignment of LCI results (classification)	
5.5	Calculation of category indicator results (characterization)	
Clause 6	Optional elements	
6.1	General	
6.2	Calculating the magnitude of the category indicator results relative to reference information (normalization)	Example 1, Example 2, Example 6, Example 7
6.3	Grouping	Example 1
6.4	Weighting	Stem example, Example 5, Example 8
Clause 7	Data quality analysis	Stem example, Example 5
Clause 8	Limitations of LCIA	Not covered in ISO/TR 14047
Clause 9	Comparative assertions disclosed to the public	
Clause 10	Reporting and critical review	Example 1

In some key areas, more than one example is provided to illustrate the different ways in which it may be possible to apply ISO 14042. It is important to stress this point. In many LCIA studies, more than one approach or practice may be used which will still allow conformance with the methodology specified in ISO 14042. There is currently no unique approach. This Technical Report may be thought of as illustrating a number of ways that may be used in the LCIA phase as specified in ISO 14042. Table 2 gives the title of the example and the purpose of the illustration.

Table 2 — Example titles and the purpose of the illustrations

Example No.	Example title	Purpose of illustration	ISO 14042:2000 subclause reference
1	Use of two different materials for gas pipelines	Full procedure of LCIA	5.2 to 5.5, 6.2 to 6.4, Clause 7 and (reference to Clause 10)
2	Two acidification impact category indicators	Consequences of using general or site-dependent models	5.3 to 5.5, Clause 6
3	Impacts of greenhouse gas (GHG) emissions and carbon sinks on forestry activities	GHG emissions and carbon sinks	5.2 to 5.5
4	Endpoint category indicators assessment	Transforming ionizing radiation inventory results into impact category indicator (YLL)	5.2 to 5.5
5	Choice of material for a wind spoiler in car design study	Impact modelling at endpoint level and weighting	5.2 to 5.5, 6.4, Clause 7
6	Normalization of LCIA indicator results for the use of different refrigerator gases	Normalization using different types of reference information	6.2
7	Normalization in a waste management study	Use of normalization in the communication processes	6.2 and (reference to Clause 10)
8	A technique for the determination of weighting factors	The use of a panel of experts in such a study	6.4

4.3 Organization of document and route map

This Technical Report is organized along the lines of a process "plant". First, Clause 5 begins with a "General description of LCIA" and introduces the examples. A central "stem" example, Example 1, runs through the document illustrating the key areas between Clauses 5 to 10 of ISO 14042:2000. This uses one set of LCI data and processes it through the LCIA stages. Examples illustrating the different paths possible within the ISO 14042 methodology run in parallel to Example 1. These examples use different source data from Example 1. Figure 1 presents the process in a flow diagram.

NOTE Following Clause 5 the examples are organized as follows:

Examples in Clause 6 are mandatory elements running consecutively, i.e. Example 1, Illustration of 5.2 to 5.5 of ISO 14042:2000, followed by Example 2, followed by Example 3, and so on.

Examples in Clause 7 are organized on a "topic" basis, e.g. with all examples on Illustration of 6.2 of ISO 14042:2000 on normalization, followed by examples on Illustration of 6.3 of ISO 14042:2000 on Grouping, and so on.

The reader may adopt a number of alternative ways of using this Technical Report. These are broadly as follows:

— follow Example 1 from start to finish;

— select an alternative example and follow the process flow;

— select a topic and read all the alternative approaches on that particular topic.

Each example is preceded by an overview to describe the key area of ISO 14042 which will be illustrated. The body of the example follows the overview. Where an example continues through the document, it generally has not been necessary to precede each clause with an overview.

