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Level(s) indicator 1.2: Life cycle Global Warming Potential (GWP)

User manual: introductory briefing, instructions and guidance (Publication version 1.1)

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Title
Level(s) indicator 1.2: Life cycle Global Warming Potential (GWP) user manual: introductory briefing, instructions and guidance (Publication version 1.1)

Abstract

Developed as a common EU framework of core indicators for assessing the sustainability of office and residential buildings, Level(s) can be applied from the very earliest stages of conceptual design through to the projected end of life of the building. As well as environmental performance, which is the main focus, it also enables other important related performance aspects to be assessed using indicators and tools for health and comfort, life cycle cost and potential future risks to performance.

Level(s) aims to provide a common language of sustainability for buildings. This common language should enable actions to be taken at building level that can make a clear contribution to broader European environmental policy objectives. It is structured as follows:

1. Macro-objectives: An overarching set of 6 macro-objectives for the Level(s) framework that contribute to EU and Member State policy objectives in areas such as energy, material use, waste management, water and indoor air quality.
2. Core Indicators: A set of 16 common indicators, together with a simplified Life Cycle Assessment (LCA) methodology, that can be used to measure the performance of buildings and their contribution to each macro-objective.

In addition, the Level(s) framework aims to promote life cycle thinking. It guides users from an initial focus on individual aspects of building performance towards a more holistic perspective, with the aim of wider European use of Life Cycle Assessment (LCA) and Life Cycle Cost Assessment (LCCA) methods.

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Figure 1. The Level(s) document structure

How this indicator user manual works

Level(s) is a framework of core indicators of sustainability that can be applied to building projects in order to report on and improve their performance. The supporting documentation has been designed to be accessible to all the actors that may be involved in this process.

If you are new to the assessment of building sustainability, we recommend reading the **first part of the Level(s) user manual**. This will provide you with an introduction to the basic concepts behind Level(s) and how you can apply it to a building project.

If you haven't yet set up your building project to use Level(s), including completing the project plan and the building description, then we recommend reading the **second part of the Level(s) user manual**.

This indicator user manual forms part of the third part of the Level(s) user manual where you will find instructions on how to use the indicators themselves. It is designed to help you apply your chosen indicator to a building project. It will help you to do this in the following way:

- **Introductory briefing:** This section provides an overview of the indicator, including:
  - ✓ why you may wish to measure performance with it,
  - ✓ what it measures,
  - ✓ at which stages in a project it can be used,
  - ✓ the unit of measurement, and
  - ✓ the relevant calculation method and reference standards.
- **Instructions on how to use the indicators at each level**: This section provides:
  - ✓ step by step instructions for each level,
  - ✓ what is needed to make an assessment,
  - ✓ a design concept checklist (at Level 1), and
  - ✓ the reporting formats.

  The instructions often refer to the guidance and further information section, which can be found after the instructions.
- **Guidance and further information for using the indicator**: This section provides more background information and guidance to support you in following specific steps in the instructions, including the design concepts introduced at Level 1 and the practical steps to calculate or measure performance at Levels 2 and 3. They are all cross-referenced to specific instruction steps at either level 1, 2 or 3.

This indicator user manual is structured so that once you are familiar with using the indicator and you know how to work with it, you may no longer need to refer to the guidance and background information, but only work directly with the instructions at the level of your choice.

Technical terms and definitions used

Term	Definition
Biogenic carbon	carbon derived from biomass
Biomass	material of biological origin excluding material embedded in geological formations and material transformed to fossilized material, excluding peat
Carbon dioxide equivalent (CO_2e)	unit for comparing the radiative forcing of a greenhouse gas to that of carbon dioxide
Carbon footprint (or whole life carbon measurement)	sum of greenhouse gas emissions and removals in a product system, expressed as CO_2 equivalents and based on a life cycle assessment using the single impact category of climate change
Carbon storage	carbon removed from the atmosphere and stored as carbon in a product
Design life	service life intended by the designer
Direct land use change (dLUC)	change in human use or management of land within the product system being assessed
Exported energy	energy, expressed per energy carrier, delivered by the technical building systems through the system boundary and used outside the system boundary
Fossil carbon	carbon which is contained in fossilised material
Functional unit	quantified performance of a product system for use as a reference unit
Global Warming Potential (GWP)	characterization factor describing the radiative forcing impact of one mass-based unit of a given greenhouse gas relative to that of carbon dioxide over a given period of time
Greenhouse gas (GHG)	gaseous constituent of the atmosphere, both natural and anthropogenic, that absorbs and emits radiations at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds
Greenhouse gas emission	mass of a greenhouse gas released to the atmosphere
Greenhouse gas emission factor	mass of a greenhouse gas emitted relative to an input or output of a unit process or a combination of unit processes
Greenhouse gas sink	process that removes a greenhouse gas from the atmosphere
Indirect land use change (iLUC)	change in the use or management of land which is a consequence of direct land use change but which occurs outside the product system being assessed
Maintenance	combination of all technical and associated administrative actions during the service life to retain a building or an assembled system (part of works) in a state in which it can perform its required functions
Offsetting	mechanism for compensating for all or for a part of the carbon footprint through the prevention of the release of, reduction in, or removal of an amount of greenhouse gas emissions in a process outside the boundary of the product system
Operational energy use	energy use of the building-integrated technical systems during use and operation of the building

Term	Definition
Operational water use	water use of the building-integrated technical systems and of the user, as needed for the technically and functionally defined operation of the building
Primary energy	energy from renewable and non- renewable sources which has not undergone any conversion or transformation process.
(Total) Primary energy factor	for a given energy carrier, non-renewable and renewable primary energy divided by delivered energy, where the primary energy is that required to supply one unit of delivered energy, taking account of the energy required for extraction, processing, storage, transport, generation, transformation, transmission, distribution, and any other operations necessary for delivery to the building in which the delivered energy will be used
Reference study period	period over which the time-dependent characteristics of the object of assessment are analysed
Refurbishment	modification and improvements to an existing building to bring it up to an acceptable condition
Repair	returning an item to an acceptable condition through the renewal, replacement or mending of worn, damaged or degraded parts
Required service life	service life required by the client or through regulations
Scenario	collection of assumptions and information concerning an expected sequence of possible future events
Service life	period of time after installation during which a building or an assembled system (part of works) meets or exceeds the technical requirements and functional requirements
Technical building system	technical equipment for heating, cooling, ventilation, domestic hot water, lighting and electricity production

Introductory briefing

Indicator 1.2: Life cycle Global Warming Potential (GWP)

***Note for users**: Once users have gained experience using this indicator, these instructions can also be followed in order to go a step further and carry out a cradle to grave Life Cycle Assessment (LCA) involving other impact categories than GWP.*

Why measure performance with this indicator?

This indicator aims to quantify the Global Warming Potential (GWP) contributions of a building along its life cycle from the 'cradle' (the extraction of the raw materials that are used construction the building) through to the 'grave' (the deconstruction of the building and how to deal with its building materials, i.e. recovery, reuse, recycling and disposal).

Carbon emissions embodied in building materials are brought together with direct and indirect carbon emissions from use stage performance (e.g. energy consumption and water consumption) in this indicator. Cradle to grave thinking allows for building design solutions that seek the optimum balance between embodied carbon and use stage carbon emissions. In particular with embodied carbon, it is important to recognise that buildings are a significant material bank, being a repository for carbon intensive resources over many decades, and so it is important to explore designs that facilitate the future reuse and recycling at the end of the building life.

What does it measure?

This indicator measures the greenhouse gas (GHG) emissions associated with the building at different stages along the life cycle. It therefore measures the building's contribution to emissions that contribute towards the earth's global warming, and the associated effects on climate change. This is sometimes referred to as a carbon footprint assessment or whole life carbon measurement.

At what stage of a project?

Level	Activities related to the use of indicator 1.2
1. Conceptual design (following design principles)	✓ Aspects of the building that contribute most to GHG emissions, or 'hot spots', along a buildings life cycle can be identified in order to improve design concepts;
2. Detailed design and construction (based on calculations, simulations and drawings)	✓ The greenhouse gas emissions associated with a building design and each life cycle stage can be calculated and modelled. The emissions from different design scenarios and future life cycle scenarios can be tested;
3. As-built and in-use (based on commissioning, testing and metering)	✓ The building materials used and assumptions made in order to calculate the life cycle greenhouse gas emissions can be validated against the as-built information as it becomes available.

Unit of measurement

The indicator is measured according to the Global Warming Potential (GWP) of the greenhouse gases emitted. The unit of measurement is kg CO_2 equivalents per m^2 useful internal floor area for a reference study period of 50 years. The results are to be reported for each life cycle stage, of which there are four – production (A), use (B), end of life (C) and additional benefits and loads (D).

In cases where users wish to go a further step and carry out a cradle to grave LCA using the same methodology as for indicator 1.2, then the indicator will also report on nine other environmental impact category indicators in addition to GWP. These indicators are detailed further in the supporting guidance under L2.6.

