European Commission

JRC TECHNICAL REPORTS

Level(s) – A common EU framework of core sustainability indicators for office and residential buildings

Parts 1 and 2: Introduction to Level(s) and how it works (Draft Beta v1.0)

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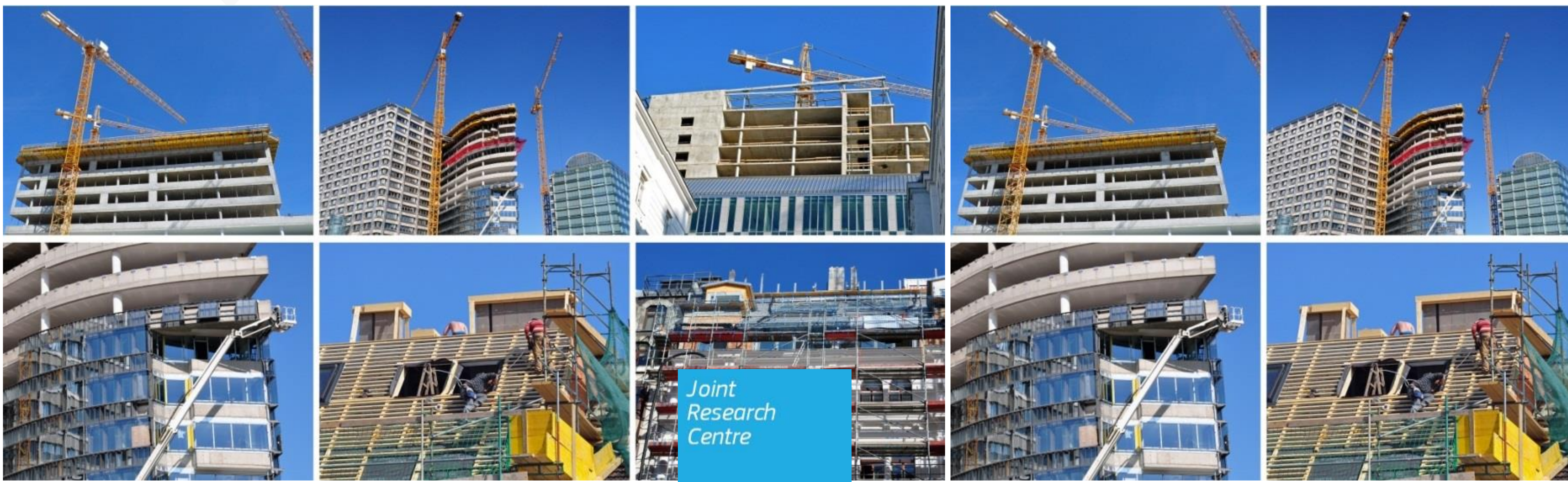

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Table of contents

Part 1 of the Level(s) framework

1. Introduction to Part 1 of the Level(s) framework

1.1 What is the Level(s) framework?

Developed as a common EU framework of core indicators for the sustainability of office and residential buildings, Level(s) provides a set of indicators and common metrics for measuring the environmental performance of buildings along their life cycle. As well as environmental performance, which is the main focus, it also enables other important related aspects of the performance of buildings to be assessed using indicators for health and comfort, life cycle cost and potential future risks to performance.

Level(s) aims to provide a general 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 six macro-objectives for the Level(s) framework that contribute to EU and Member State policy objectives in areas such as energy, material use and waste, water and indoor air quality.
2. Core Indicators: A set of 9 common indicators for measuring the performance of buildings which contribute to achieving each macro-objective.
3. Life cycle tools: A set of 4 scenario tools and 1 data collection tool, together with a simplified Life Cycle Assessment (LCA) methodology, that are designed to support a more holistic analysis of the performance of buildings based on whole life cycle thinking.
4. Value and risk rating: A checklist and rating system provides information on the reliability of performance assessments made using the Level(s) framework.

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 ultimate aim being the potential for wider use across Europe of two main tools – Life Cycle Assessment (LCA) and Life Cycle Cost Assessment (LCCA).

1.2 For which types of buildings can Level(s) be used?

The scope of the Level(s) framework is office and residential buildings. This scope encompasses both new and existing buildings at the point of major renovation[1].

Performance may be assessed and reported on at a number of different levels depending on the nature of the development:

- individual office and residential buildings
- multiple office building developments (for each distinct building type within the development)

[1] A major renovation is where 1) the total cost of the renovation relating to the building envelope or the technical building systems is higher than 25 % of the value of the building, excluding the value of the land upon which the building is situated, or b) more than 25 % of the surface of the building envelope will undergo renovation.

- multiple residential building developments (for each distinct typology of house or apartment within the development)
- housing stock (for each distinct typology of house or apartment types within the stock)
- office building portfolio (for each distinct building type in the portfolio)

1.3 Why use the Level(s) framework?

The idea of designing and constructing 'sustainable' buildings is very straight forward - use less energy, water and materials, achieving buildings with better environmental performance, while at the same time making the buildings healthier and more comfortable for their occupants, in turn making them less costly to run and financially more valuable in the long term.

The Level(s) framework focuses attention on the most important aspects of a building's performance, providing a simple entry point for someone who wants to work on 'sustainable' buildings for the first time. The level of complexity that one might want to use for the project (or that may be requested by clients) could differ – ranging from very basic requirements to the use of more challenging performance assessment schemes and tools.

As a result, the European Commission has developed this framework in order to:

- provide an easy starting point to introduce sustainability and life cycle thinking into projects;
- focus on a manageable number of essential concepts and indicators that contribute to achieving environmental policy goals;
- support efforts to optimise building designs and their operation, with a focus on the precision of data, calculation methods and simulations;
- support efforts to minimise gaps between design and actual performance, in terms of both measured performance and occupant satisfaction;
- support commitments to track performance all the way from design stage through to operation and occupation of a building;
- enable comparisons to be made between buildings in a geographical area or in a portfolio, or between design options at an early stage;
- allow users to select between three different levels of comprehensiveness in how performance can be calculated and reported on, chosen according to the different priorities and goals of users;
- ensure that when using these indicators, users will be working to common performance assessment methods and standards used in the EU, so as to complement and reinforce existing initiatives;

The intention is not to create a new standalone building certification scheme, or to establish performance benchmarks, but rather to provide a consistent and comparable voluntary reporting framework that works across national boundaries and has a broad potential for use by building sector professionals across the EU.

1.4 Who are the target groups for the Level(s) framework?

The Level(s) framework is aimed at professionals that play a critical role in the development of building projects. It has been designed to provide a common language of sustainability performance assessment for use by the following project actors:

- Property owners, developers and investors.
- Design teams (including architects, engineers and quantity surveyors).
- Construction and demolition management (including construction managers and lead contractors).
- Property agents and valuers.

- Asset and facilities managers.
- Public and private organisations that will occupy the buildings assessed.

These actors include both public and private clients and managers of building projects. Throughout the Level(s) framework, guidance notes are provided which are orientated towards these six different target groups.

1.4.1 Building designers, constructors and managers

In addition to the general advantages of using the Level(s) framework that were described in section 1.3, specific added value can be realised by these target groups. The Level(s) framework supports the professional development of project teams to assess the performance of buildings along their life cycle.

Table 1.1 Potential advantages for project teams of using the Level(s) framework

Project actors	**Potential advantages of using Level(s)**
Design teams *(including architects, engineers and quantity surveyors)*	✓ It provides flexibility in the level of detail at which sustainability aspects can be addressed in the design process. ✓ It has a focus on the performance of the completed building, and the steps to be taken at design stage to ensure high performance. ✓ It provides a simple structure that can be presented to clients in order to prioritise attention on sustainability aspects. ✓ It supports the user at each stage in a project, with guidance notes on how to make accurate performance assessments.
Construction management *(including construction managers and lead contractors)*	✓ It provides a simple structure that can be used to prioritise attention on sustainability aspects. ✓ It identifies the role that can be played in monitoring and checking that design performance is met.
Property agents and valuers	✓ It identifies how improved performance may be reflected in valuation and risk rating criteria. ✓ It provides simplified ratings of how reliable an estimated performance of a building may be.
Asset and facilities managers	✓ It provides guidance on how to carry out building performance monitoring and evaluation, including post-occupancy surveys. ✓ It provides guidance on life cycle management of a building, including maintenance and replacement planning.

1.4.2 Project investors, promoters and end-users

The Level(s) framework supports the decision making process for property owners, developers and investors, by ensuring transparency in reporting on how performance assessments are carried out, and by providing an outlook on the reliability of data that may be used to inform investment decisions, appraisals and risk ratings.

The satisfaction, comfort and productivity of building occupiers is also critical to maintaining property values and differentiating sustainable buildings in the property market, so is a natural focus of attention for the Level(s) framework.

Table 1.2 Potential advantages for clients of using the Level(s) framework

Project actors	**Potential advantages of using the Level(s) framework**
Property owners, developers and investors	✓ It provides a clear set of priority aspects of performance to focus attention on, forming a basis for instructing design professionals. ✓ It ensures transparency in the reporting of performance assessment, and the associated data, calculation methods and assumptions. ✓ It focusses on minimising the gap between design and occupied performance. ✓ It provides simplified ratings of how reliable an estimated performance of a building may be. ✓ It identifies how the cost, value and risk associated with a building's performance can be managed to deliver long-term benefits. ✓ It provides tools to identify opportunities to extend the lifespan and improve the long term value of building assets.
Public and private organisations that will occupy the buildings assessed.	✓ It focusses on performance aspects that are of direct ongoing financial interest to occupiers, such as operating and maintenance costs; ✓ It includes headline indicators that measure comfort aspects of a building and its internal environment, e.g. indoor air quality, thermal comfort. ✓ It provides recommendations on how the performance of an occupied building can be monitored and surveyed.

1.4.3 Public authorities and third party performance assessment

The Level(s) framework provides a common set of performance based indicators that reflect EU policy objectives for the environment, health and the built environment. Moreover, their calculation is supported, wherever possible, by EN and ISO reference standards. This results in a common approach to performance assessment that is suitable for broad use across the EU.

If building assessment schemes, investor reporting schemes and public policy instruments are aligned with, or incorporate the Level(s) framework within their criteria, then they can be used as a means of ensuring that building designs contribute to the same common policy objectives.

1.5 At what stage in a building project can the Level(s) framework be used?

In order to make the link between design, as-built and occupied performance, the Level(s) framework makes it possible to report on building performance by using the indicators at the following project stages along the life cycle of a building:

- Design stage (based on calculations, simulations and scenarios)
- Implementation stage (based on as-built drawings, specifications and tracking)
- Completion stage (based on commissioning and testing)
- Operation stage (based on measured performance and occupant satisfaction)

In order to make the link between these project stages, and those related to property valuation and investment appraisal, the Level(s) framework also provides information to support the following stages in financing a building project:

- Outline financial appraisal (based on an outline design)
- Detailed financial appraisal (based on a detailed design)
- Financial approvals and due diligence (upon achieving planning permission and permitting)
- Cost control and value engineering (during the construction process)
- Asset management and leasing (upon completion and occupation)

The Level(s) framework does this by focussing on how performance estimates can be made more reliable, providing transparent information and promoting the use of standardised calculation methods. Moreover, it focuses on several aspects of performance that have been shown to be important in sustaining the value of property over time.

2. The structure of the Level(s) framework

2.1 The macro-objectives of the Level(s) framework

The Level(s) framework consists of six macro-objectives, which set goals for the contribution of buildings across the EU to environmental, health and comfort, and cost, value and risk objectives.

Based on these goals, building specific indicators have been developed. In this way, users can be sure that by using the Level(s) framework, or schemes or tools that are aligned with the framework, they are contributing to meeting these goals. The macro-objectives are summarised in table 2.1.

An overview of the indicators, scenarios and LCA tools that form part of the Level(s) framework is presented in figure 2.1.

