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Trajnostnost gradbenih objektov - Dodatne kategorije in kazalniki vplivov na okolje - Temeljne informacije in možnosti - Vrednotenje možnosti dodanih kategorij vplivov na okolje in sorodnih kazalnikov ter računske metode za ocenjevanje učinkov ravnanja z okoljem v stavbah

Sustainability of construction works - Additional environmental impact categories and indicators - Background information and possibilities - Evaluation of the possibility of adding environmental impact categories and related indicators and calculation methods for the assessment of the environmental performance of buildings

Nachhaltigkeit von Bauwerken - Hintergrundinformationen zu möglichen, zusätzlichen Wirkungskategorien und Indikatoren für die Erfassung der umweltbezogenen Qualität von Gebäuden

Indicateurs complémentaires pour la déclaration de la performance environnementale des produits de construction et pour l'évaluation de la performance environnementale des bâtiments

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Sustainability of construction works - Additional environmental impact categories and indicators - Background information and possibilities - Evaluation of the possibility of adding environmental impact categories and related indicators and calculation methods for the assessment of the environmental performance of buildings

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This Technical Report was approved by CEN on 26 August 2016. It has been drawn up by the Technical Committee CEN/TC 350.

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European foreword

This document (CEN/TR 17005:2016) has been prepared by Technical Committee CEN/TC 350 “Sustainability of construction works”, the secretariat of which is held by AFNOR.

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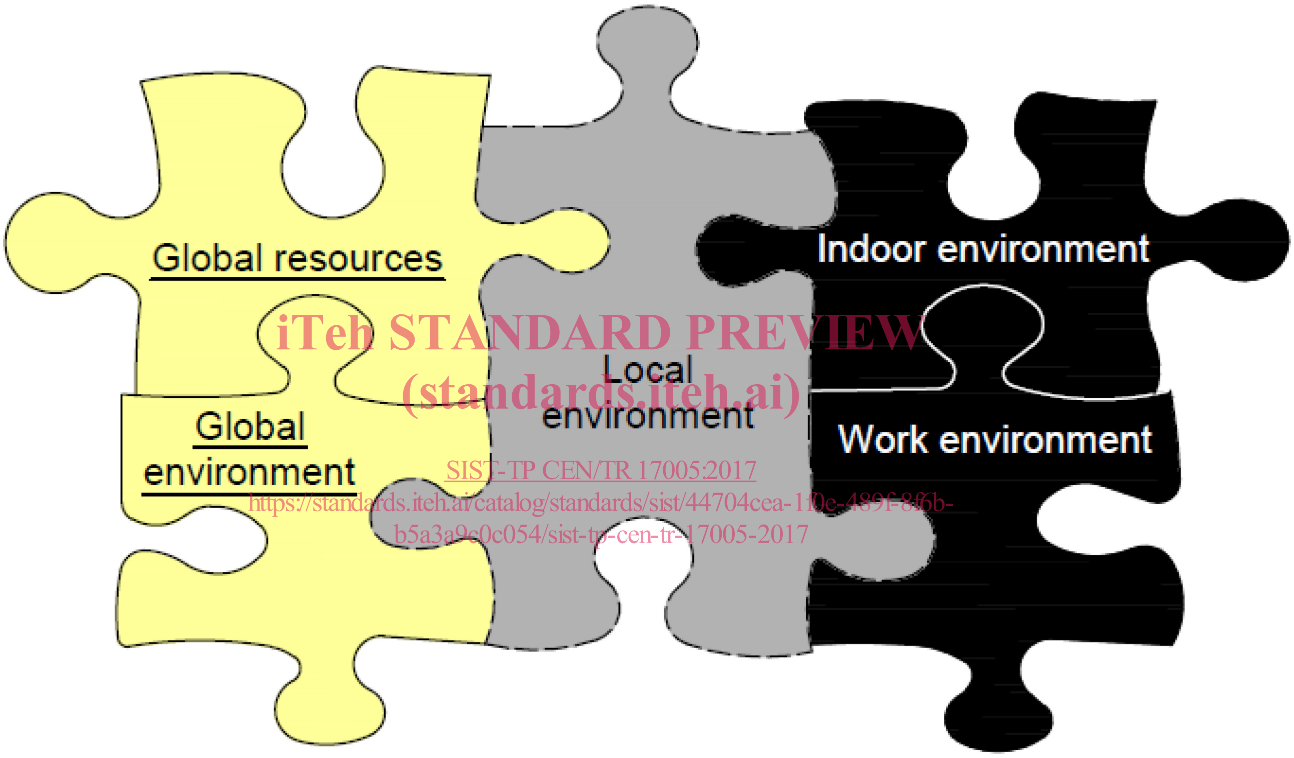

Figure 1 — Domain of LCA ([14], p. 33)

NOTE 1 One of the main drivers for using LCA, is the prevention of burden shifting.