System boundary

The system boundary is 'cradle to grave' as defined by EN 15978, i.e. from the production of building materials to the end of the building's useful life and the subsequent demolition and recovery of the building materials. It is

defined in terms of life cycle stages, which are in turn split into modules as defined by EN 15978:

- The product stage (A1-5)
- The use stage (B1-6)
- End of life stage (C1-4)
- Benefits and loads beyond the system boundary (D)

This boundary includes both the assessment of use stage greenhouse gas emissions (those directly associated with the energy used for heating, cooling and supplying electricity to a building), and 'embodied' greenhouse gas emissions (those that are indirectly the result of the construction, repair, maintenance, renovation and eventual deconstruction of a building). Emissions are accounted for in the life cycle stage where they occur so if, for example, a renovation takes place, the emissions associated with new building materials would be allocated to the use stage.

Scope

For the purpose of comparability, a minimum scope of building elements, components, products and materials to be assessed is defined within the Level(s) building description (see the User Manual 2 document – Completing the building description).

Calculation method and reference standards

The main reference standard providing the calculation method is EN 15978. Reference is also made to ISO 14040/44, EN 15804 and the European Commission's Product Environmental Footprint (PEF) method. The detailed calculation method, including the 'characterisation factors' used to convert energy use to CO_2 equivalent emissions (the Global Warming Potential), is summarised in the accompanying technical guidance in this document. The guidance assumes that calculations are made using a software tool that is pre-programmed with calculation routines from the EN 15978 standard.

Instructions on how to use the indicator at each level

Instructions for Level 1

L1.1. The purpose of this level

This Level is for those who do not intend to *calculate* the life cycle GWP emissions of their building project. Instead it provides instructions on:

- How to incorporate some important life cycle concepts into design concepts and, later, into detailed designs.
- How to interpret and use the results of previously carried out life cycle GWP assessments and Life Cycle Assessments that are based on the analysis of similar building types.

L1.2. Step-by-step instructions

These instructions should be read in conjunction with the accompanying Level 1 technical guidance and supporting information (see page 15).

1. Read the section on Whole Life Cycle thinking in User Manual 1, if required.
2. Make sure to have completed the Level(s) building description (see User Manual 2 for further details), as some of the information may be needed to check the relevance of design concepts.
3. Consult the checklist of life cycle design concepts in section L1.4 below and read the background descriptions in Level 1 supporting guidance later in this document.
4. *Optional step:* make a review of relevant LCA/whole life carbon studies of similar building types in the same country and, preferably, the same region or locality.
5. *Optional step*: Interpret and identify 'hot spots' and recommendations for improvements along the building life cycle from the studies reviewed.
6. Within the design team, review and identify options for using the life cycle design concepts and for addressing the hot spots identified from previous studies.
7. Once the design concept is finalised with the client, record the life cycle design concepts that were taken into account using the L1 reporting format.

L1.3. Who should be involved and when?

Actors involved at the conceptual design stage, usually led by the concept architect. The life cycle design concepts can be further explored once professionals such as a structural engineer, quantity surveyor and property market expert become involved in the project.

L1.4. Checklist of relevant design concepts

The following design concepts have been identified from a review of scientific literature by the Joint Research Centre as having a basis in a robust life cycle analysis of hot spots for environmental impact. Moreover, they provide scope to inform design concepts and to improve performance without necessarily having to make a new Life cycle GWP assessment.

Level 1 design concept	Brief description
1. Efficient building shape and form	✓ Minimise the surface area to volume ratio of a building and individual residential units, as well as its height, in order to improve material efficiency and minimise energy use.
2. Optimised NZEB construction	✓ Consider the potential trade-off between reducing CO_2 emissions in the use stage to achieve NZEB performance levels and the embodied energy CO_2 emissions associated with the manufacture of higher performance insulation,

Level 1 design concept	Brief description
	façade and wall systems, windows, structural thermal mass and renewable energy technologies.
3. Optimised material utilisation and circular value	✓ Consider the feasibility of reusing the structure of an existing building or for optimising the structural design of a new building in order to minimise material use. ✓ Consider options to minimise or even design out waste generated during product manufacturing, construction on-site in order to optimise the utilisation of materials on a construction site.
4. Extending building and component service lives	✓ Consider the options to extend the lifespan of significant building components and to minimise the number of replacement and renovation cycles.
5. Design for adaptability	✓ Consider the potential of the building design to adapt and be flexible to changing market and occupier needs in the future so as to extend the life of the building, including its structure and main elements.
6. Design for deconstruction	✓ Consider how the building design and information records about the building's material bank can facilitate future end of life deconstruction in order to recover materials for re-use and recycling.

It can be seen that improvements against many of these 'hot spots' can be measured using other indicators from the Level(s) framework. For example, indicator 1.1 (use stage energy consumption), indicator 2.1 (bill of quantities, materials and lifespans), indicator 2.2 (construction and demolition waste and materials), indicator 2.3 (design for adaptability and renovation) and indicator 2.4 (design for deconstruction and recycling).

L1.5. Reporting format

To complete the reporting format for Level 1 you should answer yes or no for each of the design concepts that you have addressed and then provide brief descriptions of the measures or decisions taken for each one.

Life cycle design concept	Addressed? *(yes/no)*	How has it been incorporated into the building design concept? *(provide a brief description)*
1. Efficient building shape and form		
2. Optimised NZEB construction		
3. Optimised material utilisation and circular value		
4. Extending building and component service lives		
5. Design for adaptability		
6. Design for deconstruction		

Instructions for Level 2

L2.1. The purpose of this level

This Level is for those who intend to calculate the life cycle GWP emissions of their building project. It provides instructions on:

- How to use the Level(s) building description.
- How to select software tools and databases.
- The basic parts of the calculation and the calculation steps according to the standard EN 15978.
- Additional information and assumptions beyond the EN standard that can be used to make a calculation, including default parameters that shall be used and data gap filling.
- How to interpret and use the results from a 'hot spot' analysis.

The instructions and methodology may also be used by those who wish to go a step further and carry out a cradle to grave LCA.

L2.2. Step-by-step instructions

The assessment process must be followed in order to produce reproducible and comparable results. It is important that all assumptions used and any deviations from the standardised method are recorded in the reporting for indicator 1.2 and, if you go a step further, for a cradle to grave LCA. Also see the accompanying Level 2 technical guidance and supporting information (see page 18).

1. Make sure to have completed the Level(s) building description, as the information is required in order to make the assessment (see User Manual 2 for further details).
2. Select a life cycle software tool that can be setup to make life cycle calculations according to EN 15978 for the GWP impact category and ensure that you or a relevant team member using it has at least basic training in its use (consider the supporting guidance later in this document when deciding which software tool(s) to use).
3. Setup the model for the project based on the Level(s) building description and follow the detailed guidance later in this document for defining the scope of building elements, the reference study period, the use of cut-offs and the scope of life cycle stages.
4. Determine the scope of the life cycle scenarios that will be calculated – consult the detailed guidance in order to select the scenarios recommended for Level(s) and to develop assumptions.
5. Identify data sources from available databases, including EPDs, and use representative average data and additional data to fill any gaps (consider the supporting guidance later in this document which database(s) to use).
6. Make a classification of the data quality of each source of data using the data quality assessment method (see the supporting guidance for level 2 later in this document).
7. Process the data and assumptions using the chosen life cycle software tool.
8. Use the chosen software tool to compile the life cycle inventory and calculate the related impacts for the impact category life cycle GWP.
9. *Going a step further:* If an LCA software has been used, the option can be taken to calculate the impacts for the full set of environmental impact categories specified in EN 15978.
10. Interpret the results, which could include analysis of different designs, the identification of hotspots, the identification of any trade-offs and accounting for uncertainty and the quality of data.
11. Within the design team, review and identify options for addressing the hot spots identified, as well as any trade-offs.

12. If possible, make improvements to the design until reaching a design freeze prior to going to market to select a contractor.
13. Complete the reporting format with the results and main assumptions, together with a concise background report for the client.

L2.3. What do you need to make an assessment?

The main items needed are as follows:

- ✓ a completed Level(s) building description,
- ✓ the complete bill of quantities for the building design(s) that will be modelled,
- ✓ a calculation software tool with the correct functionalities and
- ✓ access to databases and EPDs that have a good coverage of the construction products planned to be used.

L2.4. Who should be involved and when?

Those members of the project team involved at the design stage should be involved, led by the technical architect. The support of other professionals such as a structural engineer, quantity surveyor, contractors (for demolition and construction) and a property market expert may become relevant for the modelling of certain life cycle scenarios.

L2.5. Ensuring the comparability of results

The standardised basis for ensuring the comparability of Level(s) life cycle GWP assessments is:

- A calculation routine that is compliant with EN 15978.
- A calculation routine that is compliant with the additional Level(s) requirements, as required for any software tools used.
- The use of life cycle inventory data from EPDs and databases that are compliant with EN 15804 and for which a data quality assessment has been provided, as a minimum according to the Level(s) guidance (see the supporting guidance later in this document, L2.4: Steps 5-6).

L2.6. Going a step further

Once users have gained experience with following the instructions and obtaining results for the single environmental impact category, life cycle GWP, there is the potential to use Life Cycle Assessment (LCA) software in order to obtain results for the full set of environmental impact categories specified in EN 15978. The steps to follow are essentially the same, being based on the preparation of life cycle inventory data, but the main difference can be found in the results and their interpretation. The relevant impact categories are detailed in the guidance under L2.6.

L2.7. Format for reporting the results of an assessment

The reporting format for GWP at each life cycle stage is presented in tabular form below.