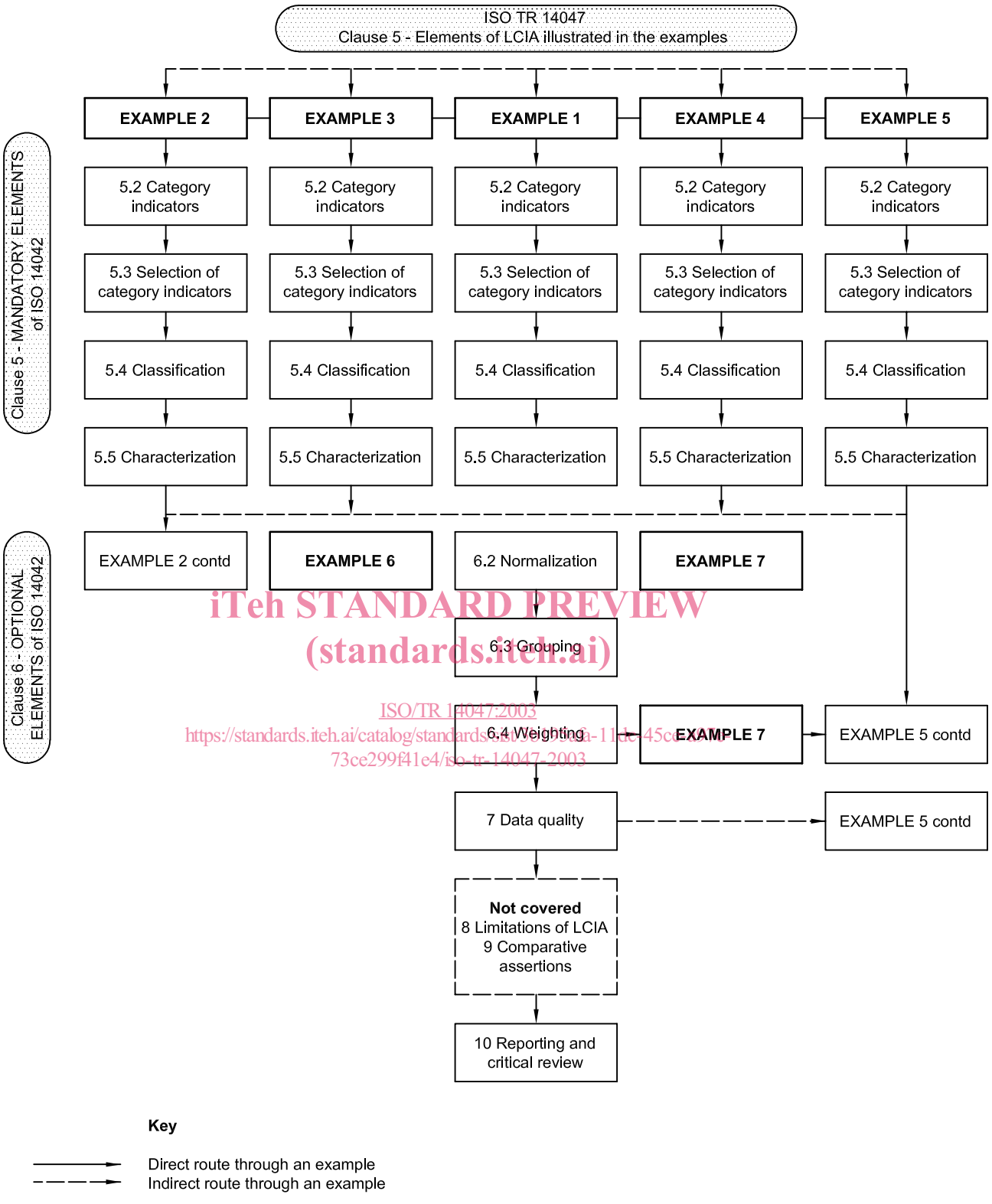

Figure 1 — Organization and route map for this Technical Report

5 Elements of LCIA as illustrated in the examples

5.1 General

This clause gives a general description of LCIA, explaining key elements of the procedure, and places the examples in the context of ISO 14042:2000. The LCIA process elements are shown in Figure 2.