NOTE 2 If in future, models become available that combine global environmental impacts with health impacts to the building users due to direct exposure, these might be considered in the context of the CEN/TC 350 framework in future.

Although the EN 15804 standard follows the LCA approach, it also states that additional information on release of dangerous substances to indoor air, soil and water during the use stage shall be provided (EN 15804:2012+A1:2013, 7.4). EN 15804:2012+A1:2013, 7.4.1 stipulates the requirements related to releases to indoor air, and EN 15804:2012+A1:2013, 7.4.2 stipulates the requirements related to releases to soil and water. Such releases are included in EN 15804 as these have a potential direct impact/risk for the inhabitants/users of the building.

Both EN 15804 and EN 15978 contain seven life cycle environmental impact categories. Since their publication, however, a perceived need has arisen to include in these standards a broader set of environmental impacts categories due to the following:

— Additional environmental impact categories are currently part of European recommendations and of national legislation of several Member States.

— Additional environmental indicators are used in current practice (see EN 15643-2:2011, B.2 [3]).

— New research and developments in life cycle impact assessment (LCIA) methods and the characterization of environmental impacts.

This Technical Report (TR) has been developed to provide guidance to the working groups of CEN/TC 350 on the extension of the impact categories in EN 15804 and EN 15978. The TR provides a framework for the evaluation of environmental impact categories and evaluates the impact categories human toxicity and ecotoxicity, particulate matter, land use, biodiversity, water scarcity; and ionizing radiation by implementing the framework developed.

During the preparation of the TR a range of experts, such as developers of impact assessment models, LCA software developers and experts from the EC-JRC were consulted.

NOTE 3 Although this report is primarily referenced to buildings, the indicators and methods reviewed might have equal application in other construction works.

Introduction

List of abbreviations:

CDV	Critical Dilution Volume
CF	Characterization Factor
EPBD	Energy Performance of Buildings Directive
EPD	Environmental Product Declaration
ILCD	International Reference Life Cycle Data System
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
PCR	Product Category Rules
PEF	Product Environmental Footprint
RA	Risk Assessment
TR	Technical Report
TSP	Total Suspended Particles

The standards EN 15804 [1] and EN 15978 [2] provide a basis for the environmental assessment of buildings using a life cycle assessment approach.

The EN 15804 standard [1] provides core product category rules (PCR) for Type III environmental declarations of any construction product and services. An Environmental Product Declaration (EPD) is a verified document that reports environmental data of products based on life cycle assessment (LCA) and other relevant information and in accordance with the international standard ISO 14025 (*Type III Environmental Declarations*).

The EN 15978 standard [2] specifies the calculation method to assess the environmental performance of a building, based on LCA (i.e. using EPD for construction products and services) and other quantified environmental information (i.e. (1) indicators describing resource use based on input flows of the life cycle inventory (LCI) and (2) indicators describing waste categories and output flows derived from scenarios and LCI), and gives the means for the reporting and communication of the outcome of the assessment.

Life cycle Assessment (LCA) is defined as the "*compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle*". (ISO 14040).

In LCA, the modelling is typically made at the global level, resulting in global characterization factors. Inherent to the modelling, the (current) environmental impact assessment models within LCA do not cover local impacts/risks due to direct exposure of some persons to a certain emission/hazardous substance. As it is acknowledged that the variation in population density influences the exposure rate and hence also the potential health damage, regional characterization factors (based on regional differences in population density) for some health related impact categories are being developed. The same is true for ecosystems related impact categories.

As is illustrated in Figure 1, LCA (in current practice) covers a great part of the total environmental perspective but is clearly restricted to regional and global impacts to the external environment (i.e. it does not include effects due to indoor exposure of the users of a building). Effects for which there is a low plausibility that they will occur (e.g. risks from nuclear waste) and local effects from the products on the manufacturers or users are disregarded. Recently, research has started to also address health effects due to indoor emissions on building users with similar approaches as used in LCA [13].