Indicator	Unit	Product (A1-3)	Construction process (A4-5)	Use stage (B1-7)	End of life (C1-4)	Benefits and loads beyond the system boundary (D)
(1) GWP - fossil	kg CO_2 eq					
(2) GWP - biogenic	kg CO_2 eq					
GWP – GHGs (1+2)	kg CO_2 eq					
(3) GWP – land use and land use change	kg CO_2 eq					
GWP – overall (1+2+3)	kg CO_2 eq					
Notes:						

Impacts referred to the use of 1 m^2 of useful internal floor per year for a default reference study period of 50 years[1].

Instructions for Level 3

The same procedure and instructions as defined in Level 2 can be equally applied to the building assessment after its construction or renovation. The only difference would be that the design data is supported by the certainty of materials procured and technical building systems installed instead of being based on a design only.

[1] A further table shall be prepared if, in addition to the reference study period, an intended service life has been modelled.

Guidance and further information for using the indicator

For using level 1

Additional background guidance and explanations are provided for two key concepts introduced in the Level 1 life cycle GWP design concept checklist, namely:

- L1.2. Step 4: Using and interpreting existing life cycle assessment studies and literature
- L1.4. General background to life cycle design concept checklist

L1.2. Step 4: Using and interpreting existing life cycle assessment studies and literature

A brief introduction is provided here to some of the key factors to take into account when reviewing life cycle GWP or LCA studies. Note that LCA studies often include assessment of the impact category life cycle GWP.

At a basic level, the following information shall be gathered about each study reviewed:

- General information: year of publication, authors, journal/source, article title, region.
- Life cycle stages considered: manufacture, Use, End-of-life, System boundaries.
- Technical aspects: the functional unit, building lifetime, type of building (object of assessment).
- Methodological aspects: environmental impact categories, assessment method, main database used, software, data quality and data quality rating.
- Results and interpretation: hot spots, technology comparison.

These following factors are important because they can help to understand the basis on which the study has been carried out and the extent to which the findings can be relevant to your specific project. The reason for collecting this information is explained further below for some of the most important items:

- Object of the studies: The building(s) studied should have representative features of the building project being assessed using Level(s).
- Goal and scope: Ideally studies should have a scope that is cradle-to-grave.
- Functional unit, system boundaries and life time:
  - The functional unit refers to a quantified performance of a product system for use for comparisons on the basis for functional equivalence in LCA studies. Findings from studies are difficult to compare if a different functional units have been used e.g. impacts normalised by m2 of floor area or with impacts normalised by occupation.
  - The system boundary describes which processes are taken into account in the LCA analysis and which processes are not. For example, the manufacturing of construction products for repair or replacement.
  - The lifetime is the reference duration that the building will be in service. The default for life cycle GWP and LCA in Level(s) is 50 years.
- Time-related coverage of data: This refers to the year the inventory data of the analysis is based on. Studies should ideally be less than 4 years old.
- Comprehensiveness and robustness: This refers to which environmental impacts are considered in the study. Only GWP is relevant in all cases for indicator 1.2. If users wish to look further (i.e. beyond GWP impacts) the other impact categories should be compared with those specified by EN 15978. Attention should also be paid to the LCA methodologies used.

- Assumptions: It is important to understand some of the main technical assumptions made in the selected life cycle GWP or LCA studies. These include how the specification of the building and its services, how the building is used by the occupants and by how many future repair/replacement cycles are foreseen.
- Data quality level: The mix of primary and secondary data sources are important to understand as it will determine the extent to which the results reflect the real specifications of the building studied or a building with generic construction materials. The time-related, geographical and technological representativeness of the selected LCA studies are important aspects of any data quality assessment.

L1.4. General background to the life cycle design concept checklist

As part of the development of Level(s), the JRC made a review of LCA studies in published literature in order to identify the key hot spots for the environmental impact of buildings. This literature and the hot spots identified from it, forms the basis for the Level 1 design checklist. The background to each of the checklist items is briefly summarised below, together with identification of the life cycle stages that can be influenced.

Design concept 1: Efficient building shape and form

Life cycle stages influenced: prior to stages A1-3

The surface area to volume ratio of a building, also sometimes referred to as its density or compactness, as well as its height, strongly influences the material efficiency and energy use of a building. A more compact building form may use more than 20% less materials in construction and consume 20% less energy in the use stage. The intensity of use of a building also influences its material efficiency. This can be measured on a temporal basis (e.g. the proportion of time the space is used during the day or week) or a functional basis (e.g. use of the resource invested in the building per household, person or workstation instead of per m^2).

Design concept 2: Optimised NZEB construction

Life cycle stages influenced: A1-3, B4-6

This aspect applies to both new-build and major renovation projects, in which the trade-off between the following life cycle modules should be considered. For new buildings, the construction phase has become proportionally more important as new buildings are now required to achieve high performance in Nearly Zero Energy (NZEB) standards:

- Use stage energy consumption (B6): The use phase of buildings is the most important life cycle hot spot for old buildings that may undergo renovation. This is because of primary energy use for, in particular, space heating, hot water and lighting;.
- Production stage energy consumption (A1-3): The move to nearly zero energy buildings (NZEBs), whilst reducing use-stage energy consumption, requires more embodied energy to be used to manufacture higher performance insulation, windows, façade systems, thermal mass and renewable energy technologies.

From a life cycle CO_2 emissions perspective, a building structure can account for some 30-64% of embodied emissions. Facades made of glass and metal are a specific consideration, as they may have a replacement cycle of less than 20-30 years, so a focus on use stage B4 and potentially also end of life stages C1 and C4 would be beneficial. The replacement cycle for certain façade designs is a key consideration because of the tendency towards the use of flexible curtain wall systems incorporating glazing and louvres.

Considerations at the point of renovation are components such as new paint, window frames and copper piping and wiring. This is because as well as contributing to life cycle GWP, they have the potential to contribute to toxicity impact categories.

Design concept 3: Optimised material use cycles

Life cycle stages influenced: A1-3

As has already been mentioned, the structure of a building in can typically account for over half of the embodied greenhouse gas emissions associated with construction. By reusing the structure of an existing building or by

optimising the structural design of a new building, significant reductions in material use and associated GHG emissions can be made. Evidence suggests that by optimising structural designs, material use can be reduced by 20-36% whilst still maintaining the required technical characteristics.

Design concept 4: Extending building and component service lives

Life cycle stages influenced: B4-6

The lifespan, or useful service life of the building, as well the service life of its components, are important factors influencing construction and use phase impacts. In general, the more replacement and renovation cycles that are needed, the greater the embodied impact. This is particularly the case for the renovation of building services, including wiring and piping, as well as finishes, such as paints.

Design concept 5: Design for adaptability

Life cycle stages influenced: B4-6

The potential for buildings to adapt and be flexible to changing market and occupier needs will extend the lifespan of the building, including its structure and main elements. Considerations include:

- Adaption to the changing needs of occupiers over time, and adaption to changing demands in the property market over time.
- More efficient use of space: More effective usage as occupier needs change, for example as a business or family expands, which in turn may bring higher space utilisation;
- Increased longevity: Extension of the total lifetime of a building, ensuring that this lifetime reflects the design life of components and major structural elements.
- Improved operational performance: Ease of change to new, more efficient technology as it becomes available.
- Adaption to new technology, with the potential for future upgrades of lighting, heating, cooling, ventilation and energy generation systems.

Major changes to a building's internal layout and fittings can contribute to significant aggregate embodied emissions over a 50 year reference service life. Measures that can minimise the number of interventions needed to keep the building on the property market will thus have a positive effect. Specific design aspects that can be taken into account are listed under indicator 2.3.

Design concept 6: Design for deconstruction

Life cycle stages influenced: C1-4

Waste generated during product manufacturing, construction on-site and demolition processes can account for a significant proportion of the overall material flows on a construction site and, if not reused or recycled, can lead to wasted resources.

Building elements such as structures, envelopes and facades account for the majority of the embodied environmental impacts of constructing a building. As a result, any progress to achieve 'circularity' by reusing these materials – either in situ within a new building or on another site, or by recycling them to make new building products – will serve to progressively reduce the embodied life cycle impacts of the building sector as a whole.

Buildings can be designed so that at the end of their useful life, they can easily be deconstructed, thereby making it easier to access and use the buildings material bank. Specific design aspects that can be taken into account are listed under indicator 2.4.

For using level 2

This guidance is directed at entry-level users and assumes that a software tool will be used to obtain results. It therefore focusses on aiding a user's understanding of the basic processes that they will have to understand when using a software tool that follows EN 15978 calculation routines and in order to make decisions about the data used. The specific topics covered are as follows:

- L2.2 – Step 2: Selecting software tools and databases
- L2.4 – Step 3: The calculation process for life cycle GWP
- L2.4 – Step 3: Calculation rules relating to the life cycle stages
- L2.4 – Step 4: Scenarios for the building life cycle
- L2.4 – Step 10: Carrying out a hot spot analysis
- L2.4 – Step 5 and 6: Data selection and quality
- L2.6 - Going a step further – Optimisation steps to improve the assessment and building performance

L2.2. Step 2: Selecting software tools and databases

In order to use indicator 1.2, it is assumed that in most cases a software calculator tool will be used. To further support Level(s) users, a listing has therefore been developed of software calculation tools and supporting databases that can be used to make an assessment using indicator 1.2. The listing is provided separately to this user manual and can be downloaded here.