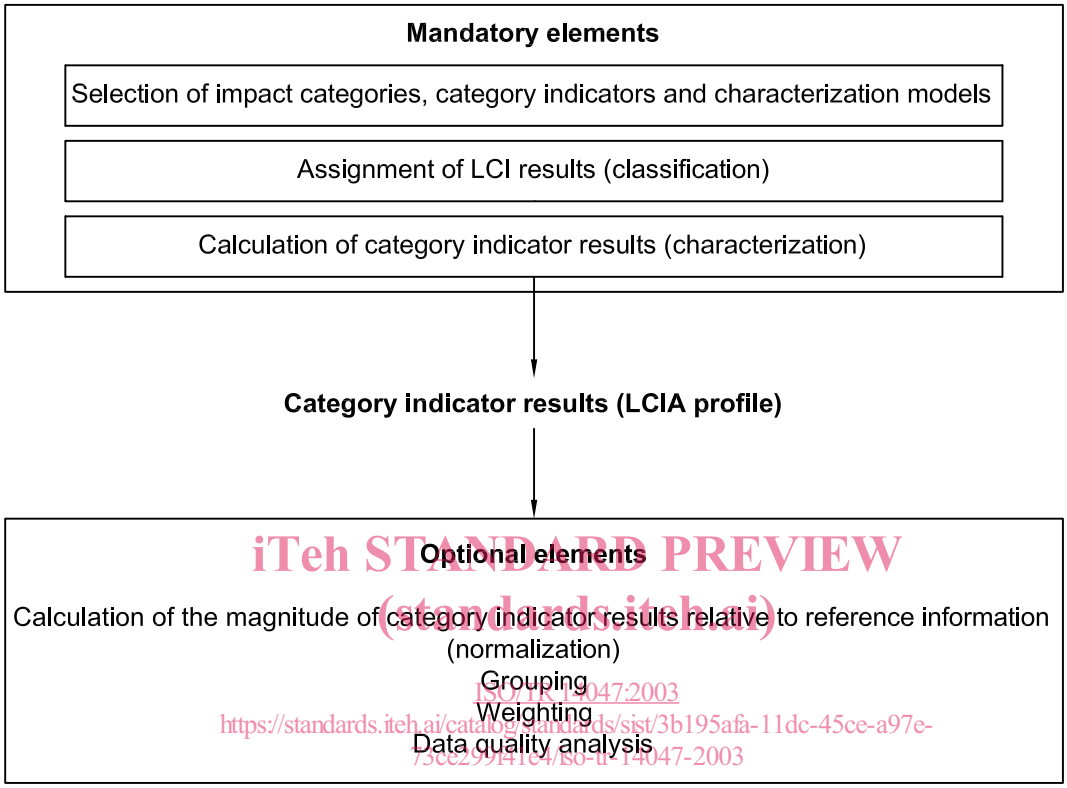

Figure 2 — Elements of the LCIA phase (ISO 14042:2000)

5.2 Mandatory elements

5.2.1 General

According to ISO 14042, the mandatory elements of LCIA are:

— selection of impact categories, category indicators and characterization models;

— assignment of LCI results (classification) to the impact categories;

— calculation of category indicator results (characterization).

5.2.2 Selection of impact categories, category indicators and characterization models

5.2.2.1 General

For each impact category, a distinction can be made between LCI results, including extractions (inputs) and emissions (outputs), category endpoints and intermediate variables in the environmental mechanism between these two groups (sometimes called "midpoints"). This is illustrated in Figure 3.