Table 2.1 The six macro-objectives of the Level(s) framework

Macro objectives	**Description**
Thematic area: Life cycle environmental performance	
1. Greenhouse gas emissions along a buildings life cycle	Minimise the total greenhouse gas emissions along a buildings life cycle, from cradle to cradle, with a focus on emissions from building operational energy use and embodied energy.
2. Resource efficient and circular material life cycles	Optimise the building design, engineering and form in order to support lean and circular flows, extend long-term material utility and reduce significant environmental impacts.
3. Efficient use of water resources	Make efficient use of water resources, particularly in areas of identified long-term or projected water stress.
Thematic area: Health and comfort	
4. Healthy and comfortable spaces	Create buildings that are comfortable, attractive and productive to live and work in and which protect human health.
Thematic area: Cost, value and risk	
5. Adaptation and resilience to climate change	Futureproof building performance against projected future changes in the climate, in order to protect occupier health and comfort and to sustain and minimise risks to property values.
6. Optimised life cycle cost and value	Optimise the life cycle cost and value of buildings to reflect the potential for long term performance improvement, inclusive of acquisition, operation, maintenance, refurbishment, disposal and end of life.

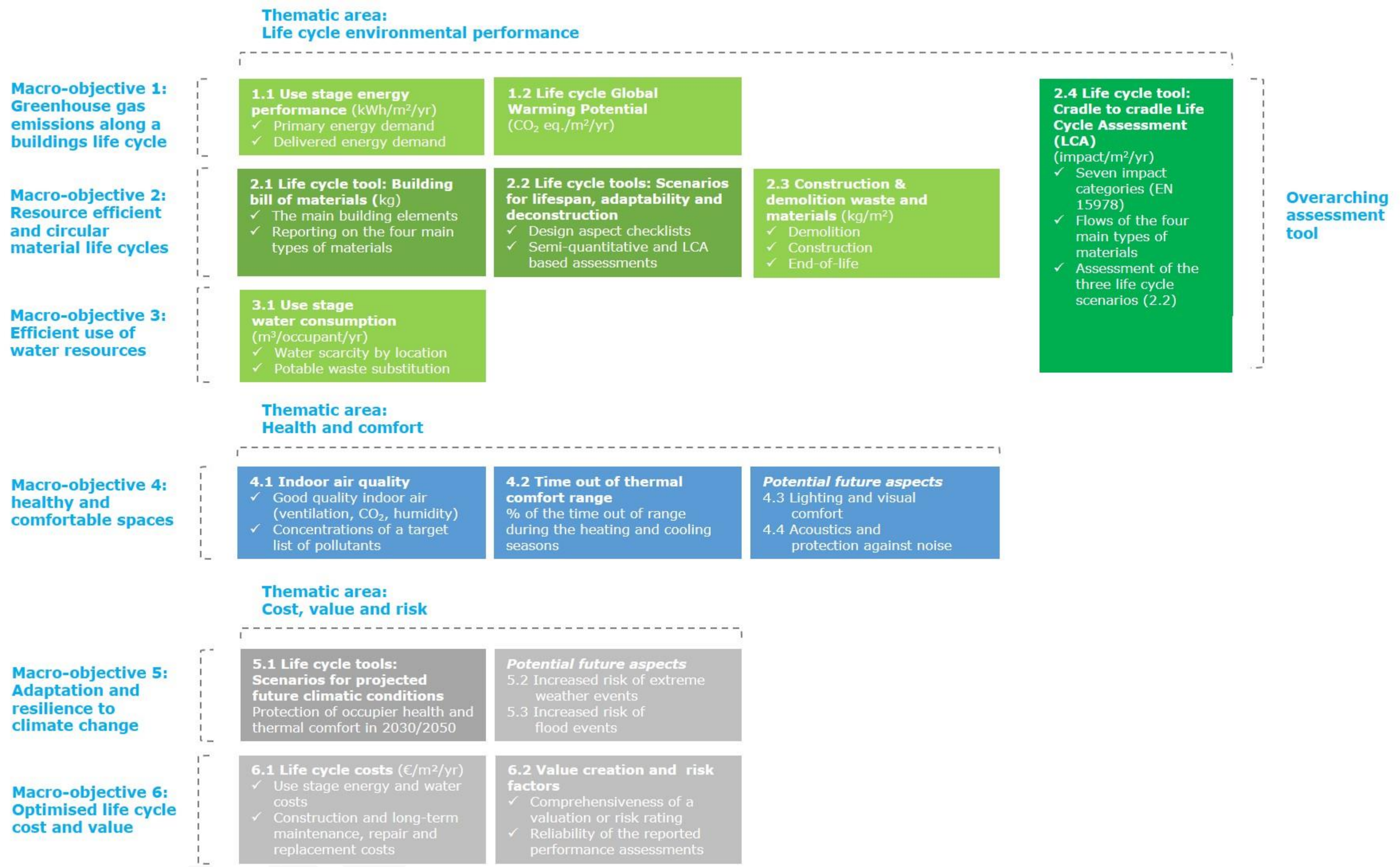

Figure 2.1 Overview of the Level(s) framework

2.2 Encouraging a life cycle approach

The framework encourages users to think about the whole life cycle of a building – from the manufacturing of the products and materials used to construct the building, right through to the building's eventual deconstruction and re-use and recycle of materials. In life cycle assessment, this concept is referred to as 'cradle to cradle'.

The framework is designed in a way that users can start by learning about the different necessary steps to conduct both Life Cycle Assessment (LCA) and Life Cycle Cost Assessment (LCCA). Having learnt about these different steps, users can be more confident to move towards using LCA, and also LCCA, as life cycle tools to support performance improvement. These steps are illustrated in figure 2.2.

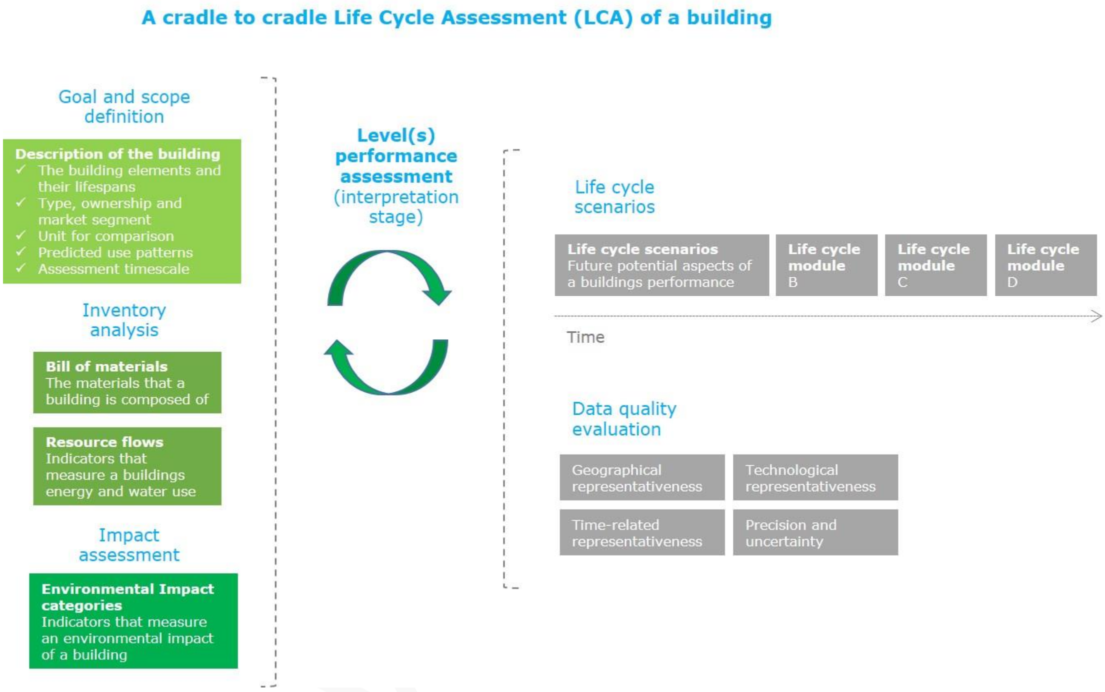

Figure 2.2 The stages in carrying out an LCA that form part of the Level(s) framework

Source: adapted from CEN (2011), ISO (2006)

The more experience gained in using the framework, the easier it will therefore become to conduct a fully-fledged LCA, which is increasingly encouraged in building assessment and investor reporting schemes.

The principle is broadly the same for the assessment of Life Cycle Costs (LCC), with performance indicators such as energy use and water use providing data that can be converted into costs. Projected future scenarios, such as for maintenance and refurbishment, require analysis in order to develop cost plans. It is also important to consider data quality as a step in the assessment of life cycle costs.

2.3 Working at different levels to obtain performance data

Users of the Level(s) framework will learn how to collect, simulate, measure and analyse a range of data relating to the performance of an office or residential building. This data may be estimated or measured, depending on the stage in the project, and will include:

- for energy and water
  - consumption

- emissions
  - costs
- for building element and materials:
  - quantities
  - emissions
  - costs
  - lifespans
- for the indoor environment:
  - ventilation system monitoring
  - indoor air monitoring
  - indoor thermal monitoring

Users will be able to work with data and calculation methods at three defined levels of expertise and comprehensiveness – a common level (Level 1), a comparative level (Level 2) and a performance-optimised level (Level 3) - with each in turn requiring an increased level of competence and expertise in data handling and manipulation.

Once the data has been collected, the building's performance can be analysed for:

- hot spots of environmental impact along the life cycle
- scenarios for future performance that may be influenced by decisions at the design stage
- design parameters that may influence indoor environmental quality
- short, medium and long term costs along the life cycle
- the extent to which design performance estimates have been achieved when compared to as-built or measured performance

In addition, users will be able to take the additional step of rating how reliable their assessment is. This rating will be based on the quality and representativeness of the data and the calculation methods used.

3. How the Level(s) framework can be used

3.1 How to carry out and report on a performance assessment

Users have two main routes to carry out a performance assessment in accordance with the Level(s) framework:

- Direct route: By following the guidance and using the reporting formats provided by the European Commission in Part 3 of the documentation.
- Indirect route: By using a building assessment scheme, investor reporting tool or indicator set that is specifically aligned with the Level(s) framework.

Guidance is provided in the following sub-sections on how to follow these two routes.

3.1.1 Direct use of the Level(s) framework

In Part 2 of the framework documentation, the indicators, their units of measurement and their boundary and scope are defined. In Part 3 of the framework, all the reference material required to carry out a performance assessment is provided, along with data reporting formats.

In order to follow this option, a stepwise process is suggested to be followed, which is outlined in the following guidance note.

Guidance note 1 for all users of the Level(s) framework

A stepwise approach to performance assessment and reporting

Step 1: Define the building to be reported on	– Part 3, section 1.1 should be followed in order to define the building, and the associated goal and scope of the performance assessment.
Step 2: Choose the level of performance assessment	– Based on the goal and scope of the performance assessment, the appropriate assessment level for the project should be selected from the three available options. – Part 1, section 3.2 provides further guidance on the difference between the three levels.
Step 3: Follow the guidance and rules on how to carry out an assessment	– Part 2 provides a general introduction to each indicator. – Part 3 should thereafter be consulted, where guidance is provided for each level on how to carry out a performance assessment. Rules are also laid down for reporting in the public domain. – The Level 1 guidance forms the common basis for all assessments, and should be consulted before using Levels 2 and 3. – Part 3, table iii provides an overview of where to find the appropriate level of technical guidance for each indicator.
Step 4: Complete the reporting format	– In each set of technical guidance in Part 3, a format for reporting is provided.
Step 5: Determine the valuation influence and reliability of the assessment	– As an optional last step for each indicator, the potential influence on a property valuation and reliability of the data and calculation method may be rated and reported on. Part 3 provides a rating methodology for each indicator.

3.1.2 In-direct use of the Level(s) framework

The scheme operator will generally provide all the information needed to make a performance assessment with reported outputs that are aligned with the framework. It is therefore recommended to consult the guidance provided by the specific scheme operator.

In some cases, the framework also allows for the use of calculation methods and parameters that are defined by a criterion within an existing scheme or tool. In this case, the scheme or tool used shall always be reported, so as to provide a transparent basis for comparability.

3.2 The three levels of performance assessment

The framework supports the use of three levels of performance assessment that can be carried out using the indicators:

1. The common performance assessment,
2. The comparative performance assessment,
3. The optimised performance assessment.

The three Levels represent a progression in terms of the accuracy and reliability of carrying out a performance assessment, as well as the level of professional expertise and capability required to use each Level. This progression is illustrated in Figure 3.1.