The listing classifies tools and databases according to a list of parameters and criteria addressing three key aspects that they offer in varying degrees:

- Comprehensiveness: Whether the tools are specific for construction, the building elements they cover, the life cycle stages they cover and the indicators for which they calculate results.
- Robustness: The extent to which the calculation rules are aligned with EN 15978/15804, how data quality is accounted for and transparency in reporting data sources and assumptions.
- Operability: Accessibility of the software to users, interoperability with other software, the cost and available training and support.

Learn more about:

Minimum requirements that tools and databases shall fulfil to support a Level(s) assessment

Comprehensiveness

- Level(s) compliance-tick mark box

Robustness

- Alignment of EPDs with EN 15804+A2
- High-quality and industry-specific data

Operability

- User-friendliness, the availability of training and flexible pricing
- Interoperability, plug-in info, import/export interfaces for relevant data formats (e.g. to read in data from BIM and other CAD systems, and to exchange LCI data).

Additional requisites

- 'Official' approval and validation of tools by national authorities
- External independent and qualified review of data

Developers and users were consulted to provide input with respect to the tools and databases available on the market, the classification criteria and the key characteristics of the tools and databases. The classification is based on what has been judged to be relevant information for users of the Level(s) guidance, but is not meant as a ranking

system. Possible commercial bias in providing the information has been controlled through additional verification by experts.

Table 1 provides an overview of the criteria used to list and provide information about available LCA software and databases.

Table 1. The Level(s) criteria used to list LCA software and databases

Parameter	Software tools	Databases
A. Comprehensiveness		
A1) Construction-specificity	I) Construction-specific II) Broader scope	I) Construction-specific II) Broader scope
A2) System boundaries & scope	• Allowing the assessment of the following EN 15978 modules A0: 'Pre-construction stage' A1-A3: 'Product stage' (material extraction and processing, transport, manufacturing) A4-A5: 'Construction process stage' (transport to the building site, and installation) B1-B5: 'Use stage – building fabric' (use or application, maintenance, repair, replacement, refurbishment) B6-B7: 'Use stage - operation of the building' (operational energy and water use) B8: users' activities C1-C4: 'End-of-life stage' (de-construction & demolition, transport, waste processing for reuse, recovery and/or recycling, disposal) D: 'Benefits and loads beyond the system boundary' Extra: Separate reporting [Y/N] • Databases used • End of Life scenario information and modelling (if applicable) • Languages available	• Allowing the assessment of the following EN 15804 modules A1-A3: 'Product stage' (material extraction and processing, transport, manufacturing) A4-A5: 'Construction process stage' (transport to the building site, and installation) B1-B5: 'Use stage – building fabric' (use or application, maintenance, repair, replacement, refurbishment) B6-B7: 'Use stage - operation of the building' (operational energy and water use) B8: users' activities C1-C4: 'End-of-life stage' (de-construction & demolition, transport, waste processing for reuse, recovery and/or recycling, disposal) D: 'Benefits and loads beyond the system boundary' Extra: Separate reporting [Y/N] • End of Life scenario information (if applicable) • Countries covered • Languages available
A3) Indicators	I) Full coverage of indicators set in EN 15978:2011 II) Full coverage of indicators set in EN 15978:2011 III) Full coverage of indicators set in EN 15978:2011 IV) Partial coverage of indicators set in EN 15978:2011 in addition to GHG emissions (please specify which indicators) V) GHG emissions only Extra: LCC coverage	I) Full coverage of indicators set in EN 15804:2012+A2:2019 II) Full coverage of indicators set in EN 15804:2012+A1:2013 III) Full coverage of indicators set in EN 15804:2012+A1:2013 IV) Partial coverage of indicators set in EN 15804:2012+A1:2013 in addition to GHG emissions (please specify which indicators) V) GHG emissions only Extra: LCC coverage
A4) Modelling granularity	Options for the assessment, from the most to the least detailed: a) Specific parts of the building	Options for the assessment, from the most to the least detailed: a) Building material

Parameter	Software tools	Databases
	b) Whole building, with enough flexibility to adapt to specificities of the building c) Whole building **Note: a part can refer to one or more construction products**	b) Whole building part with enough flexibility to adapt to specificities of the product c) Whole building part **Note: a part can refer to one or more construction products**
B. Robustness		
B1) Methodological adherence to Levels and EN standards	I) Aligned with EN 15978 with extension to fit with Level(s) II) Aligned with EN 15978 – either based on self-declaration or external evaluation III) Not aligned for specific aspects **Note: Class I recommended**	I) Aligned with EN 15804 with extension to fit with Level(s) II) Aligned with EN 15804 III) Not aligned for specific aspects Extra: • EN 15804:2012+A1:2013 or EN 15804:2012+A2:2019 **Note: Class I recommended**
B2) Data quality	The tool supports: a) Reliability assessment of the quality of the data input b) Sensitivity analysis (e.g. check influence of parameters and datasets on results) c) Uncertainty analysis (e.g. check variability of results) d) Scenario analysis (e.g. check of alternative options) e) None of them	The database provides/enables data quality assessment for the following aspects: a) Geographical representativeness (e.g. local vs. EU/global average) b) Time-related representativeness (e.g. plausible until a certain year) c) Technological representativeness (e.g. material-specific vs. generic) d) Uncertainty analysis is supported (e.g. uncertainty distributions provided) e) None of them Extra: Specify whether the database provides data quality assessment or enables it when adapting a dataset. **Note: The provision and use of high-quality and representative data (in terms of geography, time, technology, and accuracy) is recommended**
B3) Transparency and verification	I) Sources of information, key data and modelling assumptions are trackable and verifiable, or have been documented in detail inside the software (data available and accessible at unit process level) II) Sources of information, key data and modelling assumptions are reported, but they are not trackable and verifiable nor they have been documented in detail inside the software III) Sources of information, key data and modelling assumptions are not documented inside the software Extra:	I) Sources of information, key data and modelling assumptions are trackable and verifiable, or have been documented in detail (data available and accessible at unit process level) II) Sources of information, key data and modelling assumptions are reported, but they are not trackable and verifiable nor they have been documented in detail III) Sources of information, key data and modelling assumptions are not documented Extra: • Proportion (%) of data that has been verified by a third party

Parameter	Software tools	Databases
	• Proportion (%) of data that has been verified by a third party • National authority validation **Note: Third party verification and national authority validation are recommended**	• National authority validation **Note: Third party verification and national authority validation are recommended**
C. Operability		
C1) Accessibility	a) Web interface b) Excel-based tool c) Software to install on a computer/server **Note: options not listed in a hierarchy order**	a) Datasets provided at the detail level of unit processes b) System process datasets or EPDs providing elementary flows and/or quantified indicators ("black-boxes") c) Information locked in specific software
C2) Data exchange & interoperability	I) Import/export of design and LCA information possible II) Import/export of design information possible (e.g. BIM) III) Import/export of LCA information possible IV) No import/export possible Extra: • Provision of conversion factors between measurement units [Y/N] • Software-independency [Y/N] **Note: Class I recommended**	I) Import/export of LCA information possible (e.g. import new material EPDs into the database) II) No import/export possible Extra: • Provision of conversion factors between measurement units [Y/N] • Software-independency [Y/N] **Note: Class I recommended**
C3) Cost	I) Freely available II) Available at a commercial price	I) Freely available II) Available at a commercial price
C4) Training and support	a) Demo version, documentation and/or initial training available for free b) Long distance learning offered c) After sale support offered (e.g. helpdesk) d) No training support **Note: a+b+c recommended**	a) Demo version, documentation, and/or initial training available for free b) Long distance learning offered c) After care support offered (e.g. helpdesk) d) No training support **Note: a+b+c recommended**
D. Additional information	Example: - Background information about maturity, development, management and update of the tool	Example: - Background information about maturity, development, management and update of the database - Breadth of the database: number of materials, types of construction materials and equipment covered, level of detail, level of adaptation provided.

L2.2. Step 3a: The calculation process for life cycle GWP

The Level 2 instructions provide a set of generic steps that users can follow in order to make an assessment. The standardised basis for these steps is the methodological process set out in EN 15978. Figure 2 provides an overview of the methodological steps in EN 15978. The first two steps are already be addressed by completing the Level(s) building description, which provides the following items of data:

- The intended use of the building: The building type and conditions of use.
- The functional unit of equivalence: kg CO_2 equivalents per m^2 of useful floor area over a reference study period of 50 years.
- The system boundary: The whole 'cradle to grave' life cycle encompassing stages A,B,C and D for which calculations shall be made.
- The building model: The minimum scope of building elements for which calculations shall be made.

This information can then be used as the basis for setting up the model of the building's life cycle. More information about the mass and energy flows, for which data will be required, is provided in the box below. In the case of any significant gaps in the data, assumptions or scenarios for specific life cycle stages or building elements, default or generic data, assumptions or scenarios may be used but must be declared in the reporting.

Learn more about:

The mass and energy flows used to make the calculations

The indicator calculates the Global Warming Potential along the life cycle of a building by splitting the greenhouse emissions that arise at different life cycle stages into:

1. Direct emissions, e.g. those coming from on-site power generation, refrigeration and air-conditioning equipment.
2. Indirect emissions, i.e. those coming from production and distribution of electricity and steam/heat used in the building and from the production and supply of materials and construction products of which the building is made up. For construction products, the term 'embodied' emissions is often used.

Mass and energy flows of the building have to be quantified based upon the design description of the building (a new building or refurbishment of an existing building) or with the actual quantities (post-completion, post-refurbishment) and the scenarios for each module of the life cycle of the object of assessment.