1 Scope

This Technical Report (TR) has been developed by CEN/TC 350/WG 1 and WG 3 to provide a clear and structured view on the relevance, robustness and applicability of a predefined set of additional impact categories and related indicators for the assessment of the environmental performance of construction works, construction products and building materials.

The TR describes the evaluation criteria that are used to determine, for these impact categories, the suitability of indicators and calculation method(s) for inclusion in the standards EN 15978 and EN 15804 (or other CEN/TC 350 standards as appropriate) in terms of their:

a) relevance to:

   1) the environment,

   2) construction works,

   3) construction products, and

   4) EU policy;

b) scientific robustness and certainty; and

c) applicability of the impact assessment method(s).

The additional impact categories examined in the TR are:

— human toxicity and ecotoxicity;

— particulate matter;

— land use;

— biodiversity;

— water scarcity; and

— ionizing radiation.

Because EN 15978 and EN 15804 are founded on a life cycle approach, the impact categories, indicators and methods reviewed are predominantly based on their potential suitability for application in LCA. In relation to some of the areas of concern, however, where LCA methods might not be sufficiently robust or developed, some non-LCA based indicators and methods are also considered.

Due to the scope of LCA used in the EN 15804 and EN 15978, impacts to users of buildings due to direct exposure to harmful emissions fall outside the scope of this TR. This falls under the scope of CEN/TC 351. Important information related to this aspect found during the development of this TR, is however mentioned in the TR.

Uncertainty is an important issue in LCA. General assessment of the uncertainty related to impact assessment models is considered in the evaluation framework of this TR. However, the TR does not lay down a maximum uncertainty level to be considered acceptable in the context of the CEN standards EN 15804 and EN 15978, nor does it provide exact figures on uncertainties.

Annex A of the TR provides a description of options that may be considered for incorporating selected impact categories/indicator in the standards EN 15978 and EN 15804.

The TR recognizes and takes account of:

— the work done by the European Commission, Joint Research Centre (EC-JRC), in the development of the International Reference Life Cycle Data System (ILCD) Handbook Recommendations,

— other reports and scientific studies into the methods and application of the indicators reviewed,

— findings of specific activities connected with this work such as of the CEN/TC 350 Workshop, held in Brussels on 24-25 June 2014.

2 The need for additional impact categories

2.1 Environmental relevance

It is widely recognized that the extraction and combustion of fossil fuels is a dominant cause of the environmental impact of a building across its life cycle ([23], 22], [24]). This is especially the case for existing European buildings that were constructed before national and European Energy regulations were introduced. The use of low efficiency gas and oil heating systems combined with a poorly insulated building envelop results in a high yearly combustion of fossil fuels and this combined with a relatively long lifespan of buildings, makes the operational energy use the dominant aspect in the environmental profile of many existing European buildings.

The extraction and combustion of fossil fuels is responsible for environmental impacts related to:

— **Global warming:** mainly CO_2 emissions related to the use, production and transport stages

— **Depletion of abiotic fossil fuels**: extraction of oil, gas and coal related to use, production and transport processes

— **Acidification**: SO_2 and NO_x emissions related to the combustion of fossil fuels related to the production or transport phases

— **Eutrophication:** nitrogen emissions related to the combustion of fossil fuels

— **Photochemical ozone creation:** emissions of nitrogen oxides related to the combustion of fossil fuels

— **Particulate matter formation:** emissions of nitrogen oxides, sulphur dioxides and small particulates

These impact categories except particulate matter formation are already integrated in the current version of the standards EN 15804 (2012+A1:2013) and EN 15978 (2011).

The increase in heating efficiencies and insulation level, and the growing use of renewable energy will result in a smaller influence of the operational energy of buildings on its overall environmental profile. With the 2019-2021 EPBD targets[1] in view, the environmental impacts of buildings of the near future will be less dependent on their operational energy use and increasingly influenced by the life cycle impacts of the constituent building products (cf. manufacturing, replacement and/or end-of-life) and other processes during the use phase, such as water consumption and transport of building users (e.g. commuting related to the dwelling location). [20], [22]

[1] The re-cast Energy Performance of Buildings Directive (EPBD) requires that from 2019 onwards 'all the new buildings occupied and owned by public authorities are nearly zero-energy buildings' (nZEB) and by the end of 2020 'all new buildings are nearly zero-energy buildings'.

With this gradual shift in the relative environmental importance of a building's energy use, the need to consider other types of environmental impact, such as land occupation impacts of the building during its life cycle and land transformation impacts related to the provisioning of raw materials for building materials (e.g. sand, gravel, clay, ore and wood) [21] will become more apparent and increasingly important.