The simplest starting point for using the framework Levels is the 'common performance assessment'. It is recommended to read the overview of each indicator provided in section 4.3 before consulting the Level 1, 2 or 3 guidance and methodologies.

The common units of measurement and calculation methods laid down at Level 1, form the basis for two further Levels – a comparative performance assessment level and an optimised performance assessment level.

These two additional types of performance assessment are intended to fulfil more specific requirements and to allow flexibility when addressing priorities and the level of detail and precision that is being aimed at. In order to do this, specific rules and guidance shall be followed in each case. How these two Levels compare with Level 1 is summarised in table 3.1.

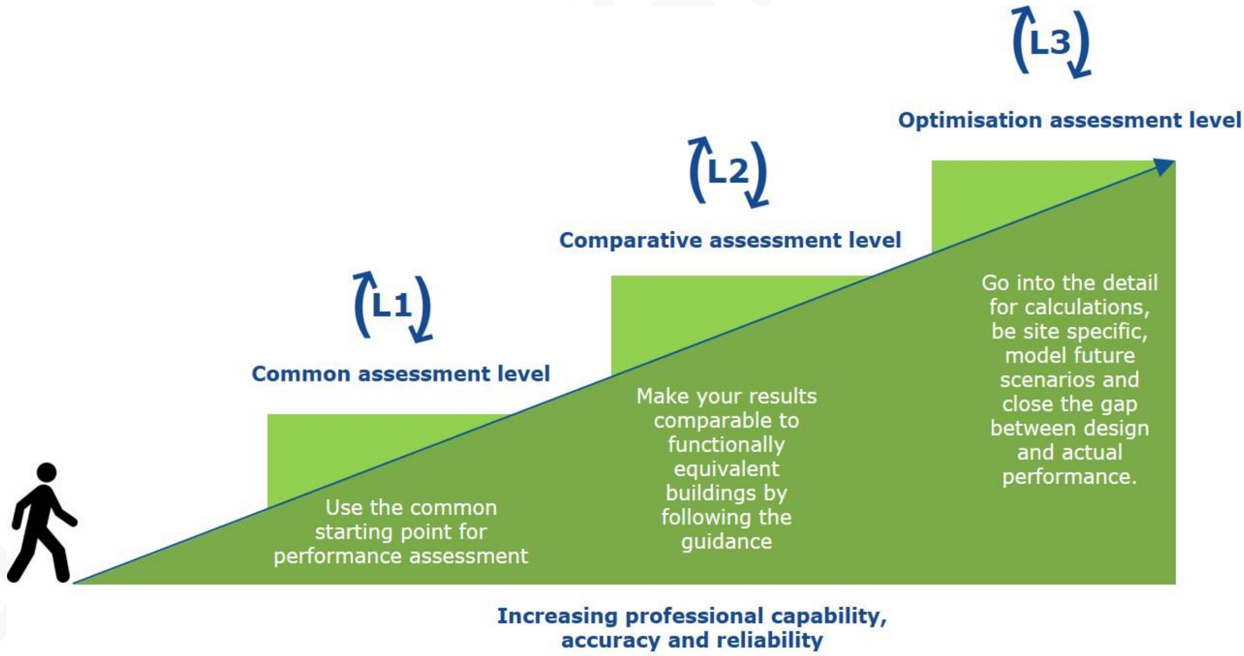

Figure 3.1 The three levels of performance assessment

3.2.1 Level 1: The common performance assessment

The common performance assessment option provides the simplest and most accessible type of use for each indicator. It is intended to provide a common reference point for the performance assessment of buildings across Europe.

Common units of measurement and basic, reference calculation methodologies are provided. These can be used directly by professionals but are also intended to be readily adoptable by building assessment schemes, investor reporting tools and the public sector.

3.2.2 Level 2: Comparative performance assessment

This second level is for professionals that wish to make meaningful comparisons between functionally equivalent buildings. The framework lays down rules to support the comparability of results at national level or building portfolio level. This can include the need to fix certain key parameters and the input data used for calculations.

3.2.3 Level 3: Optimised performance assessment

This is the most advanced use of each indicator. The framework provides guidance to support professionals that wish to work at a more detailed level to model and improve performance, which may include:

- making more accurate calculations;
- carrying out modelling in order to optimise design and as-built performance;
- anticipating future costs, risks and opportunities along the building's life cycle.

Table 3.1 provides a brief overview of the differences between the common performance assessment and the other two types of assessments described here.

Table 3.1 Comparison of the three levels of performance assessment

Methodological aspects	Level 1: Common performance	Level 2: Comparative performance	Level 3: Optimised performance
General description	Use of the same common unit of measurement, calculated according to defined reference standards.	Calculation according to more specific rules in order to make results more comparable.	Calculation using more representative and precise data, as well as more advanced simulation models and calculation methods.
The metric	Use of the common unit of measurement.	Use of the common unit of measurement.	Use of a common metric, with the potential for reporting on more detailed performance aspects.
Reference unit	m^2 useful floor space/yr	m^2 useful floor space/yr	Possibility to use other units such as per bed space or workspace.
Calculation method	Common reference standards are specified. Some flexibility to reflect variations in methods between Member States is allowed.	Common reference standards are specified.	Common reference standards are specified. The possibility is given to use more complex methods.
Input data	Simplified guidance on quality and sources of input data.	Certain input data items and assumptions needed for calculations are pre-defined or based on default values in reference standards.	Detailed guidance on which aspects of input data selection can be improved in order to achieve greater representativeness and precision from calculations.
Use of life cycle tools	Simplified method to calculate Global Warming Potential (as an individual indicator) and LCA as an overarching assessment tool.	Simplified method to calculate Global Warming Potential (as an individual indicator) and LCA as an overarching assessment tool.	Advanced method to calculate Global Warming Potential (as an individual indicator) and LCA as an overarching assessment tool for different life cycle scenarios.
Inspection and sampling methods ***(where relevant)***	Common methods specified.	Common methods specified.	More complex methods may be more appropriate for use in order to improve the analysis.

3.3 Providing a reporting format for the indicator results

In Part 3 of the framework documentation, a reporting format is provided for each indicator, making it easy to follow a common approach to reporting on a building's performance. The reporting is split into five parts, with the minimum requirements for reporting identified below:

Minimum reporting requirements

1. the goal and scope definition (see Part 3, section 1), which describes the fundamentals of the building, where it is located and how it will be used.
2. the calculated or actual performance for the core indicators, as a minimum according to the common performance assessment and its reference methodology.

Optional additional reporting

3. the bill of materials for a building (see Part 3, Life cycle tool 2.1), which describes the materials that each building element and component are made up of.
4. the results for the life cycle scenarios (see Part 3, life cycle tools 2.2 and 5.1), which provide an insight into the potential future performance of a building.
5. the reliability rating (see Part 3, indicator 6.2), which provides an outlook on the underlying data, calculation method and simulation tools used that form the basis for a performance assessment.
6. The results from a Life Cycle Assessment (see Part 3, section 3), Users may report on the results obtained from carrying one out, potentially incorporating the results of life cycle scenarios (see Part 3, scenario tools 2.2).

If results are to be reported in the public domain, the rules laid down for each type of performance assessment in part 3 of the Level(s) framework documentation must be followed.

3.4 Valuation influence and reliability rating of the reported results

Linked to each performance assessment is the potential to report on, for any chosen level:

1. the influence of the assessment on a property's valuation appraisal, and
2. a rating of the reliability of a performance assessment.

These two components are specifically directed at investors and valuers, but can equally be used by a range of building professionals. The rating is designed to provide an understanding of how accurate and representative design estimates reported for each indicator are likely to be.

In particular, the rating supports investors and valuation professionals by:

1. Checking which aspects of performance that may affect a building's value have been addressed within the appraisal methodology used. It focuses on those that may strongly affect:
   - the properties risk profile (e.g. adaptation to future climate change), or
   - the value creation potential (e.g. lower utility costs)
2. Providing transparency in understanding the reliability of results that may be used to inform property risk assessments and in making property valuations (e.g. the precision of methods used to estimate performance).

For each indicator, a rating tool is provided so that users can rate the calculation method, data and modelling used to produce the reported result.

In general, the more realistic the performance modelling is and the higher the quality of the data that is used, the better the rating will be. Actual data from a completed and occupied building will receive the highest rating. In this way, the rating will help in minimising potential gaps between the estimated and actual performance, as well as encouraging the accurate monitoring of performance upon occupation.

The overall rating will be adjusted positively where the assessment results or monitoring data have been third party verified (i.e. are of an 'investment grade') and have been calculated or collected by professionals with relevant accreditations.

3.5 A focus on as-built and occupied performance

To ensure that goals like efficient operational performance and occupant satisfaction with the interior environment are actually met (e.g. energy use and cost, indoor air quality), it is important to monitor the performance of a building post-completion and to consider surveying occupant satisfaction post-occupancy.

3.5.1 Post-completion performance evaluation and monitoring

Accurate monitoring of the performance of a completed building will provide measured data for reporting purposes – sometimes referred to as Building Performance Evaluation (BPE). BPE will help in diagnosing and remedying any problems or defects which may result in a reduced performance compared to that which was expected.

For each indicator, options for monitoring are specified, as well as reference standards. This not only includes a traditional focus on energy and water consumption, but also the building materials used and their cost.

Guidance on metering strategies to support BPE can be found in guidance note 2.

Guidance note 2 for building owners, investors and occupiers

The role of metering in Building Performance Evaluation

A metering strategy is essential to ensure accurate measurement of a building's energy and water use. Care should be taken to ensure meters are installed as specified, and with due attention to calibration and placement.

The setting up of meters and monitoring systems should be addressed during the commissioning process. This shall include the reconciliation of sub-meter readings with the main meters and the logs of the building energy management system (if installed).

All meters should be correctly set up to facilitate their use as a monitoring tool, either through the taking of direct readings or the collation of data from a building energy management system. The storage capacity of Building Energy Management Systems (BEMS's) can be a constraint, so the provision of sufficient data capacity to support ongoing monitoring should be checked.

Moreover, during handover, the metering and building energy management system shall be fully documented, so that they can be correctly operated by the facilities manager and occupiers.

Smart meters can provide additional disaggregated consumption data that can be used to manage the energy use of a building. Such meters can also eliminate problems that may occur with the use of data obtained from estimated bills, which can lead to incorrect reporting. However, care should be taken to avoid over-complication of the sub-metering design, as this can lead to problems if they are incorrectly installed or commissioned.

Adapted from the Carbon Trust(2012), Innovate UK (2016)

3.5.2 Post-occupancy evaluation of satisfaction

Occupant satisfaction is a critical parameter for the success of a building. The evaluation of occupant satisfaction requires a process of structured interviews and surveys, with a focus on specific performance aspects considered to be important for achieving healthy and comfortable buildings.

The evaluation process may be referred to as a Post Occupancy Evaluation (POE), occupant Indoor Environmental Quality (IEQ) survey or a Building User Survey (BUS). For the purposes of this framework, the process is referred to as a Post Occupancy Evaluation (POE).

Examples of POE tools and methods can be found in guidance note 3.

Guidance note 3 for building owners, investors and occupiers

Post Occupancy Evaluation (POE) of comfort and satisfaction

A POE is typically carried out a minimum of one year after the building has been fully occupied. They normally consist of interviews with occupiers to evaluate qualitative aspects related to the building performance indicators. The POE should generally be carried out by a third party using a standardised methodology.

A number of evaluation methods and standards have become standard reference points for Post Occupancy Evaluations. These methods and standards each provide a toolkit of guidance on how to carry out combinations of subjective and objective evaluations, as well as providing model survey questions that can be used.

A non-exhaustive list of the most referenced methods and standards is as follows:

- Building User Survey (BUS) method which was developed from the experience of evaluating low energy buildings in the 1980s and 1990s [2].
- CBE (Berkeley) occupant Indoor Environmental Quality (IEQ) survey, which is a web-based format addressing seven aspects of indoor quality[3].
- Soft Landings process, which is a multi-stage approach to delivering better buildings that includes a final stage of extended after care and POE[4].