To facilitate the quantification, the building is separated into:

- its constituent parts (all building elements, building components, building products, building materials), which are the object of indicator 2.1;
- related processes such as transport, construction, maintenance, repair, replacement, end-of-life processes;
- operational use (energy, water), which are the object of indicators 1.1 and 3.1, respectively.

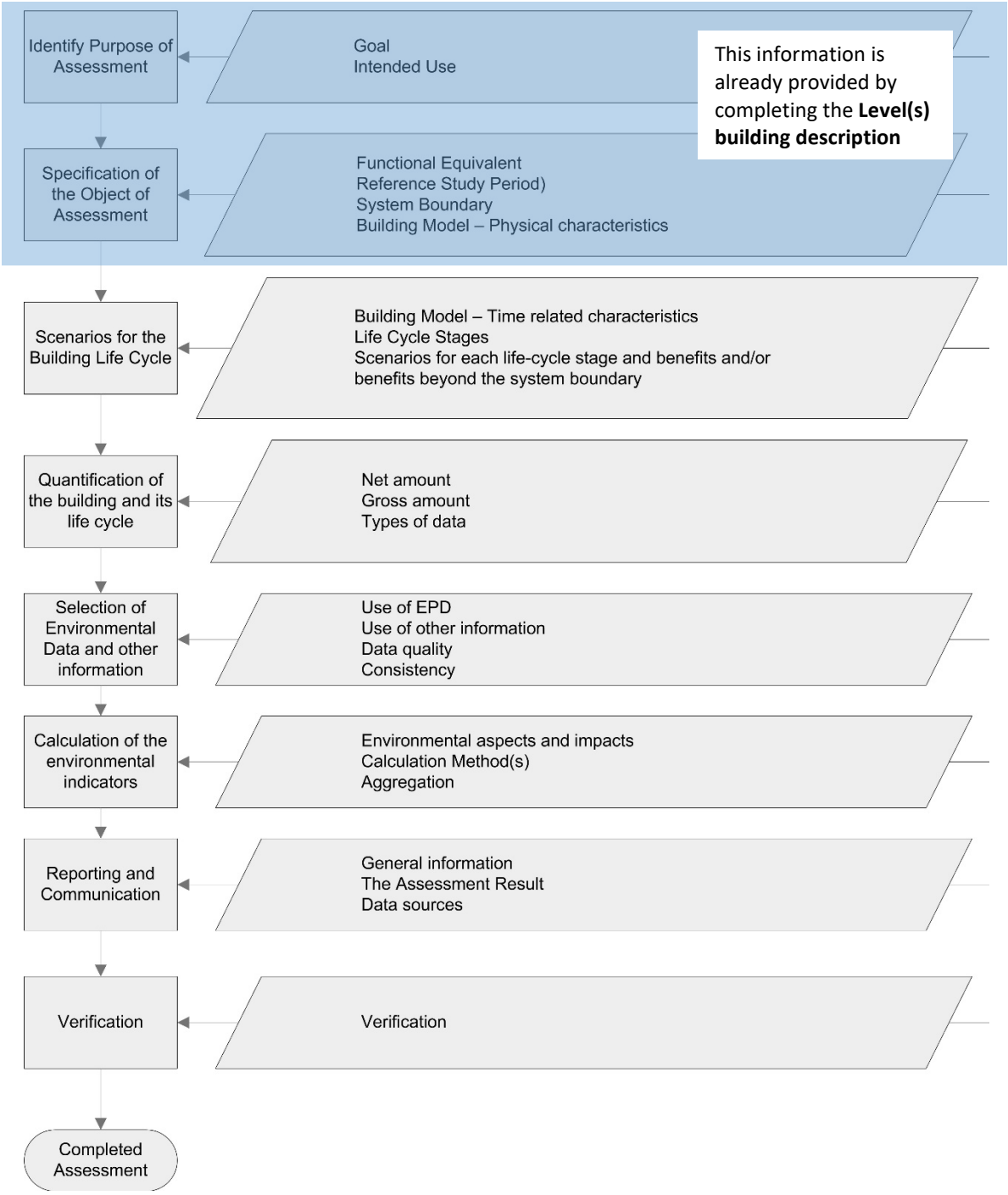

Figure 2. Flow chart of the process for making an assessment according to EN 15978[2]

[2] Adapted from CEN 2011. EN 15978. Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method.

L2.2. Step 3b: Calculation rules relating to the life cycle stages

In order make an assessment using indicator 1.2, it is important to understand the life cycle stages that are represented graphically in Figure 3. For each life cycle stage, there are associated calculation rules, which must be taken into account. More detailed descriptions of the modules within each life cycle stage are provided in table 2.

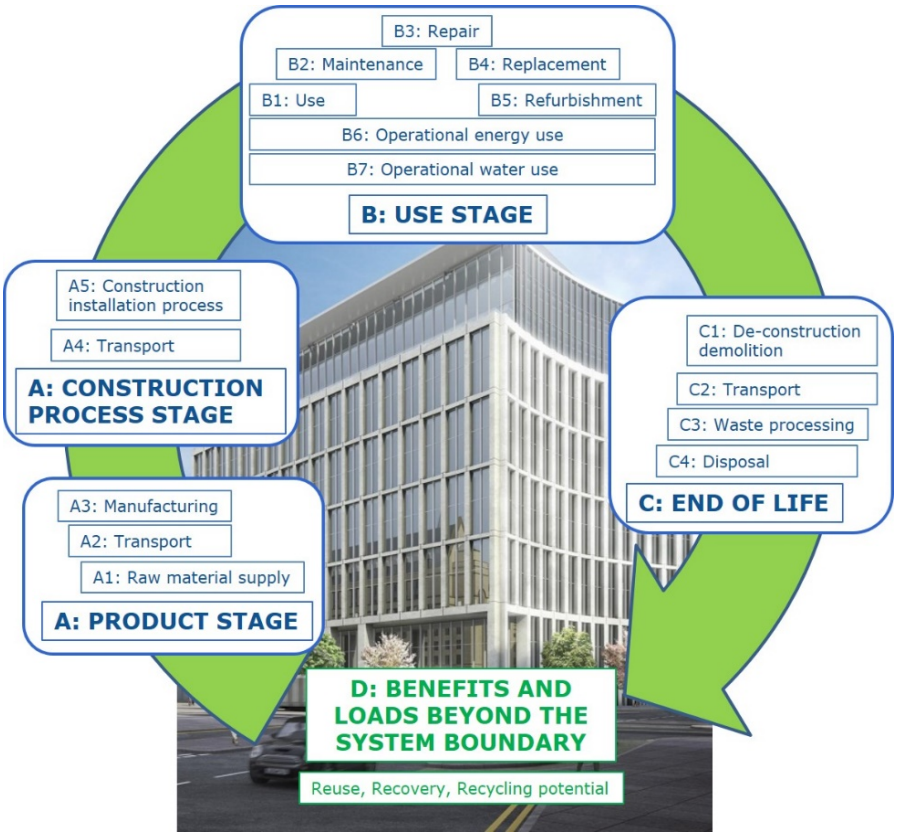

Figure 3. The stages in a buildings life cycle [3]

<u>The system boundaries and life cycle stages for new and renovated buildings</u>

The system boundary for **new buildings** shall encompass all the life cycle stages illustrated in Figure 3. For **major renovations** of existing buildings, the system boundary shall encompass all life cycle stages that relate to the extension of the building's service life. In practice, this means B1 onwards as the stages relating to the original production (A1-3) and construction (A4-5) have already taken place.

Any omission from the system boundary, for the purpose of making a performance assessment using the Level(s) framework, shall be clearly stated in the reporting. Guidance on the statements that should accompany the reporting is provided within this section.

For each life cycle stage (or module) to which impacts are assigned, the system shall include all upstream and downstream processes needed to establish and maintain the function of the building. This shall include the point where materials and energy exit the system boundary during or at the end of the building's life cycle – referred to in the reference standard EN 15978 as life cycle Module D.

[3] Adapted from CEN 2011. EN 15978. Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method.

In some cases, existing buildings on the site to be developed may be need to be demolished prior to the construction of a new building, or an existing building may be the subject of strip out or remodelling works prior to a major renovation. In both of these cases, the benefits and loads arising from the recovery of demolition or strip out materials shall be considered to be outside of the system boundary. The benefits and loads must therefore be allocated to the previous building in order to avoid double counting.

Understanding the activities and processes assigned to each life cycle stage

In order to model and analyse a buildings life cycle performance, it is important to understand the concept of life cycle stages. EN 15978 defines four main life cycle stages and these are divided into modules to which environmental impacts associated with activities and processes are assigned. An overview of the life cycle stages and associated modules is presented in Table 2.