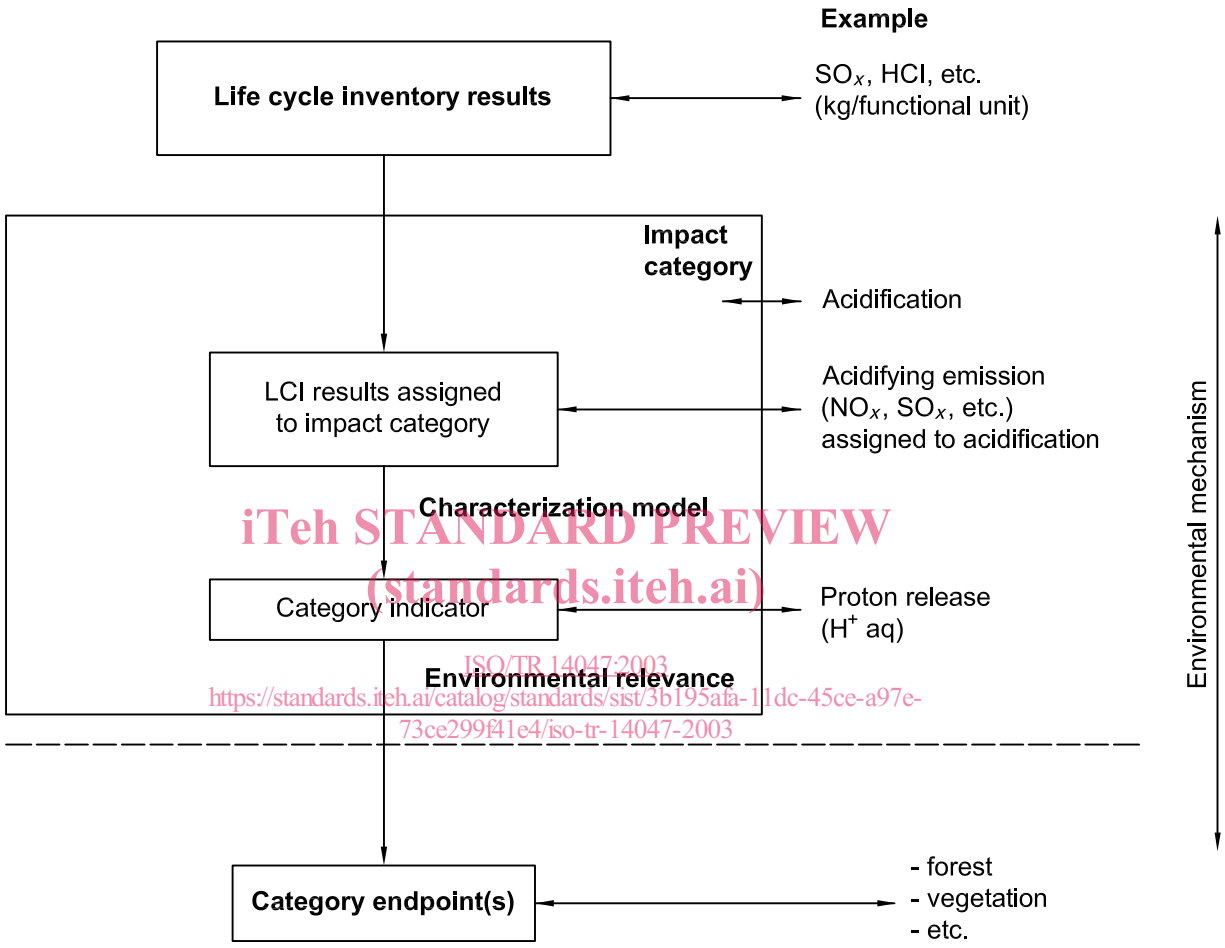

Figure 3 — Concept of category indicators (Figure 2 from ISO 14042:2000)

When defining the impact categories, an indicator must be chosen somewhere in the environmental mechanism. Often indicators are chosen at an intermediate level somewhere along that mechanism; sometimes they are chosen at endpoint level. Table 3 shows examples of relevant intermediate variables and relevant category endpoints for a number of impact categories.

Table 3 — Examples of intermediate variables and category endpoints for a number of impact categories

Impact category	Choices of indicator level	
	Examples of intermediate variables	Examples of category endpoints
Climate change	Infrared radiation, temperature, sea-level	Human life expectancy, coral reefs, natural vegetation, forests, crops, buildings
Stratospheric ozone depletion	UV-B radiation	Human skin, ocean biodiversity, crops
Acidification	Proton release, pH, base-cation level, Al/Ca ratio	Biodiversity of forests, wood production, fish populations, materials
Nutrification	Concentration of macronutrients (nitrogen, phosphorus)	Biodiversity of terrestrial and aquatic ecosystems
Human toxicity	Concentration of toxic substances in environment, human exposure	Aspects of human health (organ functioning, human life expectancy, number of illness days)
Ecotoxicity	Concentration or bio-availability of toxic substances in environment	Plant and animal species populations

In Tables 4, 5 and 6, LCI results and indicator results are expressed using the same functional unit (the one selected in the LCI phase, Scope).