In addition, a number of building assessment schemes and reporting tools provide for Post Occupancy Evaluations:

- as a fundamental requirement of the scheme (e.g. Miljöbyggnad, Sweden; SSO, Spain),
- as an optional indicator, criterion or credit (e.g. BREEAM New Construction, LEED Building Operations & Maintenance, Finland GBC Building Performance Indicators).

[2] Arup, *BUS methodology*, http://www.busmethodology.org/
[3] University of California Berkeley, *Occupant Indoor Environmental Quality (IEQ) Survey and Building Benchmarking*, Centre for the Built Environment, https://www.cbe.berkeley.edu/research/briefs-survey.htm
[4] BSRIA, *Soft landings process*, https://www.bsria.co.uk/services/design/soft-landings/

Part 2 of the Level(s) framework

Introduction to part 2 of the Level(s) framework

In Part 2 of the Level(s) framework documentation, potential users are provided with a basic introduction to all of the elements of the framework, and how it can be used as a whole, or in part, to report on the performance of building projects.

The four main elements of the Level(s) framework described in this section are:

1. How life cycle thinking is encouraged throughout the framework.
2. The macro-objectives of the framework and how they relate to EU environmental policy.
3. The indicators that can be used for entry level performance assessment and how they can be calculated and used.
4. How more advanced users can carry out a cradle to cradle Life Cycle Assessment (LCA).

In the separate Part 3 of the Level(s) framework documentation, further detailed guidance is provided on the calculation and reporting of results, including how to make more advanced use of the indicators. The guidance in Part 3 includes:

- More detail on the calculation methods and data requirements.
- A reporting format for performance assessments made according to the common performance assessment methods.
- Guidelines and rules on how to make assessments and report on results for the comparative and design optimisation performance options.

Life cycle thinking at building level

Users are encouraged throughout to think about and analyse buildings from a life cycle perspective. To achieve this, the Level(s) framework is structured in a way that users can learn about the different aspects of life cycle thinking and the assessment of life cycle performance.

Each part of the framework therefore contributes to, and forms part of, an overall life cycle approach. Table i provides an overview of how the different parts of the framework work together.

Table i. How parts of the Level(s) framework contribute to a life cycle approach

Part of the Level(s) framework	How it contributes to a life cycle approach
Goal and scope definition	A functional description of the building and how it will be used (see Part 3, section 1).
Inventory flow data	Data about the buildings construction (the bill of materials) and flows of energy and water along its life cycle (see life cycle tool 2.1 and Indicators 1.1 and 3.1).
Indicators that measure the environmental impacts of a building	These allow specific environmental impacts to be measured either using simple common indicators or indicators based on Life Cycle Impact Assessment methods (see Indicator 1.2).
Scenarios that describe a life cycle aspect of a building	Guidelines to support building professionals to analyse how building designs may perform in the future and along the life cycle (see life cycle tools 2.2 and 5.1).

A cradle to cradle Life Cycle Assessment (LCA) of a building	This is the most advanced option within the framework. Users of the framework may choose to go directly to an LCA, or to use other separate LCA steps from the framework first (see Section 7).
The quality and reliability of life cycle inventory data	The quality and reliability of data is a key challenge in seeking to ensure that the results are as representative as possible of the building being assessed (see Indicator 6.2).

Description of the building to be assessed

An important principle of the Level(s) framework is comparability on the basis of functional equivalence. It is therefore important for any building whose performance is assessed and reported on, that the basis for functional equivalence is reported alongside the performance assessment results.

Part 3, section 1 of the documentation therefore provides guidelines on how to compile and report on the basic description of a building (a 'goal and scope definition' in LCA terms), which will establish the basis for functional equivalence.

The description comprises the following information, with in brackets the equivalent terminology used in a Life Cycle Assessment:

- The building and its elements: The building type (or use class) and the pre-defined minimum scope of building parts and elements (the 'object of assessment').
- The building type, ownership and market segment: A description of the building's market segment, ownership structure and intended service life (the 'functional unit and equivalent').
- The unit to be used for comparative purposes: The common methods to be used for measurement of the total useful floor area within a building (the 'reference unit').
- How the building will be used and the lifespan of its elements: A description of the outdoor environment to which the building is exposed and the intended conditions of use. Default service lifespans for building parts and components are also provided (the 'reference in-use conditions').
- The timescale for the performance assessment: The intended or default service life of the building being studied (the 'reference study period').
- Which stages in the life cycle: The life cycle stages that shall be taken into account when making the performance assessment (the 'system boundary').

Taken together, this information provides a comparative basis for the results for the indicators and scenarios, as well as providing a goal and scope definition for carrying out an LCA.

The macro-objectives and their associated indicators

This section provides an introduction to the macro-objectives and their related indicators.

For each macro-objective, the definition, policy context and intended scope and focus are provided.

For each indicator, a brief overview of what they measure, why their use should be considered and how they can be used on building projects is provided. This comes together with the unit of measurement and a technical summary of the methodology to be followed for a Level 1: Common performance assessment, according to the framework.

Table i provides an overview of the framework as a whole, signposting where in Part 2 and Part 3 the relevant guidance can be found to make a performance assessment at Levels 1 (common assessment), 2 (comparative assessment) and 3 (optimisation assessment).

Table ii. Signposting of where to find guidance for each indicator or life cycle tool in the Level(s) Framework

Indicator or life cycle tool	**Unit of performance measurement**	**Where to find an overview of each indicator or tool**
Macro-objective 1: Greenhouse gas emissions along a buildings life cycle		
1.1 Use stage energy performance *1.1.1 Primary energy demand* *1.1.2 Delivered energy demand* *(supporting indicator)*	kilowatt hours per square metre per year (kWh/m^2 /yr) Design	Overview of the indicator Outline methodology
1.2 Life cycle Global Warming Potential	kg CO_2 equivalents per square metre per year (kg CO_2 eq./m^2/yr)	Overview of the indicator Outline methodology
Macro-objective 2: Resource efficient and circular material life cycles		
2.1 Life cycle tools: Building bill of materials	Reporting on the Bill of Materials for the building, as well as for the four main types of materials used.	Overview of life cycle tool
2.2 Life cycle tools: scenarios for building lifespan, adaptability and deconstruction	According to the performance assessment level: 1. Design aspects 2. Semi-qualitative assessment 3. LCA-based assessment	Overview of life cycle tool Outline methodology
2.3 Construction and demolition waste and materials	kg waste and materials per m^2 of total useful floor area *(per life cycle and project stage reported on)*	Overview of the indicator Outline methodology
2.4 Cradle to grave Life Cycle Assessment	Seven environmental impact category indicators *(see the detailed guidance provided under Overarching assessment tool 7)*	Overview of life cycle tool
Macro-objective 3: Efficient use of water resources		
3.1 Total water consumption	m^3 of water per occupant per year	Overview of the indicator Outline methodology
Macro-objective 4: healthy and comfortable spaces		
4.1 Indoor air quality	4.1.1 Good quality indoor air: Parameters for ventilation, CO_2 and humidity 4.1.2 Target list of pollutants: Emissions from construction products and external air intake.	Overview of the indicator Outline methodology

4.2 Time outside of thermal comfort range	% of the time out of range of defined maximum and minimum temperatures during the heating and cooling seasons	Overview of the indicator Outline methodology
Macro-objective 5: Adaptation and resilience to climate change		
5.1 Life cycle tools: scenarios for projected future climatic conditions	*Scenario 1: Protection of occupier health and thermal comfort* Simulation of the building's projected time out of thermal comfort range for the years 2030 and 2050.	Overview of the life cycle tool Outline methodology
Macro-objective 6: Optimised life cycle cost and value		
6.1 Life cycle costs	Euros per square metre of useable floor area per year (€/m^2/yr)	Overview of the indicator Outline methodology
6.2 Value creation and risk factors	Reliability ratings of the data and calculation methods for the reported performance of each indicator and life cycle scenario tool.	Overview of the indicator Outline methodology

Macro-objective 1: Greenhouse gas emissions along a buildings life cycle

Definition: Minimise the total greenhouse gas emissions along a building's life cycle, with a focus on emissions related to energy in the use phase of a building and emissions embodied in building materials and associated processes along the life cycle.
Intended scope and focus: The macro-objective encompasses action at building level with a focus on: 1. energy performance during the use phase, including the contribution of cost effective and low/zero emissions energy technologies and infrastructure, 2. reduction in use phase and embodied greenhouse gas emissions along the building life cycle, including those associated with the manufacturing of construction materials. There shall be a focus on the potential trade-offs between the production stage and the use stage, so as to enable minimisation of total greenhouse gas emissions along the life cycle.

The macro-objective 1 indicators

Indicator	**Performance metric**
1.1 Use stage energy performance *1.1.1 Primary energy demand* *1.1.2 Delivered energy demand (supporting indicator)*	kilowatt hours per square metre per year ($kWh/m^2/yr$)
1.2 Life cycle Global Warming Potential	kg CO_2 equivalents per square metre per year (kg CO_2 eq./m^2/yr)

1.1 Indicator of use stage energy performance

The focus of indicator 1.1 is on the energy consumed by a building during the use stage[5]. It consists of two sub-indicators:

- the headline indicator 1.1.1 which is based on the calculation of primary energy demand
- a supporting indicator 1.1.2 which is based on the calculation or measurement of delivered energy demand

The first indicator forms part of the definition of a Nearly Zero-Energy Building (NZEB) in accordance with Article 9 of the EPBD. The two indicators are intended to ensure an emphasis on both the efficiency of a building's fabric and the primary energy efficiency of its systems.

[5] In the reference standard EN 15978 the relevant module of the use stage is B6 'Operational energy use'

1.1.1 Overview of the indicators

What do they measure?

Primary energy is defined by Article 2(5) of the Energy Performance of Buildings Directive [6] as *'the energy that has not undergone any conversion in the transformation process, calculated by energy carrier using a primary energy factor'*. It is the energy that is required to generate the electricity, heating and cooling used by a building. Reporting is disaggregated into renewable, non-renewable and exported energy. This is so that the benefits of generating low carbon or renewable energy can be taken into account.

Delivered energy measures is the energy delivered to the building in the form of electricity, heat and fuel. It is the energy per 'carrier' supplied to the building, to satisfy uses within the building (heating, cooling, ventilation, domestic hot water, lighting, appliances, etc.). The 'delivered energy' is generally the one metered by the utilities. Reporting is therefore disaggregated into the energy used for heating, hot water, cooling, ventilation and lighting. Reporting of other aspects of occupant energy use [7] is also encouraged.

Why measure performance with these indicators?

The indicators provide users with an understanding of a building's energy demand in the use stage.

Use stage energy demand is in general responsible for the majority of life cycle energy use in the case of buildings constructed before the turn of the millennium. Building materials assume greater importance for new buildings, where the use stage may be responsible for up to 30-70% of life cycle energy use, depending on the building type, form and specification.

Moreover, reporting on primary and delivered energy demand might be required for the purpose of building permitting in each Member State, while the EPBD requires Energy Performance Certificate (EPC) to be issued when a building is sold or let. The EPC include the energy performance of a building (primary energy demand) and reference values such as minimum energy performance requirements, or additional information such as the annual energy consumption for non-residential buildings and the percentage of energy from renewable sources in the total energy consumption.

In addition, reporting on these two use stage indicators can provide useful insights on the buildings total emissions of air pollutants to the ambient air. Whereas an overall reduction of the delivered energy measures will generally have a positive effect on air quality[8], a fuel switch may also lead to an increase of emissions of specific ambient air pollutants[9].It is therefore important to also

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[6] Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast)

[7] Referred to in EN 15603 as *'other uses of energy'* (see Annex C) and in pr EN 52000-1 as *'energy use for other services*' or *'non-EPB uses'*

[8] Commission Impact Assessment accompanying the proposal for a Directive amending Directive 2012/27/EU on Energy Efficiency, SWD(2016) 405 final/2, part 1/3, Brussels, 6 December 2016, p.57: *The residential sector in particular holds big potentials for untapped energy efficiency and, as a result, air pollution abatement* […]. *The size of this potential depends on the fuel choice of households and the efficiency of the heating system.*

[9] See also European Environment Agency, November 2016, Air quality in Europe – 2016 report, chapter 3 *Residential biomass combustion: an important source of air pollution*, https://www.eea.europa.eu/publications/air-quality-in-europe-2016

minimise primary energy use, as this is an indicator of the amount of fuel used to service the building's energy needs.