Table 2. Summary descriptions and rules for the life cycle stages and modules

Life cycle stage	Modules	Description and rules
Production stage	**A1-3**	The boundary for modules A1 to A3 covers the 'cradle to gate' processes for the materials and services used in the construction; the rules for determining their impacts and aspects are defined in EN 15804.
	A3-4	The construction process stage covers the processes from the factory gate of the different construction products to the practical completion of the construction work.
Use stage	**B1-5**	The use stage covers the period from the practical completion of the construction work to the point of time when the building is deconstructed/demolished. The system boundary includes: - the use of construction products and services for protecting, conserving, moderating or controlling the building; - scenarios for maintenance including cleaning, operation and replacement of machinery; - impacts and aspects of the building-integrated technical system and building-related furniture, fixtures and fittings.
	B6	The boundary shall include energy used by building-integrated technical systems during the operation of the building.
	B7	The boundary shall include all water used and its treatment (pre- and post-use) during the normal operation of the building (excluding during maintenance, repair, replacement and refurbishment),
End of life stage	**C1-4**	The end-of-life stage of a building starts when the building is decommissioned and is not intended to have any further use. At this point, the building's demolition/deconstruction may be considered as a multi-output process that provides a source of materials, products and building elements that are to be discarded, recovered, recycled or reused [4].
Benefits and loads beyond the system boundary	**D**	Components for reuse and materials for recycling and energy recovery are considered as potential resources for future use. Module D quantifies the net environmental benefits or loads resulting from reuse, recycling and energy recovery resulting from the net flows of materials and exported energy exiting the system boundary.

[4] The scenarios for these end-of-life options for the products and materials determine the system boundary.

Learn more about:

Examples of how to assign impacts to life cycle stages and modules

Example 1: Repairs

All impacts and aspects due to the unscheduled replacement of a broken window pane in the use stage, which includes production, transport, use of ancillary materials, packaging waste and recycling, are assigned to 'Repair', module B3.

Example 2: Replacements

All impacts and aspects due to the scheduled replacement of a complete window (glazing, frame, handles, and locks etc.) in the use stage, which includes production, transport, use of ancillary materials, packaging waste and recycling, are assigned to 'replacement', module B4.

Example 3: Refurbishments

All impacts and aspects due to the replacement of all the windows in a façade, (glazing, frame, handles, and locks etc.) as part of a major renovation in the use stage, which includes production, transport, use of ancillary materials, packaging waste and recycling, are assigned to 'refurbishment' module B5.

Adapted from CEN (2011)

The reference study period

The reference study period is the period over which the time-dependent characteristics of the building are to be analysed. Level(s) assessments shall be carried out for a reference study period of 50 years. Any deviations from this shall be clearly stated and reasons explained. The reference study period may differ from the required service life.

In addition, it should be noted that:

- Absolute impacts at pre-construction stage (Module A0), product stage (modules A1, A2, A3), construction/process stage (modules A4, A5), and end of life stage (modules C1-C4) are independent of the value of the reference study period.
- Absolute impacts of use stage (modules B1-B7 and B8), and benefits and loads presented in module D that come from modules B1-B7 and B8, are proportional to the length of the reference study period. The opposite applies when results are normalised to m^2 per year.
- Scenarios that compare refurbishment with demolition and new construction, and that potentially lead to an extension on the service life have to refer to an equivalent new building. The full value of impacts and aspects for both the actual required service life and the extension to the service life must be taken into account.

Simplified options for calculating life cycle GWP

It is anticipated that, over time, the better availability of data and software tools, as well as improved access to professional training, will facilitate the calculation of life cycle GWP across the EU. In the short term, however, Level(s) encourages design professionals to start calculating life cycle GWP by carrying out simplified assessments that focus on a reduced number of life cycle stages and building elements.

Two simplified approaches may be used. In option 1, a simplified approach may be adopted by focussing on the possible trade-off between the embodied impacts of construction materials and achieving a Net Zero Energy Building (NZEB) performance. This is particularly important because the impacts associated with the manufacture of construction materials will already have taken place upon completion of the building and, moreover, can be directly influenced by design decisions.

In addition to the embodied impacts associated with construction materials, the use stage modules relating to maintenance, repair and replacement (B2, 3 and 4) shall be based on the clients required service life for the building as well as scheduled maintenance, repairs and replacements of construction products.

In option 2, instead of looking at life cycle stages relating to repair and replacement, the focus is instead on the 'building material bank'. Stage D represents the net benefit of the materials used in the building if they were to be reused and/or recycled – sometimes referred to as the building material bank – and is also the starting point for considering whether a building is easy to deconstruct for reuse and recycling. The specific calculation rules stipulated in EN 15978 shall be followed.

Table 3. Indicator 1.2 simplified reporting options

Simplified reporting option 1: 'incomplete life cycle: product stage, calculated energy performance and projected service life'	• The product stage (A1-3) • The use stage (B4, B5, B6)
Simplified reporting option 2: 'incomplete life cycle: product stage, calculated energy performance and the building material bank'	• The product stage (A1-3) • The use stage (B6) • End of life stage (C3-4) • Benefits and loads beyond the system boundary (D)

Cut-off rules and data gaps

Cut-off rules exclude inputs and outputs in the life cycle modules according to specific criteria. They establish lower thresholds for the contribution of a material or process to either an impact or the material mass. The following rules laid down by EN 15804 for construction products shall be followed:

Learn more about:

Calculation cut-off rules for establishing the building model

- ✓ All inputs and outputs to a (unit) process shall be included in the calculation, for which data are available. Data gaps may be filled by conservative assumptions with average or generic data. Any assumptions for such choices shall be documented.
- ✓ In case of insufficient input data or data gaps for a unit process, the cut-off criteria shall be 1 % of renewable and non-renewable primary energy usage and 1 % of the total mass input of that unit process.
- ✓ The total of neglected input flows per module shall be a maximum of 5% of energy usage and mass. Conservative assumptions in combination with plausibility considerations and expert judgement can be used to demonstrate compliance with these criteria.
- ✓ Particular care should be taken to include material and energy flows known to have the potential to cause significant emissions into air and water or soil related to the environmental indicators of EN 15978. Conservative assumptions in combination with plausibility considerations and expert judgement can be used to demonstrate compliance with these criteria.

L2.2. Step 4: Scenarios for the building life cycle

Scenarios are an important concept when making an assessment with indicator 1.2. Life cycle scenarios describe assumptions in time about specific characteristics of a building, its location and how it will be used. These in turn can influence the performance of the building and associated impacts at each life cycle stage.

The scenarios may be refined as additional information and detail becomes known, and must be based on real-life data and/or professional evaluations. Where projections or probabilistic modelling are used as the basis for scenarios then the source and assumptions shall be reported. The box below outlines the main scenarios that are recommended as being developed by users of indicator 1.2.

Learn more about:

Recommended scenarios to be developed when using indicator 1.2

Scenarios and assumptions shall be developed to take into account the influences listed below. For each scenario, guidance and instructions are provided. Links shall be made to other Level(s) indicators which, if used, may provide data and assumptions:

- Comparative evaluation of scenarios for the **re-use of an existing building and its structure** compared to its demolition plus the construction of a new building, with reference to the bill of quantities of indicator 2.1;
- **design options and specifications to meet client requirements** (as expressed in the brief), with reference to manufacturers information about construction products, with reference to the bill of quantities of indicator 2.1;
- **service life planning**, with reference to input data from indicators 2.1 and 6.1;
- **present and (projected) future electricity grid emissions**, with reference to input data from indicator 1.1;
- **present and (projected) future climatic conditions**, with reference to input data from indicators 1.1 and 5.1;
- **property market assessments and predicted patterns of future use**, with reference to input data from indicator 2.3;
- **local and regional end of life and circular infrastructure**, with reference to input data from indicators 2.2 and 2.4

Comparative evaluation of building renovation with demolition and new construction

Influence on the life cycle: modules A1-5

This scenario will become increasing important as the focus shifts from the performance of new buildings to large scale, deep renovation. Functional equivalence shall be established based on the clients brief. Design scenarios for different depths of renovation should be developed.

If the outcome is to renovate, then a further step would be the evaluation of renovation designs. The scope of the building elements could be narrowed based on the extent of the interventions to the existing building envelope that are planned, including primarily layout modifications/interventions, insulation, windows, HVAC, lighting, flooring and internal finishes. The calculations should ideally be cross-checked with dynamic energy simulation of the improvement in use stage primary energy demand.

Design options and specifications to meet client requirements

Influence on the life cycle: modules A1-5, B5

These scenarios relate to the design options that may be devised in response to client requirements. This could lead to distinct variations in the bill of materials and associated impacts for the designs. These could relate to new build and major renovation projects and could have an influence on modules A4-5 (in the case of new build) and B5 (in the case of major renovation).

Design processes may also, in conjunction with contractors, result in new scenarios for the construction process. These could also lead to different design bills of materials, as well as options for reducing construction waste and

improving efficiency – for example through off-site construction of pre-fabricated products or assemblies. These could have an influence on modules A4-5 and B5.

Service life planning

Influence on the life cycle: modules B2-4

Specific service lifespans for building parts and elements shall be estimated according to the factor methodology in ISO 15686-8. Specific standards relating to building elements may also be valuable, e.g. EN 15459 and heating systems. In the absence of estimations made by manufacturers and suppliers, generic lifespans shall be taken either from an LCA software, or a building costing tool or internal estimates used for the purpose of building management. Alternatively the default service lifespans provided in Table 4 shall be used.