EXAMPLE For a single family dwelling representative for the Belgian building stock, which was upgraded from current common practice to the passive house standard, it was observed that there was a life cycle decrease in CO_2 emissions but at the same time there was a life cycle increase in SO_2 emissions (contributing to acidification impacts), $PM_{2,5}$ emissions (contributing to particulate matter) and ecotoxicity. [18]

In order to gain an insight into the potential relevance of the additional impact categories compared to the ones already included in the CEN standards, a comprehensive life cycle assessment was made of 16 residential buildings in Belgium, ranging in typology and construction period. For each home, an optimization of the life cycle environmental impact and financial cost was made. The optimization included both a differentiation in energy performance, heating and ventilation system, material choice, air tightness and overall design of the building. The outcome of the study is shown in Figure 2.

For the life cycle assessment a comprehensive set of impact categories was included (i.e. the impact categories included in Eco-indicator99) and an approach was developed to calculate a single score environmental impact (i.e. based on the calculation of external environmental cost through monetary valuation). By calculating this single score, it was possible to analyse the relative contribution of each of the impact categories to the overall environmental impact. This relative contribution can give a rough idea on the relevance of the impact categories.

The monetary valuation approach used within this study was based on the European project ExternE, in combination with other monetary valuation studies. For some harmful emissions monetary values were directly available, others required first an assessment at end point level, which were then translated into external environmental cost. For this end point impact assessment, Eco-Indicator99 was used.

NOTE The impact assessment method in this study was not in line with the ILCD recommendations (i.e. the ILCD handbook only recommends midpoint methods). As the impact assessment is partially based on Eco-Indicator99, there are some methodological limitations.

The results shown in Figure 2, are for one of the 16 residential buildings analysed. For this dwelling more than 2500 alternatives were analysed ranging in material choice (i.e. solid versus timber frame structures, different finishing materials at the outside and inside, different glazing and window frames), in insulation level, in heating system, in air tightness, in ventilation system, etc. For each of the 2500 alternatives, the total life cycle environmental impact (i.e. single score) was calculated and then the percentage contribution of each of the impact categories to this total score was calculated. The contribution of a particular impact category to the total environmental impact changed from one building alternative to another and, therefore, for each impact category the minimum and maximum contribution was determined; these values are presented in Figure 2. As the majority of the buildings had an energy performance which was far above the passive standard, the result (i.e. contribution of each impact category to the total environmental impact) is shown for the life cycle impact of the building together with the cradle-to-gate impact of the construction materials in the building.

The figure shows the minimum contribution to climate change was 31 % and the maximum contribution was 54 %. The dwellings with a climate change contribution of 31 % had a better energy performance than the dwellings with a climate change contribution of 54 %. The analysis revealed that the following impact categories are relevant (where a threshold of 10 % contribution has been defined as minimum value to be perceived as relevant), in order of importance:

— climate change;

— acidification;

— eutrophication;

— particulate matter formation;

— ecotoxicity, land use; and

— fossil fuel depletion.

The indicators; particulate matter formation, ecotoxicity, and land use are not currently included in either EN 15804 or EN 15978.

Similar results were obtained in a more recent Belgian research project, the OVAM:MMG project. [16]