How can they be used in building projects?

Reporting on the indicators can be based on both calculated and measured performance. This means they can be used by a range of project actors, including during the design stage to simulate performance and upon completion to check how the building actually performs in real life.

Delivered energy consumption can also be reported in terms of life cycle costs using indicator 6.1a: Use stage utility costs.

Guidance is provided on how the gap between design and actual performance can be minimised, with a focus on calculation precision, construction quality and commissioning routines.

Table 1.1.1 The project stages at which indicator 1.1 can be used

Project stage	Activities related to the use of indicator 1.1
1. Design stage (based on calculations)	✓ Calculated Energy Performance of Buildings (EPB) assessment sub types: design or tailored
2. Completion stage (based on as-built drawings)	✓ Calculated EPB assessment sub types: as built ✓ Quality testing: air tightness and building fabric integrity
3. Post-completion (based on commissioning and testing)	✓ Commissioning: functional performance testing and seasonal testing.
4. Occupation (based on measured performance)	✓ Measured EPB assessment sub types: climate corrected, use corrected or standard

1.1.2 Outline methodology for making a common performance assessment

Unit of measurement

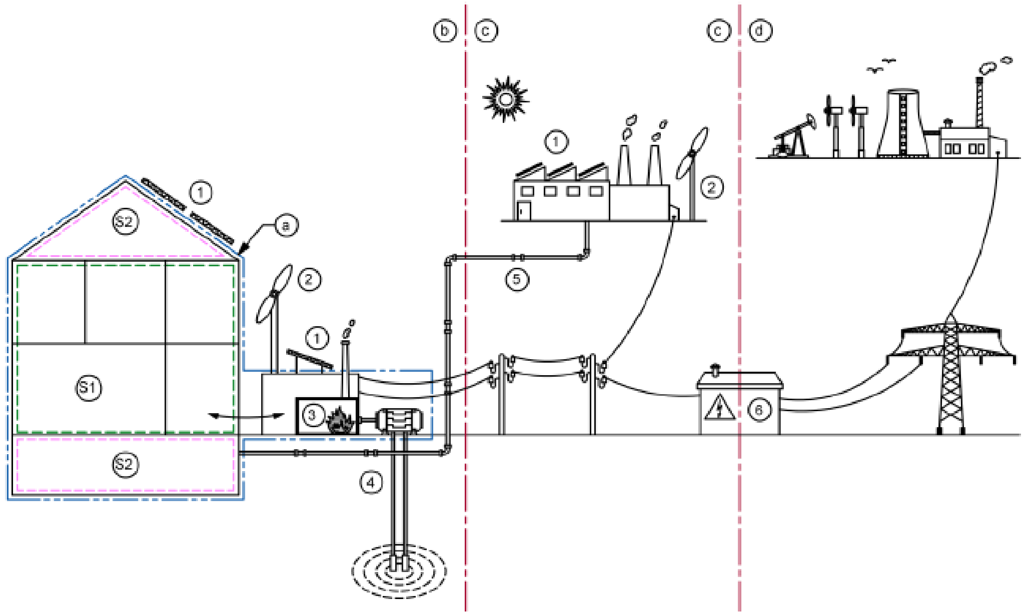
The common unit of measurement for both use stage primary energy demand and use stage delivered energy is **kilowatt hours per square metre per year (kWh/ m^2 / yr).**

The performance is assessed for the reference floor area and building size, which are defined by the methodology in Part 3, section 1.3.1. Zoning criteria are then applied according to the reference standards or national/regional calculation methods. These zoning criteria can be used to determine whether spaces are included or excluded.

Boundary and scope

The scope of the indicator includes the following energy uses, which are also referred to as technical building services – heating, cooling, ventilation, domestic hot water and (built-in) lighting. In a life cycle approach, these uses are referred to as operational energy consumption.

The assessment boundary is the building. Energy can be imported or exported through the assessment boundary (the building) from/to on-site, nearby and distant locations – as illustrated by Figure 1.1.1. Inside the assessment boundary, the system losses are taken into account explicitly in the conversion factor applied to the energy carrier, also referred to as a primary energy factor[10].



Key

a	Assessment boundary (use energy balance)	S1	Thermally conditioned space	1	PV
b	On-site	S2,	Space outside thermal envelope	2	Wind
c	Nearby			3	Boiler room
d	Distant			4	Heat pump
				5	District heating / cooling
				6	Substation (low voltage and possible storage)

Figure 1.1.1 Building assessment boundary and energy balance locations

Source: CEN (2017)

Calculation method and reference standards

The underlying calculation method for each sub-indicator is provided by the CEN standards series that support implementation of the Energy Performance of Buildings Directive (EPBD) across the EU.

The CEN standards series that currently forms the basis for the majority of national calculation methods includes EN 15603 and EN ISO 13790. As of 2017, this standards series will progressively be replaced by the new EN ISO 52000 series[11], but it is anticipated to take some time before national calculation methods are updated accordingly.

This means that most national calculation methods that are required to be used to meet performance requirements or to complete Energy Performance Certificates (EPCs), and which are aligned with the EN standards series, can be used. An important first step is selection of the appropriate assessment type and sub-type from those presented in EN 15603 and prEN ISO 52000-1 (see section 1.1.1, table 1.1.1 in Part 3 of the documentation).

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[10] Primary energy factors are, in most cases, provided in each national calculation method. If not default factors can be found in the reference EN standards series.

[11] The 'overarching standards' developed under mandate M/480 given by the European Commission to the European Committee for Standardisation (CEN) are the following: ISO/EN 52000-1, 52003-1, 52010-1, 52016-1, and 52018-1.

1.2 Indicator of life cycle Global Warming Potential (GWP)

The focus of indicator 1.2 is on the contribution of a building to global warming along its life cycle.

This is sometimes also referred to as a carbon footprint assessment or whole life carbon measurement. It includes the assessment of what are also sometimes referred to as embodied CO_2 emissions – those that are not directly related to the use of energy in a building, but are instead the indirect result of processes to produce, construct, repair, maintain, renovate and eventually deconstruct a building.

Performance shall therefore be reported by life cycle stage. The quality of the data used to estimate the life cycle emissions shall additionally be evaluated and reported on.

1.2.1 Overview of the indicator

What does it measure?

This indicator measures the contribution of the greenhouse gas (GHG) emissions associated with a building's life cycle to the earth's global warming or climate change.

GHGs are constituents of the atmosphere which absorb and emit radiation at specific wavelengths within the spectrum of the thermal infrared radiation emitted by the earth's surface, by the atmosphere itself, and by clouds. By doing so, GHGs obstruct the loss of thermal energy towards the space and act like a blanket which insulates the Earth and keep it warmer.

Effects on the Earth are different for different GHGs. The Global Warming Potential (GWP) was developed to allow for the comparison of the impact on global warming caused by different gases. Specifically, it is a relative measure of how much energy can be trapped in the atmosphere over a set time horizon by a mass of gas in comparison with the same mass of carbon dioxide (CO_2). A higher GWP means a larger warming effect in that period of time.

Why measure performance with this indicator?

The presence of GHGs is essential for allowing life on the planet. However, the concentration in the atmosphere has risen in the last decades to hazardous and never-registered levels, which can contribute to an excessive global warming and provoke catastrophic effects on the climate. GWP provides a common unit of measure which allows assessing the impact on the climate due to GHGs.

How can it be used in building projects?

The final objective of the quantification of GWP associated to a building is to reduce its impact on the global climate. Following the different reporting options of the framework, intermediate goals can vary depending on the field of application of the indicator:

- Level 1 assessment: Promoting the measurement of this indicator and the comprehensive understanding of the key contributions to the overall carbon footprint of buildings, which would be the minimum objective for the common assessment metric;
- Level 2 assessment: Provision of a reference measurement and reporting method, which could ultimately enable comparison, benchmarking and target setting;
- Level 3 assessment: Integrating the 'carbon performance' among the criteria to consider for the design performance optimisation.

1.2.2 Outline methodology for making a common performance assessment

Unit of measurement

The unit of measurement to be used for reporting on this indicator is **kg CO_2 equivalents/m^2/yr** for each life cycle stage. This unit of measurement is a commonly specified environmental impact category indicator used in Life Cycle Assessment.

Additional information needed to describe the functionality of the building shall also be reported in accordance with the guidance laid down for carrying out a cradle to cradle Life Cycle Assessment (LCA) (see 2.4 life cycle tool).

Boundary and scope

The scope comprises the evolution of the building from cradle to cradle, i.e. from the production and supply to the end of life disposal and recycling of materials.

The setting of the system boundaries follows the 'modularity principle' according to the EN 15978. This means that the unit processes influencing the building's environmental performance during its life cycle shall be assigned to the module in the life cycle where they occur.

In addition to the general approach based on assessment of all the life cycle stages of a building, entry level rules are provided which allow for focus on particularly relevant parts of the building's life cycle, such as:

- The product stage (A1-3)
- The use stage (B2-4, B6)
- End of life stage (C3,4)
- Benefits and loads beyond the system boundary (D)

If only some life cycle stages are calculated and reported on, strict rules shall be followed on how the results shall be reported, as the results will not be representative of the full life cycle performance (see section1.2.1.1).

The building shall be documented following the scope defined in Part 3, section 1.1.2:

- Components (elements, structural parts, products, materials) needed during its life time. This also includes the consideration of in-use conditions (such as damage caused by the weather or daily wear and tear) and time-dependent qualities (such as the need to replace components after a specific period of time);
- Associated processes such as maintenance, exchange and End of Life processes and re-use, recycling and energy retrieval;
- Energy and water use during the operation of the building.

Additional methodological rules and cut-off criteria are described in Part 3, section 1.2.1.

The end of life of a building starts when the building is decommissioned and no further use is intended. Components and materials to clear from the site have to be removed and the site has to be made ready for the next use. The End of Life stage shall be defined according to Module C1-C4 of EN 15978. Net environmental loads and benefits from the eventual reuse, recycling and energy recovery of materials are reported in Module D. The environmental benefit of exported energy from the building is also reported in Module D, such as exported electricity from PV panels into the grid.

As described under macro-objective 2, additional rules for using LCA are provided within the framework for the 2.2 life cycle scenarios, which focus on resource efficiency:

Scenario 1: Building and elemental service life planning
Scenario 2: Design for adaptability and refurbishment
Scenario 3: Design for deconstruction, reuse and recyclability

Calculation method and reference standards

The detailed calculation method, including GWP 'characterisation' factors to convert delivered energy to CO_2 equivalent emissions, is provided in Part 3 of the framework documentation. The main reference standards for the indicator are ISO 14040/44, EN 15804 and EN 15978.

The Global Warming Potential shall be reported separately for each life cycle stage. This is so that the trade-offs between decisions taken at different stages can be understood and taken into account.

Macro-objective 2: Resource efficient and circular material life cycles

Definition:

Optimisation of building design, engineering and form in order to support lean and circular flows, extend long-term material utility and reduce significant environmental impacts.

Intended scope and focus:

This macro-objective encompasses actions that can be taken at building level with a focus on material efficiency and circular utility. This shall encompass actions along the life cycle relating to construction product manufacturing, building design, structural engineering and construction management, and addressing replacement cycles, adaptability and deconstruction.

The overall objective shall be to reduce waste, optimise material use and reduce the life cycle environmental impacts of designs and material choices. This can be done using metrics to measure specified building elements or waste, but also by looking at potential performance over time using scenarios.

The macro-objective 2 life cycle tools

Life cycle tool	**Performance metric or reporting form**
2.1 Life cycle tools: Building bill of materials	Reporting on the Bill of Materials for the building, as well as for the four main types of materials used.
2.2 Life cycle tools: scenarios for building lifespan, adaptability and deconstruction	According to the performance assessment level: 1. Design aspects that are proposed/have been implemented (common performance assessment) 2. Semi-qualitative assessment giving a score (comparative performance assessment) 3. LCA-based assessment of scenario performance (design optimisation)

The macro-objective 2 indicators

Indicator	**Performance metric**
2.3 Construction and demolition waste	kg waste and materials per m^2 of total useful floor area (per life cycle and project stage reported on)
2.4 Cradle to grave Life Cycle Assessment	Seven environmental impact category indicators (detailed guidance is provided under 4.4 Overarching assessment tool)

2.1 Life cycle tool: Building bill of materials

The aim of this life cycle tool is to provide guidance on how to put together a Bill of Materials (BoM) for a building and then report on the four main types of materials used.