Learn more about:

Using data from a clients' maintenance, repair and replacement plans

Where the client will operate a long term management plan for building stock, such as in the case of social housing, this will make provisions for the maintenance, repair and replacement of building elements and components. Such a plan might typically include the following headings, which also align with those referred to under indicator 6.1: Life cycle costs:

- ✓ **Unscheduled replacement, repairs and maintenance costs**: These relate to unforeseen failure or damage before the design life expires. This might normally be estimated on the basis of probability.
- ✓ **Periodic predicted replacement, repairs and maintenance costs**: These relate to costs that reoccur during the service life, which can include the predicted wear out rates over time of elements or systems. For example, the repainting of window frames and external render, the repair/replacement of window glazed units, the repair/replacement of domestic boilers.
- ✓ **Periodic minor replacement, repair and maintenance costs**: These relate to components that may require interventions several times during the service life, but which on their own represent relatively minor costs each time. For example, parts of the external fit-out.
- ✓ **Periodic major planned replacement costs**: These relate to the planned replacement of major elements of the building upon expiry of their projected design life e.g. roofing, external render, cladding, windows and HVAC systems.

Further guidance can be found in section 5.4.2 of ISO 15686-5.

Table 4. Default service lives for the minimum scope of building parts and elements

Building parts	Related building elements	Expected lifespan
Shell (substructure and superstructure)		
Load bearing structural frame	- Frame (beams, columns and slabs) - Upper floors - External walls - Balconies	60 years
Non-load bearing elements	- Ground floor slab - Internal walls, partitions and doors - Stairs and ramps	30 years
Facades	- External wall systems, cladding and shading devices - Façade openings (including windows and external doors)	30 years (35 years glazed) 30 years

Building parts	Related building elements	Expected lifespan
	- External paints, coatings and renders	10 years (paint), 30 years (render)
Roof	- Structure - Weatherproofing	30 years
Parking facilities	- Above ground and underground (within the curtilage of the building and servicing the building occupiers) [5]	60 years
Core (fittings, furnishings and services)		
Fittings and furnishings	- Sanitary fittings - Cupboards, wardrobes and worktops - Floor finishes, coverings and coatings - Skirting and trimming - Sockets and switches - Wall and ceiling finishes and coatings	20 years 10 years 30 years (finishes), 10 years (coatings) 30 years 30 years 20 years (finishes), 10 years (coatings)
In-built lighting system	- Light fittings - Control systems and sensors	15 years
Energy system	- Heating plant and distribution - Radiators - Cooling plant and distribution - Electricity generation - Electricity distribution	20 years 30 years 15 years 15 years 30 years
Ventilation system	- Air handling units - Ductwork and distribution	20 years 30 years
Sanitary systems	- Cold water distribution - Hot water distribution - Water treatment systems - Drainage system	25 years
Other systems	- Lifts and escalators - Firefighting installations - Communication and security installations - Telecoms and data installations	20 years 30 years 15 years 15 years
External works		
Utilities	- Connections and diversions - Substations and equipment	30 years
Landscaping	- Paving and other hard surfacing - Fencing, railings and walls - Drainage systems	25 years 20 years 30 years

[5] If the share of underground car parking (usable area plus traffic area) accounts for more than 25% of the total useful floor area, the traffic area of the underground parking must be subtracted from the total useful floor area.

Adapted from RICS (2017), ETool (2017)

Present and (projected) future electricity grid emissions

Influence on the life cycle: module B6

The scenarios for energy use (module B6) shall include (but not be limited to) primary energy consumed by use of the following systems: heating, cooling, ventilation, domestic hot water, lighting and control. This data shall be taken from **indicator 1.1** and will also include building-related energy production.

The scenario for module B6 shall specify, on a per energy carrier basis, both the imported energy used to satisfy the specified demand and the energy that is exported. The scenario shall specify how the imported and exported energy flows are quantified (e.g. the energy generation estimates for the renewable energy technology, including the amount of energy produced on site and how much of this is exported). Energy that is exported shall be reported under **Module D**.

Learn more about:

Calculation rules for the use of electricity grid emissions projections

The scenarios used shall also take account of the projected decarbonisation of the electricity grid for the country where the building is located. The projections used may be at EU or at national level and shall be taken from the EU PRIMES model [6]. EU and Member State data can be downloaded here.

Present and future (projected) climatic conditions

Influence on the life cycle: stage B

Climate conditions that are compatible and consistent with those required under European or national legislation for assessing the energy requirements of a building and that are representative of the location of the building, shall be used in the relevant scenarios. **Indicator 5.1** provides guidance on the selection of weather files based on IPCC scenarios and, in their absence, worst case scenarios based on existing weather files to use for climate change.

Property market assessments and predicted patterns of future use

Influence on the life cycle: A1-5, B5, building service life

The potential of the building to adapt to changing needs and expectations in the property market may influence the pattern of future renovations, but also the overall service life of the building. **Indicator 2.3** provides a method for assessing the adaptability of a building on multiple aspects. Complementary scenarios shall be developed based on an understanding of the property market.

Learn more about:

Calculation rules for scenario development rules for future adaptability

Worst, intended and best case scenarios for continued future use of the building shall be identified in conjunction with a property market expert that has knowledge of the local and regional conditions:

- Worst case: Local precedents for low/zero occupation of buildings of the same use that have led to early demolition.
- Intended case: Local precedents that reflect the intended service life as defined by the client.

[6] European Commission, EU Reference Scenario 2016 - https://ec.europa.eu/energy/data-analysis/energy-modelling/eu-reference-scenario-2016_en

- Best case: Local precedents for continuation of the same use or changes of use that have avoided the need for demolition.

Based on this analysis, design precedents shall be identified and used to identify design pre-requisites for maintaining continued building use over time, as well as design deficiencies that may have contributed in the past to failure or voids.

The implications of adaptability measures that could be considered as part of the design shall be modelled, with a focus on their influence on life cycle stages A1-3 and B5 (Refurbishment). If a change of use is assumed, the use stage shall be modelled to reflect the new use over a second, default service life period. Variation from the default shall be justified.

If the life cycle GWP or LCA results are to be publicly reported, an independent critical review of the assumptions shall be carried out by a property market specialist and his or her opinion appended to the reporting.

Local and regional end of life and circular infrastructure

Project-specific scenarios for the end of life of a building shall be built up from primary data for the technologies and solutions applicable by the construction and demolition sector in the geographical location. Default or reference end of life scenarios may be used in the absence of project-specific data. The default or reference scenario should ideally be built up from regional or national data, but if this is not available, EU data may be used.

Data on reuse, recycling, recovery and landfill rates, as well as the solutions and technologies used, shall be based on the following, where available:

- Default EU and Member State scenarios developed to support the use of LCA. For example, the DGNB assessment schemes LCA criterion [7] or publicly available LCA studies.
- Waste diversion rates that are based on Member State statistical data and surveys[8]. These may include information on the specific separation and treatment technologies used.
- Primary data for the specific deconstruction technologies and regional or local diversion rates. These may include 'cradle to gate with options' or 'cradle to grave' EPDs for specific building elements and materials and their possible end of life scenarios.

The EeBGuide project provides further technical guidance on defining end of life scenarios[9].

Learn more about:

Calculation rules for Scenario development rules for future deconstruction

Local precedents and best case scenarios for the selective deconstruction of the same type of building in order to maximise reuse and recycling shall be identified in conjunction with a demolition contractor or waste management specialist that has knowledge of the local and regional practices.

The improvement in reuse and recycling in the end of life stage, including the benefits that could be reported under Modules C and D shall be calculated.

Assumptions relating to the ease of disassembly, reuse and recycling shall be based on solutions and technologies that have already proven to be economically and technically viable. In other words, assumptions should be based on existing solutions and technologies.

[7] The criterion document can be obtained by contacting DGNB - http://www.dgnb.de/en/services/request-dgnb-criteria/form/

[8] European Commission, *Resource efficient use of mixed wastes – Task 1 Member State factsheets*, http://ec.europa.eu/environment/waste/studies/mixed_waste.htm

[9] EeEBGuide Project, C-03 (Buildings) / C-08 (Products) LCA modelling of landfill/disposal, http://www.eebguide.eu/?p=2197

If the LCA results are to be publicly reported, an independent critical review of the assumptions shall be carried out by a demolition contractor or waste management expert, and their opinion appended to the reporting.

L2.2. Steps 5 and 6: Data selection and quality

The degree of confidence that can be placed in the results of an assessment will depend upon the level of precision and detail provided by the data and the information used to model the building being assessed. Data collection and processing shall follow the guidance provided in EN ISO 14044:2006 and with reference to the data quality considerations of EN 15804 and the PEF method.

To understand how the data quality can be assessed, it is important to highlight that the calculation of life cycle GWP generally works at two levels:

- **Foreground processes**, which directly affect the results (e.g. the actual content of concrete in a column, the consumption of electricity during the occupation of a building)
- **Background processes**, which are linked to and are nested behind the foreground processes (e.g. the production and supply of concrete, the production and supply of grid electricity).

The quantification of data for both foreground and background processes may require a combination of:

- **Primary data**, which is site-specific information based on direct measurements or the characterisation of parameters for a certain context;
- **Secondary data**, which is available from technical literature and data providers (e.g. specific studies, LCA databases);
- **Assumptions**, especially when satisfactory data is not available.

For Level(s) assessments, the following data hierarchy of preference shall be used to prioritise the data used:

- use ***specific data*** derived from specific production processes,

  This may include Environmental Product Declarations (EPDs) describing a product that has been specified to be used in the construction and that has been calculated using specific data for at least the processes the producer of the specific product has influence over.

- use ***average data*** derived from specific production processes.

  This may include EPDs describing average products and calculated using representative average data.