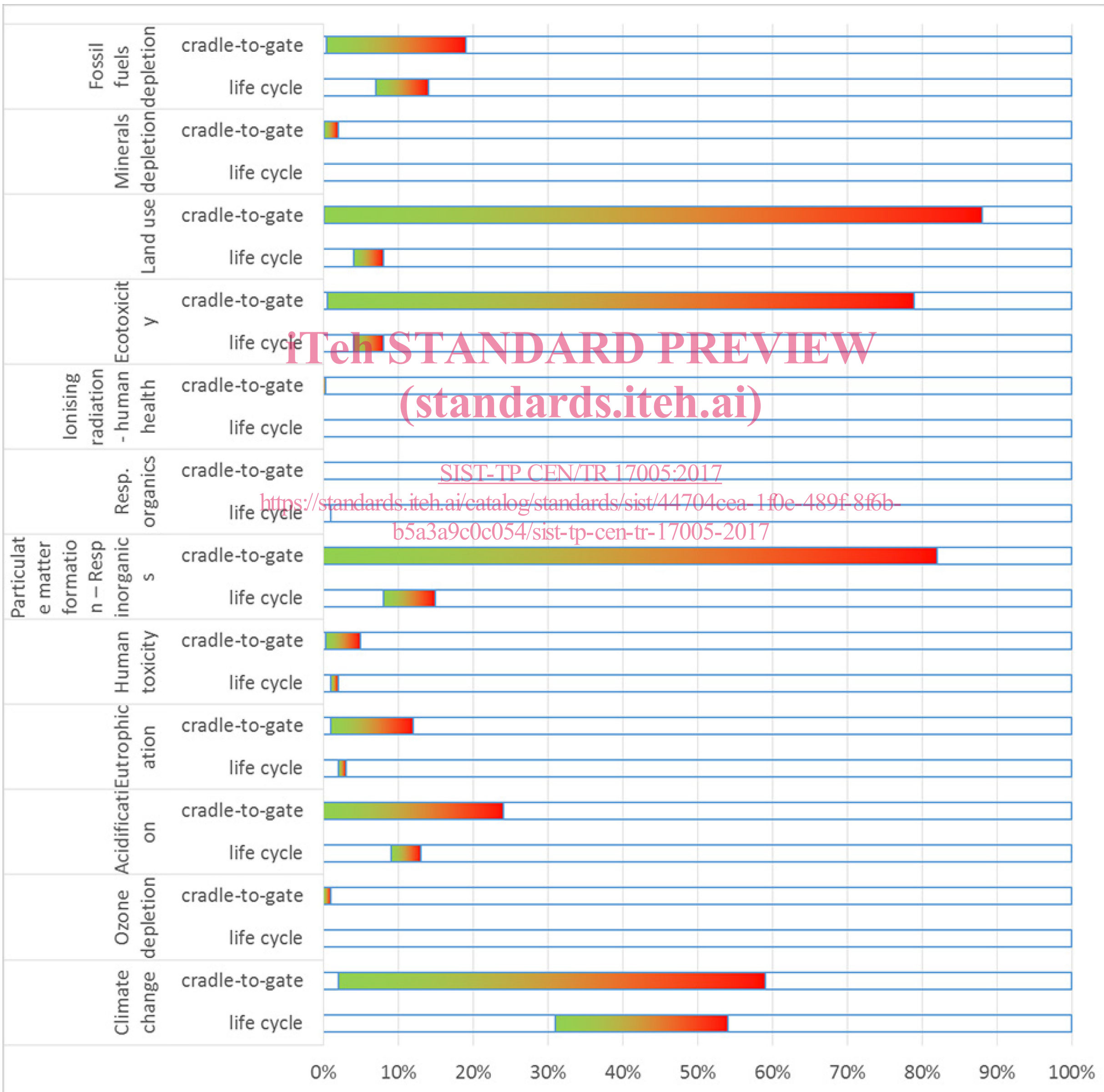

Figure 2 — Relevance of different impact categories on building level based on cradle-to-gate and cradle-to-grave assessment – impact assessment method = SuFiQuaD, based on [19]

Disclaimer: This figure shall be interpreted with caution due to methodological limitations of the impact assessment method used.

2.2 Policy relevance

Several environmental impact categories and indicators that are additional to those used in current CEN/TC 350 standards are being advanced in European and national policies/regulations. Furthermore, as well as specific policies, there are other initiatives that also require additional indicators.

The lists below identify some of these policies and initiatives without describing them in detail.

NOTE Other policies and initiatives are identified in the review of each additional impact category (4.2.2.4, 4.3.2.4, 4.4.2.4, 4.5.2.4, 4.6.2.4 and 4.7.2.4).

a) EU level:

1) The Single Market for Green Products Initiative and Product Environmental Footprint (http://ec.europa.eu/environment/eussd/smgp/index.htm);

2) The 'Resource Efficient Buildings' study for the 'development of a common EU framework of indicators for the environmental performance of buildings' (http://ec.europa.eu/environment/eussd/buildings.htm); and

3) The construction products regulation BWR7 (http:// http://ec.europa.eu/growth/sectors/construction/product-regulation/)

These initiatives consider the use of one or more of following impact categories:

— climate change,

— ozone depletion,

— ecotoxicity for aquatic fresh water,

— human toxicity – cancer effects,

— human toxicity – non-cancer effects,

— particulate matter/respiratory inorganics,

— ionizing radiation – human health effects,

— human health effect model,

— photochemical ozone formation,

— acidification,

— eutrophication – terrestrial,

— eutrophication – aquatic,

— resource depletion – water,

— resource depletion – mineral, fossil, and

— land transformation.