The main focus of attention is on the compilation of data on what the building is composed of, using the Bill of Quantities as a starting point. Reporting can be made on the four main types of materials used, according to the four types defined by Eurostat[12]. This exercise provides the raw data to calculate an environmental impact, such as for indicator 1.2.

A linked step is to understand how long each material and element of a building may last – as addressed by 2.2 life cycle tools, scenario 1.

2.1.1 What is a Bill of Materials?

A Bill of Materials is a mass-based inventory of the materials that compose a building. The BoM is organised according to main elements that a building is composed of.

2.1.2 Overview of the information that can be reported

The Bill of Quantities (BoQ) is the starting point for compiling a Bill of Materials (BoM). A BoQ specifies the elements of a building (e.g. foundations, columns), including their technical specifications and expected lifetime. The BoQ comprises different categories of elements, which can have different functional performance characteristics. A Bill of Materials (BoM) differs from a BoQ in that it describes the materials contained in the building's elements (e.g. concrete, steel, aluminium).

Once the BoM has been compiled, headline reporting is then possible for the four main material types accounted for by Eurostat – metals, non-metallic minerals, fossil energy based and biomass materials.

2.1.3 Outline methodology for compiling the information

The following steps should be followed in order to compile the BoM:

1. Compile the Bill of Quantities: A BoQ is compiled which comprises the elements accounting for at least 99% of the mass of the building.
2. Identify the basic composition of each building element: A breakdown in mass of each building element's constituent materials should be compiled.
3. Identify the technical specification of each building element: This technical information will later, if there is a lack of specific data from manufacturers, enable the selection of representative data from within a generic life cycle inventory database.
4. Aggregation by material: The mass for each material should thereafter be aggregated to obtain a mass for each type of material. The materials should be further aggregated into the four material types accounted for by Eurostat:
   - Metal materials
   - Non-metallic mineral materials
   - Fossil energy materials
   - Biomass based materials

2.2 Life cycle tools: Scenarios for building life span, adaptability and deconstruction

The Level(s) framework provides tools and guidance for describing and assessing a number of life cycle scenarios that are important from a resource efficiency perspective. The focus of the 2.2 life cycle scenario tools and guidance is on:

- Estimating the service life of the building and its elements
- Assessing how adaptable the building is to potential future market needs

[12] Eurostat, *Material flow accounting and resource productivity*, http://ec.europa.eu/eurostat/statistics-explained/index.php/Material_flow_accounts_and_resource_productivity#Consumption_by_material_category

- Assessing the potential to recover, reuse and recycle major building elements from the building at the end of life.

In this way, each scenario has the potential to contribute to extending the life span and utility of a building and its elements.

2.2.1 What is a life cycle 'scenario'?

Scenarios are not indicators as such, but are an important tool for assessing the long-term potential, future performance of a building. They are defined by EN 15978 as a *'collection of assumptions and information concerning an expected sequence of possible future events'*.

Scenarios describe future events in the life cycle of a building that complement the physical description of the building (the Bill of Materials) and for which changes in potential future performance can be analysed.

For example, a scenario may be used to describe what is predicted to happen to the building at the end-of-life and the likely recovery rates of materials achieved based on current practices. Life cycle scenarios are needed to determine several indicators, such as 1.2 Life cycle global warming potential.

2.2.2 How can the life cycle scenario tools be used in building projects?

The design of buildings for greater resource efficiency and circularity requires a focus on both present and potential future performance along the life cycle – including the construction, use and end-of-life stages.

By developing and evaluating future scenarios for the circularity of a building, designers can identify measures that have the potential to influence the service life, future adaptability and future recovery of value from building elements, systems and materials. These three life cycle scenarios reflect the state of the art in terms of circular thinking.

2.2.3 The focus of attention of the scenario tools

Three scenarios have been selected that exert a strong influence on the resource efficiency of a building. The guidance and reporting for each scenario provides users with qualitative and quantitative ways of reporting on how far the building addresses each of the following aspects of resource efficiency and circularity:

- Scenario 1: Building and elemental service life planning – A focus on the overall design service life of the building as a whole and the major building elements (e.g. facades and structures).
- Scenario 2: Design for adaptability and refurbishment – A focus on how the design of a building could facilitate future adaptation to changing occupier needs and market conditions.
- Scenario 3: Design for deconstruction, reuse and recyclability – A focus on the potential to recover, reuse and recycle major building elements from the building.

Each scenario will in turn have impacts both on input flows (material use) and output flows (construction and demolition waste) along the life cycle of a building. There are therefore strong links with indicator 2.3 Construction and demolition waste.

2.2.4 Reporting options for each scenario tool

The method to be followed for each assessment level varies according to the level of detail at which they address the resource efficiency aspect and the extent to which the benefits and burdens and potential trade-offs between different building design scenarios are modelled and quantified:

1. Common performance level (qualitative): A checklist of the most important design aspects that can be taken into consideration and whether/how they are addressed.
2. Comparative performance level (semi-qualitative): Design aspects that are important to consider are given weightings and the scores achieved by a design are then added to give an overall performance which can be reported on. This performance can be compared if the same weighting methodology has been used.
3. Performance optimisation level (quantitative): The analysis of the environmental performance of designs using other indicators of this framework, such as 1.2 (life cycle GWP) or 2.4 (cradle to cradle LCA), so that they can be evaluated, compared and reported on.

The outline rules for level 1, the common performance assessment are presented in table 2.2.1.

The focus of attention for a common performance assessment using the scenarios is on a general understanding of the concept of the service life and some of the most common design aspects that are important to support future adaptability and deconstruction.

Table 2.2.1 Life cycle scenarios for a common performance assessment

Scenario	**Common performance assessment rules**
Scenario 1 **Building and elemental service life planning**	○ An estimate of the service life shall be reported for the building as a whole and its main elements (see the reporting format in Part 3, section 2.2.2.1)
Scenario 2 **Design for adaptability and refurbishment**	○ Identify, from the checklist of design aspects provided in section 2.2.2.2, those aspects that have been addressed ○ For each aspect, describe the specific design measures that have been implemented (see the reporting format in Part 3, section 2.2.2.2)
Scenario 3 **Design for deconstruction, reuse and recyclability**	○ Identify, from the checklist design aspects provided in 2.2.2.3, those aspects that have been addressed. ○ For each aspect, describe the specific design measures that have been implemented (see reporting format in Part 3, section 2.2.2.3)

2.3 Indicator on construction and demolition waste (C&DW)

The focus of indicator 2.3 is on waste that may arise at a number of specific, defined points in the life cycle of a building. The different potential stages and building-related activities are identified in table 2.3.1.

Reporting is based on the output flows from relevant on site and off site processes. These output flows are split into the different waste fractions, so as to aid an understanding of the material flow as a whole and how much is reused and recycled.

Table 2.3.1 Life cycle stages that are relevant to the indicator

Life cycle stage(s)	***Building-related activities to report on***
Part of the previous building's life cycle	Deconstruction and demolition of a building(s) in order to clear a site for a new building construction
	Part deconstruction of a building(s) in order to prepare useful parts for in-situ reuse
	Preparation of a building in order to facilitate a major renovation
Life cycle stages A3/5	Construction on site of a new building and/or the prefabrication/construction of parts and elements off site
Life cycle stages C1/3, D	Deconstruction and demolition of the building at a future point in time beyond the end of its service life

2.3.1 Overview of the indicator

The common performance assessment focuses on gathering data to report on the total waste disposed of and waste diverted. This requires confirmation of the waste types and whether the data is estimated or from a site. The reporting is at a basic level, making a distinction between waste disposed of and waste diverted.

What does the indicator measure?

For each of the defined stages in the life cycle of a building, and as relevant to the nature of the building project being reported on, the following categories of output flows shall be reported on, with the option to disaggregate each flow by material stream:

- Waste disposed of: hazardous and non-hazardous waste streams. This shall include waste disposed of to landfill and by incineration.
- Components for re-use: This shall include all materials recovered for re-use either on or off site, with a focus on encouraging the reuse of structural elements.
- Materials for recycling: This shall include all materials recovered for recycling either on or off site. Waste materials used in backfilling operations on or off site are excluded.
- Materials for other material recovery operations: This shall include backfilling and processes that meet the EU definition of energy recovery.

Waste generated during the prefabrication or assembly of parts or elements off site that would otherwise take place on site shall be included within reporting on waste disposed of. This is to ensure that any burden shifting in order to reduce on-site waste is accounted for.

The flows reported on under the scope of this indicator reflect those defined '*indicators describing additional environmental information*' in the reference standards EN 15978.

Why measure performance with this indicator?

The building sector accounts for the largest flow of material resources across the EU and, in this respect, buildings represent a significant and large material bank. Taking the example of Germany, it has been estimated to have a building material bank of over 50 billion tonnes of mineral resources, compared to annual waste arisings of approximately 0.2 billion tonnes.

The demolition of buildings can typically generate between 664 and 1637 kg/m^2 of waste. Major renovations can generate between 20 and 326 kg/m^2 of waste and construction sites can generate a further 48 – 135 kg/m^2 of waste. Consequently, there are significant opportunities to reduce waste by moving to a more circular economy-based approach that focuses on deconstruction instead of demolition, and on reuse and recycling instead of disposal. Landfill costs and taxes in many Member States also create a significant financial incentive in the range of €36 - 170/tonne[13]. Some Member States such as the Netherlands even place a ban on the landfilling of recyclable C&DW.

How can it be used in building projects?

Depending on the project stage and the nature of the waste, reporting of the indicators can be based on both estimated and actual performance as recorded on site. This means they can be used by a range of project actors, both during the design stage to estimate performance, and during demolition and construction stages in order to check how the project actually performs in real life.

Guidance is provided to users of this indicator on the opportunities for waste minimisation, both in terms of utilising an existing building material bank and avoiding waste during construction processes, as well as the tracking of waste arisings on-site.

Table 2.3.2 Project stages at which indicator 2.3 can be used

Project stage	**Activities related to the use of indicator 2.3**
1. Design stage (*based on estimations*)	✓ Estimations of waste based on surveys of existing buildings that will undergo major renovation or where the structure will be reused (life cycle stage B5). ✓ Estimations based on scenarios for deconstruction and demolition of the building at a future point in time beyond the end of its service life (life cycle stages C1/3, D).

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

2. Construction stage (*based on data recorded from the site)*	✓ Data from deconstruction and demolition of (a) building(s) in order to clear a site for a new building construction (as part of a previous life cycle). ✓ Data from the part deconstruction of (a) building(s) in order to prepare useful parts for in-situ reuse. ✓ Data from construction on site of a new building and/or the prefabrication/construction of parts and elements off site (life cycle stages A3/5). ✓ Data from preparation of a building in order to facilitate a major renovation.
3. Completion stage (based on estimations supported by as-built drawings)	✓ Estimations based on scenarios for deconstruction and demolition of the building at a future point in time beyond the end of its service life (life cycle stages C1/3, D).
4. Post-completion (based on commissioning and testing)	n/a
5. Occupation (based on measured performance)	n/a
6. End of life (based on planned performance)	✓ Details of measures that were taken at design stage to facilitate deconstruction, reuse and recycling at a future date (life cycle stages C1/3, D).

Indicators 2.3 and 2.4 can also be used to estimate and compare the circular benefits of life cycle scenarios that may have been considered for a building. Table 2.3.3 outlines how each of the scenarios for which a method is provided by the framework creates distinct opportunities to minimise waste along the building's life cycle.