In Table 4, examples of terms used for defining an impact category and describing the chosen characterization model are given for six different impact categories to further illustrate the principles of Table 1 from ISO 14042:2000. Impact Categories 1 and 2 are input-related; Impact Categories 3 to 6 are output-related.

Table 4 — Examples of definitions and description of six impact categories

Term	Impact Category 1	Impact Category 2
Impact category	Depletion of fossil energy resources	Depletion of mineral resources, (excluding energy resources)
LCI results	Extraction of resources of different fossil fuels	Extraction of resources, expressed as useful material
Characterization model	Cumulated energy demands	Static scarcity model
Category indicator	Energy content of energy resources	Extraction of material in the ore as a function of estimated supply horizon of the reserve base
Characterization factor	Low calorific value per mass unit	Present extraction of the material in the ore divided by estimated supply horizon of the reserve base
Indicator result	Total low calorific value (megajoules)	Total mass of used material in the ore divided by estimated supply horizon of the reserve base
Category endpoints	Heating, mobility	Availability of resources
Environmental relevance	Diverse problems known from energy crises	Diverse problems from mineral resources

Table 4 (*continued*)

Term	Impact Category 3	Impact Category 4
Impact category	Climate change	Stratospheric ozone depletion
LCI results	Emissions of greenhouse gases	Emissions of ozone-depleting gases
Category indicator	Increase of infrared radiative forcing (W/m^2)	Increase of stratospheric ozone breakdown
Characterization model	The model as developed by the IPCC defining the global warming potential of different greenhouse gases [6], [7]	Table 5 — The model as developed by the WMO defining the ozone depletion potential for different ozone-depleting gases [8], [9]
Characterization factor	Global Warming Potential for time horizon of 100 years (GWP100) for each greenhouse gas emission (kg CO_2 eq./kg emission)	Ozone Depletion Potential in the steady state ($ODP_{steady\ state}$) for each emission (kg CFC-11-eq./kg emission)
Indicator result	Kilograms of CO_2-equivalents	Kilograms of CFC-11-equivalents
Category endpoints	Years of life lost (YLL), coral reefs, crops, buildings	Illness days, marine productivity, crops
Environmental relevance	Infrared radiative forcing is a proxy for eventual effects on the climate, depending on the integrated atmospheric heat absorption caused by emissions and the distribution over time of the heat absorption	Empirical and experimental linkage between UV-B radiation levels and damage
Term	**Impact Category 5**	**Impact Category 6**
Impact category	Nutrification	Ecotoxicity
LCI results	Emissions of nutrients	Emissions of organic substances to air, water and soil
Category indicator	Deposition increase divided by N/P equivalents in biomass	Predicted Environmental Concentration increase divided by Predicted No-Effect Concentration (PNEC)
Characterization model	The stoichiometric procedure as described by [10], which identifies the equivalence between N and P for both terrestrial and aquatic systems.	USES 2.0 model developed at RIVM, describing fate, exposure and effects of toxic substances, adapted to LCA by [11]
Characterization factor	Nutrification Potential (NP) for each eutrophicating emission to air, water and soil (kg PO_4^{3-}- eq./kg emission)	Ecotoxicity Potential (ETP) for each emission of a toxic substance to air, water and soil (kg 1,4-dichlorobenzene eq./kg emission)
Indicator result	Kilograms of PO_4^{3-} equivalents	Kilograms of 1,4-dichlorobenzene equivalents
Category endpoints	Biodiversity, natural vegetation, algal bloom	Biodiversity
Environmental relevance	The nutrification indicator represents a clear causal factor in the mechanism of nutrification for different types of ecosystems; it is defined at a global level	The PNEC represents a threshold for a possible effect of the substance on the species composition of an ecosystem; no spatial differentiation is considered