EPD information can be available on an aggregated level for a building part, for a building element, for a building component, or on the level of the product or material. Where relevant data for the building assessment is missing from an EPD, or where the scenario data is not relevant to the specific building being considered, data may be taken from other sources, provided that its relevance and appropriateness can be justified. Data shall be in line with the general principles expressed in EN 15804.

Where the producer of the building cannot influence performance (e.g. raw material extraction or electricity generation) generic data may be used for the processes.

Learn more about:

Minimum data quality requirements

The environmental data is deemed to meet the Level(s) requirements for data quality if it is in accordance with the data quality requirements of EN 15804/prEN15941. If the environmental data are from other sources which are not accordance with EN 15804, the following minimum data quality requirements apply:

- data shall have been checked for plausibility and compliance with the rules of EN 15804;

- data should be as current as possible. the last update of the data shall not be older than 10 years for generic data and 5 years for manufacturer's data;
- dataset for calculations should be based on one-year averaged data if relevant; reasons for a different assessment period shall be listed;
- emissions from disposal processes shall be accounted for at least 100 years, with the exception of emissions of biogenic carbon which shall be accounted for without time limit;
- emissions that occur beyond 100 years should be inventoried in a dataset as separate 'long-term' elementary flows and included in the impact assessment if relevant.

In addition:

- the technological processes associated with the product shall be representative of the declared product or product group;
- the technological processes shall be representative of the region where the production is located.

The relevance of the influence of the data chosen for the building assessment shall be determined (e.g. through a sensitivity analysis) and presented in the project report. The data used to calculate the impacts for products/ materials/ processes contributing together to at least 80 % of the absolute impact of GWP, or any other any core environmental indicators considered relevant, shall be reported on.

Adapted from CEN (2019)

Calculation of the Data Quality Index

Since Level 2 may be used for reporting the building's environmental performance in the public domain, data quality becomes an important issue. A data quality index is to be calculated according to the method set out below and shall accompany any reporting in the public domain. The overall data quality index shall be >2. For transparency reasons, data sources shall also be reported.

The rating system has a matrix form, which is adapted from the European Commission's Product Environmental Footprint method's (PEF) data quality evaluation methodology. The rating is presented in Table 5 and is based on four parameters:

- Technological representativeness of data (TeR)
- Geographical representativeness of data (GR)
- Time-related representativeness of data (TiR)
- Uncertainty of data (U)

A rating level is to be evaluated for each parameter according to the matrix in the table below. The overall rating is equal to the Data Quality Index (DQI), which can be calculated from the individual ratings as follows:

$$DQI = ((TeR+GR+TiR)/3+U)/2$$

The rating shall be calculated for each hot spot of the environmental impacts identified from the life cycle GWP calculation[10]. Hot spots may be related to a building's life cycle stages or modules, processes, components (elements, structural parts, products, materials) or elementary flow – or combinations thereof. For example, a hot spot could be the installation and replacement of a façade in life cycle modules B1-3 and B5. The rules for the identification of hot spots can be found in L2.2. Step 10.

[10] Hot spots are points in the life cycle of a product which have the highest impacts/importance in the overall life cycle GWP result .

The overall data quality shall then be calculated as the contribution-weighted average of the data quality for each hot-spot:

DQI overall = Σi (DQI hot-spot,I x Contribution hot-spot,i) / Σi (Contribution hot-spot,i)

Table 5. Data quality evaluation matrix

Rating aspect	***Brief description of each aspect***	**Rating score**			
		0	**1**	**2**	**3**
Technological representativeness	Degree to which the dataset reflects the true population of interest regarding technology (e.g. the technological characteristics, including operating conditions)	No evaluation made	The data used does not reflect satisfactorily the technical characteristics of the system (e.g. Portland Cement, without other specifications)	The data used reflects partially the technical characteristics of the system (e.g. Portland Cement type II, without further specifications)	The data used reflects the technical characteristics of the system (e.g. Portland Cement type II B-M)
Geographical representativeness	Degree to which the dataset reflects the true population of interest regarding geography (e.g. the given location/site, region, country, market, continent)	No evaluation made	The data used refer to a totally different geographic context (e.g. Sweden instead of Spain)	The data used refers to a similar geographic context (e.g. Italy instead of Spain)	The data used refers to the specific geographic context (e.g. Spain)
Time-related representativeness	Degree to which the dataset reflects the specific conditions of the system being considered regarding the time/age of the data (e.g. the given year compared to the reference year of the analysis)	No evaluation made	There are more than 6 years between the validity of the data used and the reference year to which the data applies.	There are between 2 and 4 years between the validity of the data used and the reference year to which the data applies.	There are less than 2 years between the validity of the data used and the reference year to which the data applies.
Uncertainty	Qualitative expert judgment or relative standard deviation expressed as a percentage.	No evaluation made	Modelled/similar data is used. Accuracy and precision of the data has been estimated qualitatively (e.g. by expert judgment of suppliers and process operators)	Modelled/similar data is used which is considered to be satisfactorily accurate and precise with the support of a quantitative estimation of its uncertainty (e.g. representative data from trade associations for which a sensitivity	Site specific and validated data is used which is considered to be satisfactorily accurate and precise (e.g. window system for which a verified EPD is available) The allocation hierarchy has been respected.

Rating aspect	*Brief description of each aspect*	Rating score			
		0	1	2	3
				analysis has been carried out).	

L2.2. Step 10: Carrying out a hot spot analysis

Once the calculations have been carried out and the first results obtained, it is possible to make a hot spot analysis. Hot spots are the life cycle stages, processes or direct elementary flows that contribute most to the overall life cycle GWP of the building. Hot spot analysis can support design improvements and strategic improvement plans, as well as providing a feedback loop to refine some of the scenarios developed based on the guidance in L2.5.

Learn more about:

Calculation rules for the identification of life cycle GWP hot spots

- The most relevant life cycle stages are the life cycle stages which together contribute to at least 80% of any of the most relevant impact categories identified (i.e. GWP). This should start from the largest to the smallest contributions.
- The most relevant processes shall be identified by analysing the most significant contributors to the most relevant life cycle stages, as identified in the previous step. The most relevant processes are those which together contribute to at least 80% to any of the most relevant impact categories identified.
- The most relevant direct elementary flows are defined as those direct elementary flows contributing cumulatively at least with 80% to the total impact of the direct elementary flows of the process, for each most relevant impact category.

In all cases, if the use stage accounts for more than 50% of the total impact then the procedure shall be re-run by excluding the use stage. In this case, the list of most relevant life cycle stages shall be those selected through the latter procedure plus the use stage. Specific instructions about aggregating elemental flows can be found in the PEF guidance [11].

Source: Product Environmental Footprint category rules guidance, version 6.3 (2018)

L2.6. Going a step further: Cradle to grave Life Cycle Assessment

The opportunity exists with indicator 1.2 to go further by selecting the full set of environmental impact category indicators specified in the table below instead of just GWP. The results will be obtained by applying the same methodology for each of the impact categories to the calculation of environmental impacts for the life cycle inventory. This would represent a cradle to grave Life Cycle Assessment (LCA).

Table 6. EN 15804 and EN 15978 core environmental impact category indicators

Impact category	Indicator	Unit
Climate change – total [a]	Global Warming Potential total (GWP-total)	kg CO2eq.
Climate change - fossil	Global Warming Potential fossil fuels (GWP-fossil)	kg CO2 eq.
Climate change - biogenic	Global Warming Potential biogenic (GWP-biogenic)	kg CO2 eq.

[11] European Commission, PEFCR Guidance document, - Guidance for the development of Product Environmental Footprint Category Rules (PEFCRs), version 6.3, December 2017. https://ec.europa.eu/environment/eussd/smgp/pdf/PEFCR_guidance_v6.3.pdf

Impact category	Indicator	Unit
Climate change - land use and land use change[b]	Global Warming Potential land use and land use change (GWP-luluc)	kg CO2 eq.
Ozone Depletion	Depletion potential of the stratospheric ozone layer (ODP)	kg CFC 11 eq.
Acidification	Acidification potential, Accumulated Exceedance (AP)	mol H+ eq.
Eutrophication aquatic freshwater	Eutrophication potential, fraction of nutrients reaching freshwater end compartment (EP-freshwater)	kg PO4 eq.
Eutrophication aquatic marine	Eutrophication potential, fraction of nutrients reaching freshwater end compartment (EP-marine)	kg N eq.
Eutrophication terrestrial	Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	mol N eq.
Photochemical ozone formation	Formation potential of tropospheric ozone (POCP);	kg NMVOC eq.
Depletion of abiotic resources - minerals and metals[c d]	Abiotic depletion potential (ADP-minerals&metals) for non-fossil resources	kg Sb eq.
Depletion of abiotic resources - fossil fuels[c]	Abiotic depletion potential (ADP-fossil) for fossil resources	MJ, net calorific value
Water use	Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	m3 world eq. deprived

a The total global warming potential (GWP) is the sum of:

- GWP-fossil
- GWP-biogenic
- GWP-luluc

b It is permitted to omit GWP-luluc as separate information if its contribution is <5 % of GWP-total over the declared modules excluding module D.

c The abiotic depletion potential is calculated and declared in two different indicators:

- ADP-minerals&metals include all non-renewable, abiotic material resources (i.e. excepting fossil resources);
- ADP-fossil include all fossil resources and includes uranium.

d ultimate reserve model of the ADP-minerals & metals model

Source: CEN (2019)