Table 2.3.3 Opportunities for waste minimisation arising from life cycle scenarios

Life cycle tool	**Life cycle stages of relevance**	**Areas of possible focus for waste minimisation**
2.1 Life cycle tool: Bill of Materials	– Previous building end of life – Product stage (A1-3) – Construction waste (A4-5 Construction stage)	– Use of building material bank by incorporating existing parts and components into a new or renovated building – Greater precision by using prefabrication, computer aided manufacturing and standardised components/sections – Reduction in construction waste by lean design along the supply chain
Life cycle scenario tool 1: Building and elemental service life planning	– B2-5 Use stage	– Specification of more durable, longer lasting elements and components

Life cycle scenario tool 2: Design for adaptability and refurbishment	– B5 Refurbishment – D Benefits and loads beyond system boundary	– Improve the probability that a whole building will be adapted to future needs – Design to facilitate the in-situ adaption of major parts to future needs without demolition
Life cycle scenario tool 3: Design for deconstruction, reuse and recyclability	– C1 Deconstruction demolition – C3 Waste processing – D Benefits and loads beyond system boundary	– Management of information about components, systems and materials in the building material bank – Design to facilitate disassembly so that whole elements and components can be reused or recycled. – Design to ensure the recyclability of segregated materials

2.3.2 Outline methodology for making a Level 1 common performance assessment

Unit of measurement

The common unit of measurement for output flows associated with construction and demolition processes is **kg of waste and materials generated per 1 m² of useful floor area demolished or constructed (kg/m²/life cycle stage reported on)**.

Boundary and scope

The scope shall encompass waste (output flows) arising from the end-of-life buildings and their parts, as well as all materials that are ready for construction that are brought onto a building site (input flows) and are intended to form part of a building and external works within the site boundary, as well as from associated application and assembly processes. Packaging associated with the delivery of ready for construction products shall be accounted for.

The boundary of the indicator will depend on the point in the project and its life cycle at which the waste being reported on arises. Table 2.3.1 in Part 3 of the documentation outlines which life cycle stages are relevant.

Burden shifting of waste from construction sites shall be accounted for by extending the boundary of the reporting. In practice, this means that for any task that could have taken place on-site but has been shifted off-site to a factory (e.g. prefabricated wall panels or brick facings) the waste arisings associated with that activity in the factory shall be accounted for.

2.4 Life cycle tool: Cradle to cradle Life Cycle Assessment (LCA)

Macro-objective 2 identifies the need to 'reduce significant environmental impacts' associated with material use. LCA is an overarching tool that can be used to analyse the overall performance of a building and its constituent materials for multiple environmental impacts, so is the best tool to meet this need.

However, LCA has a wider potential application than the scope of macro-objective 2, with the potential for use as a holistic tool to analyse many different aspects of the life cycle performance of buildings.

Moreover, because LCA is a complex tool that requires a certain level of expertise from users, inexperienced users are recommended to first gain experience using the individual indicators and life cycle tools, several of which will enable users to learn about different aspects of carrying out an LCA.

Guidance and rules for carrying out an LCA are, as a result, provided separately in section 7 as an overarching tool within the Level(s) framework.

2.4.1 What is a Life Cycle Assessment?

The state of the art methodology to identify and analyse the most significant environmental impacts of a building is a Life Cycle Assessment (LCA). An LCA is a tool that enables the analysis of where and when selected environmental impacts may occur at the different stages along the life cycle of a building.

Analysis of a number of environmental impacts ensures that any trade-offs between different impacts, as well as between different life cycle stages, can be identified. This ensures a more thorough analysis of the improvement potential of design options, as well as helping to identify 'hot spots' of environmental impact along the life cycle of a building.

Carrying out an LCA requires expertise. This is because the collection of data representative of the materials the building is constructed from, and their distinct production processes and origin, requires a lot of choices and assumptions to be made. Analysis and use of the results then requires expert judgement.

2.4.2 How can Life Cycle Assessment be used in building projects?

Users of the Level(s) framework are encouraged to use LCA as a tool to analyse the broader environmental impacts of the construction products used. The reference standard for carrying out an LCA is EN 15978, which provides seven environmental impact categories and other indicators describing resource use:

- Global warming potential (GWP_{100})
- Depletion potential of the stratospheric ozone layer (ODP)
- Acidification potential of land and water (AP)
- Eutrophication potential (EP)
- Formation potential of tropospheric ozone photochemical oxidants (POCP)
- Abiotic Resource Depletion Potential for elements (ADP element)
- Abiotic Resource Depletion Potential for fossil fuels (ADP fossil).
- Renewable primary energy resources used as raw material (MJ)
- Use of non-metallic mineral resources (kg)

These categories address some of the main environmental impacts that have been the focus of attention for European environmental policy.

It is important, however, to be aware of the limitations of LCA as a tool. A major challenge exists in seeking to make meaningful comparisons between building design options. This is because each of the common building materials used across the EU have distinct environmental impacts that cannot all be modelled and quantified using the seven indicators provided by EN 15978. Examples include the sustainability of forests from which timber has been obtained or the ecotoxicity of pollutants from material production processes.

More guidance on the range environmental impacts that can be analysed using LCA is provided in section 7.

Macro-objective 3: Efficient use of water resources

Definition: Make efficient use of water resources, particularly in areas of continuous or seasonal water stress.
Intended scope and focus: Action to minimise water use at the building level in all areas, with a particular focus on water reuse in buildings located in areas of continuous or seasonal water stress. This could combine efficiency measures, as well as supply-side measures such as grey water reuse and rainwater harvesting.

The macro-objective 3 indicator

Indicator	**Performance metric**
3.1 Total water consumption	m^3 of water per occupant per year

3.1 Indicator on use stage water consumption

3.1.1 Overview of the indicator

What does it measure?

The indicator estimates or measures the water consumption of sanitary fittings/devices and water consuming appliances that are relevant to the building design, based on which consumption rates are used (i.e. specific data from suppliers or default data provided) and what usage factors are assumed.

Estimation or measurement of the substitution of potable water with alternative, non-potable sources is also possible. This option is provided for buildings that are in areas of water stress, as defined by the Water Exploitation Index (WEI+) for the river basin in which the building is located [14].

How can it be used in building projects?

This indicator can be applied to new or existing buildings in order to understand, and ultimately decrease, the water demand. Specific information about the water consumption rates of sanitary fittings and water using appliances should be used where available. In other cases, relatively conservative default flow-rates and flush volumes can be used instead.

[14] The water exploitation index (WEI+), for a particular river basin is defined as the net abstraction of freshwater divided by the average freshwater resources available during a defined period. It describes how the net water abstraction puts pressure on freshwater resources.

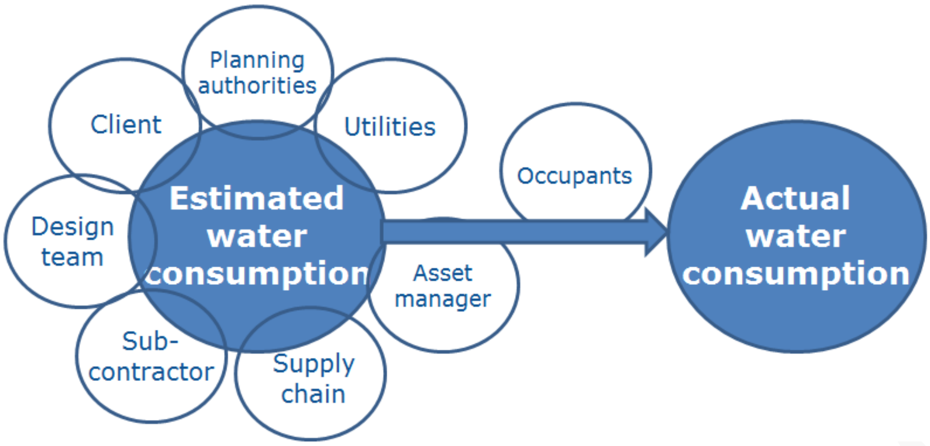

Figure 3.1.1 Relevance of different actors to the water consumption indicator.

Planning authorities can set certain minimum water efficiency requirements for sanitary fittings and devices or irrigation requirements via local (e.g. Brescia, Italy), regional (e.g. province of Madrid, Spain) or national (e.g. UK Part G) building regulations. In regions where current installed potable water and/or wastewater treatment plants are near maximum capacity, water utilities may have some influence at the planning stage.

The design team and the client will ultimately decide how ambitious the design should be in terms of water efficiency. This will be based on knowledge of the water efficiencies of sanitary devices and fittings and water using appliances that are currently on the market. It will be the job of the sub-contractor to correctly source and install these fittings, devices and appliances to avoid leakage and any sub-optimal performance caused by poor installation.

Asset managers will want to quantify the water consumption, estimate its impact on operating costs and identify cost effective savings where possible. These influences, together with assumed usage factors, allow an estimation of the per capita water consumption even before the building is occupied. However, when dealing with actual water consumption, this will ultimately be determined by occupant behaviour and occupancy rates.

Actual water consumption can be accurately monitored via periodical meter readings. The most likely source of variations between estimated and actual per capita water consumption is an inaccurate estimate of occupancy rates, especially in buildings with significant numbers of visitors. If greywater and/or rainwater harvesting systems are installed, a means of monitoring the total water passing out of storage tanks and to water consuming devices and fittings will be necessary.

Why measure performance with this indicator?

The public water supply, the majority of which is used in buildings, accounts for around 21% of total water abstracted in the EU. In residential buildings alone, water consumption is around 160 litres/person/day on average across the EU and policy tools to address water consumption in buildings are needed[15].

The drivers for a more sustainable use of water resources include growing water demand, increasing water scarcity in many regions and decreasing water quality. The provision of potable water carries both economic and environmental burdens – which could be reduced by the specification of water efficient technical systems,

[15] BIO, 2012. Water Performance of Buildings. Report for DG Environment of the European Commission by Bio Intelligence Service. Accessed online, July 2017.

water using appliances and sanitary fittings at the design stage for new buildings, or prior to renovation of existing buildings.

Water usage rates are particularly important in regions under continuous or seasonal water stress, as indicated by a high annual or seasonal Water Exploitation Index (WEI+). Even though renewable water is an abundant resource at European level, the per capita renewable water available has decreased by some 24% between 1960 and 2012[16]. Population growth and the shift to more densely populated cities and high peaks in summer tourism can strongly influence the degree of local and seasonal water stress. According to the European Environment Agency, three different levels of water scarcity can be arbitrarily defined:

- WEI+ < 20%: a non-water stressed region
- WEI+ 20-40%: a water stressed region
- WEI+ >40%: a severely water stressed region.

In those geographical locations with water stress, measurement of the rate of consumption of potable water supplies and the rate of substitution of potable water supplies by alternative sources such as rainwater and reused water becomes important. The concept of the Water Exploitation Index (WEI+) is explained further in Guidance note 3.2 in Part 3, section 3.1.1.

3.1.2 Outline methodology for making a level 1 common performance assessment

Unit of measurement

Water consumption during the use phase of the building life cycle in **m^3 per occupant per year** is calculated based on the estimated use of water consuming appliances and sanitary fittings in the building.

Although the headline indicator refers to *total water use*, there is also the option to disaggregate the reporting into *potable and non-potable water use*, for instance when rainwater or greywater collection systems are installed.

Boundary and scope

The water use measured by the indicator relates to life cycle module B7 'operational water use' in the reference standard EN 15978. The scope of the term "*operational water use*" includes the use and treatment (pre- and post-use) of both potable water and non-potable water and applies to processes for:

- drinking water,
- water for sanitation,
- domestic hot water,
- irrigation of associated landscape areas, green roofs and green walls,
- water for heating, cooling, ventilation and humidification and other specific uses of *building-integrated technical systems* (e.g. fountains, swimming pools, saunas).

The boundary covers the time period from the handover of the construction works to the point in time when the building is deconstructed/demolished.

Water used by appliances (e.g. washing machines and dishwashers) can optionally be included. The 'embodied water' of construction materials and water

[16] https://www.eea.europa.eu/data-and-maps/indicators/use-of-freshwater-resources-2/assessment-2

used during maintenance, repair, replacement and refurbishment activities is not included.

Due to a general lack of background data for default values, water consumption by fountains, HVAC (heating, ventilation and air-conditioning) equipment, cleaning (for residential buildings) and swimming pools is not considered in the generic design calculation tool.

Irrigation can optionally be included in the scope for both residential and office/commercial buildings. When used, some additional consideration of the area to be landscaped and the irrigation system to be installed is required, which users may not always be willing or able to do.

Calculation method and reference standards

The calculation methodology is provided by the framework, together with default usage factors and performance data for fittings and appliances. The methodology has been designed with the intention of being complementary to those that have been developed by the major green building assessment schemes that operate in the EU.

Macro-objective 4: Healthy and comfortable spaces

Definition:

The design of buildings that are comfortable, attractive and productive to live and work in and which protect human health.

Intended scope and focus:

The initial priority areas of focus for macro-objective 4 are indoor air quality and thermal comfort:

- For indoor air quality two composite indicators are provided, which each require the consideration of multiple parameters relating to the quality of the indoor air in the useful internal spaces of building.
- For thermal comfort, an assessment of the time out of thermal comfort range of a building's useful internal space during an average year.

In addition, and recognising that the above mentioned indicators represent only two out of the many potential aspects of this macro-objective, initial guidance is also provided on performance assessment for two further aspects that may be considered for potential future indicator development:

- Lighting and visual comfort
- Acoustic performance of the building fabric

Users of the Level(s) framework will be encouraged to start to report on how they have addressed these two aspects. Initial guidance on design aspects to focus on and reference standards is provided in sections 4.3 and 4.4 of Part 3 of the Level(s) framework documentation.

The macro-objective 4 indicators

Indicator	**Performance metrics**
4.1 Indoor air quality	4.1.1 Good quality indoor air: Parameters for ventilation, CO_2 and humidity 4.1.2 Target list of pollutants: Emissions from construction products and external air intake.
4.2 Time outside of thermal comfort range	% of the time out of range of defined maximum and minimum temperatures during the heating and cooling seasons

4.1 Indicator on indoor air quality

The focus of indicator 4.1 is on the quality of the indoor air as experienced by occupants of a building during the use stage[17]. It consists of two sub-indicators:

- Indicator 4.1.1: Assessment of three parameters of good quality indoor air, with reference to ventilation rate, CO_2 levels and relative humidity.
- Indicator 4.1.2: Assessment of the concentrations of a target list of pollutants for source control that are commonly found in indoor air.

[17] In the reference standard EN 15978, the relevant module of the use stage is B6 'Operational energy use'

The two sub-indicators provide a simplified assessment of the most important parameters for indoor air quality.

4.1.1 Overview of the indicators

What do they measure?

The indicators for good quality indoor air conditions measure the three main parameters identified in EN 15251 and EN 16978 as being important to the provision of a healthy and comfortable indoor air supply to occupants – ventilation (rate of air change), CO_2 levels and relative humidity.

The indicators for source control of target air pollutants measure the most significant potential hazards to human health that can enter indoor air. Building occupiers can be exposed to a range of potential emissions of volatile and carcinogenic organic compounds. In an air tight, modern home or office, the most significant direct emissions sources related to construction products and fit out materials are understood to be:

- paints and varnishes,
- textile furnishings,
- floor coverings,
- associated adhesives and sealants, and
- fit-out materials that incorporate particle board[18].

Some products associated with the renovation of properties may also be relevant, with evidence that internal insulation and wall linings may, in some cases, be emissions sources. For buildings with ventilation systems, indirect outdoor sources such as traffic have been identified as also being of particular significance to indoor air quality[19]. Level(s) focuses on emissions from products as a basis for source control and emissions measured upon the completion of buildings as the basis for performance monitoring.

Informative safety thresholds for indoor air concentrations for the pollutants assessed by the Level(s) framework are provided by the World Health Organisation (see Part 3, guidance note 4.2). Performance benchmarks for the emissions from building products are provided by national labelling schemes and, following a transitional period for adoption, Member States will need to adopt the new EU-wide emissions classes.

Why measure performance with these indicators?

The indicators provide users with the key parameters for the design of ventilation systems and indoor conditions which ensure a healthy supply of air for occupants. They can also be used to protect human health by minimising the potential for occupier exposure to health risks associated with pollutants that can arise from building and fit-out materials as well as being brought into the building via intake ventilation and air infiltration.

The rate of air change and the concentration of CO_2, when used together, result in an important measure of the rate at which stale air is replaced with clean intake air. The rate of air exchange also controls the build-up of other chemical and biological pollutants.

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[18] Bluyssen et al, *European Indoor Air Quality Audit in 56 office buildings*, Indoor Air: 1996, 6(4), p-221-228

[19] European Commission (2011) *Promoting actions for healthy indoor air*, DG Health & Consumers

The level of relative humidity is an important influencing factor on the comfort of occupants. High or low levels of humidity can create an uncomfortable sensation, for example by making hot conditions feel more intense or by drying out and causing irritation of the nose and throat. The control of sources of humidity, such as kitchens and bathrooms, is also important in order to avoid creating the conditions for the growth of mould, which can in turn provoke respiratory or allergenic health problems.

Additional specific potential sources of occupant exposure, which should be measured, are associated with the renovation of domestic properties. These are primarily those associated with renovation materials, as well as the need to diagnose, treat and design out the presence of mould (a biological hazard).

In both new-build and renovated properties that achieve high levels of air tightness, it is important to ensure that sources of humidity are controlled, and cold bridges in the building fabric are minimised, so as to avoid creating the conditions for mould growth.

How can they be used in building projects?

The indicators make it possible for users to evaluate indoor air conditions and the control of target air pollutants at three main points in time along the building project stages – design, post-completion (prior to occupation) and post-occupancy. These are specified in greater detail in table 4.1.1.

Table 4.1.1. Project stages at which indicator 4.1 can be used

Project stage	**Activities related to the use of indicator 4.1**
1. Design stage (based on calculations)	✓ Design of the building fabric and ventilation systems to meet target ventilation rates ✓ Control of potential sources of humidity by ventilation design ✓ Inspection of properties to be renovated in order to identify any problems relating to damp and mould. ✓ Design solutions for identified areas of cold bridging and damage from humidity in renovated properties ✓ Source control of target pollutants by selection of building products according to their tested emissions.
2. Completion stage (based on as-built drawings)	✓ Verification that as-built and installed building fabric and services reflect those as designed.
3. Post-completion (based on commissioning and testing)	✓ In-situ measurement of the indoor concentration of target pollutants prior to occupation. ✓ Functional performance testing of ventilation filters and their suitability for the building location.

4. Occupation (based on measured performance)	✓ In-situ measurement of the indoor concentration of target pollutants during occupation with furniture, fixtures and fittings in place. ✓ In-situ measurement of the CO_2 and relative humidity levels.

4.1.2 Outline methodology for making a Level 1 common performance assessment

Units of measurement

The indicator requires the measurement of a number of parameters. The common units of measurement for the parameters of the composite sub-indicators are listed below in tables 4.1.2 and 4.1.3.

Table 4.1.2 Indicator 4.1.1: Good quality indoor air conditions

Indicator scope	Headline environmental metric	Units of measurement
Good quality indoor air	Ventilation rate (air flow)	Litres per second per square metre (l/s per m^2)
	CO_2	Parts per million (ppm)
	Relative humidity	% ratio of partial to equilibrium vapour pressure

Table 4.1.3 Indicator 4.1.2: Target air pollutants for source control

Target list of pollutants *Primary source: building products*	Carcinogenic VOCs	µg/m³
	EU LCI ratio	*ratio of a substances measured concentration in product emissions to its LCI value*
	Formaldehyde	µg/m³
	Mould	*Guidance only*
Target list of pollutants *Primary source: outside air*	Benzene	µg/m³
	Particulates (PM 2,5 and 10,0),	µg/m³
	Radon (according to geographical risk)	Bq/m³

The performance is assessed for the indoor air quality as experienced by occupiers of the useful (conditioned) space within a building. Within the EPB standards EN 15603 and prEN 52000-1, the good quality indoor air condition parameters form part of the building occupancy and operating conditions module.

The ventilation rate shall be normalised to the useful floor area of the building. This shall allow for the design ventilation rate to be related to the potential for dilution of indoor emissions as specified in EN 15251 and the superseding standard EN 16978.

The determination of emissions from building products shall be in conformance with CEN/TS 16516. Test data is required from manufacturers/suppliers of the selected building products, as defined in the scope. All testing shall be on the as-finished product.

The presence of mould does not have a specific parameter because mould characterisation and quantification is still the subject of methodological development. In this first version of Level(s), guidance on testing and inspection is instead provided.

The presence of radon shall be measured based on information relating to the geographical location of the building and the underlying geology[20]. In some Member States, emissions from certain building products may also need to be taken into account because of their constituent materials.

Boundary and scope

The boundary for the indicator is the useful conditioned floor area and the related indoor air conditions as experienced by occupants of a building within those zones of the building.

The scope is defined according to the metrics in tables 4.1.2 and 4.1.3 and, at design stage, by the choice of any of the following building materials and products:

- Ceiling tiles
- Paints and varnishes, including those applied to stairs, doors and windows
- Textile floor and wall coverings
- Laminate and flexible floor coverings
- Wooden floor coverings
- Associated adhesives and sealants

In addition, internal insulation products, as well as special interior surface treatments (e.g. to resist damp), shall be included within the scope.

[20] European Environment Agency, *European indoor radon map*, December 2011 http://www.eea.europa.eu/data-and-maps/figures/european-indoor-radon-map-december-2011

4.2 Indicator on time outside of thermal comfort range

The focus of indicator 4.2 is on the ability of the building to maintain pre-defined thermal comfort conditions during the heating and cooling seasons. Thermal comfort is defined by EN ISO 7730 as:

> *'…..that condition of mind which expresses satisfaction with the thermal environment. Dissatisfaction can be caused by warm or cool discomfort of the [human] body as a whole….or by an unwanted cooling (or heating) of one particular part of the [human] body.'*

Linked to this aspect of comfort, the additional heating or cooling energy required to maintain these conditions shall also be considered.

4.2.1 Overview of the indicator

What does it measure?

The indicator measures, by proxy, the proportion of the year when building occupiers may feel thermal discomfort.

Why measure performance with this indicator?

In low or near zero energy buildings, the control of thermal comfort and, in particular, solar gains in summer, is an important factor. This is because, even in Northern European locations, uncontrolled gains from solar radiation can lead to uncomfortable conditions that may in turn require additional cooling energy.

The control of overheating is specifically addressed by the recast Energy Performance of Buildings (EPB) Directive 2010/31/EU which states that:

> *'…there should be focus on measures which avoid overheating, such as shading and sufficient thermal capacity in the building construction, and further development and application of passive cooling techniques, primarily those that improve indoor climatic conditions and the micro-climate around buildings.'*

The ability of residents to keep homes warm in winter is also an important factor. A large proportion of the EU's housing stock can be considered to be hard to heat because of a combination of a lack of insulation, poor quality windows, cold bridging through the building fabric and high levels of air infiltration. This can lead to inadequate heating which can put more vulnerable residents at risk from seasonal illnesses.

Adverse climate change may exacerbate both of these problems in the future, and is addressed by using the same indicator to calculate and report on future climatic scenarios under Macro Objective 5.

How can the indicator be used in building projects?

Reporting can be based on both calculated and measured performance. This means the indicator can be used by a range of project actors, including during the design stage to simulate performance and upon completion to check how the building actually performs based on monitored conditions and occupant surveys.

Table 4.2.1 outlines the project stage activities where Level(s) may provide valuable support. The related additional heating and cooling consumption can also be reported in terms of energy demand using indicator 1.1 and life cycle costs using indicator 6.1

The project stages at which the indicator(s) can be used are provided, together with guidance, on how the gap between design and actual performance can be minimised, with a focus on weather data representativeness, calculation intervals, the duration and intensity of heat waves, and consideration of localised thermal discomfort.

Table 4.2.1 The project stages at which indicator 4.2 can be used

Project stage	Activities related to the use of indicator 4.2
1. Design stage (based on calculations)	✓ As a component of calculated EPB assessment sub types: design or tailored ✓ Consideration of different aspects of thermal comfort, including localised discomfort effects
2. Completion stage (based on as-built drawings)	✓ As a component of calculated EPB assessment sub types: as built
3. Post-completion (based on commissioning and testing)	✓ Commissioning: functional performance testing
4. Occupation (based on measured performance)	✓ As a component of measured EPB assessment sub types: climate corrected, use corrected or standard ✓ Comparison of estimated satisfaction levels with those obtained from occupier surveys.

4.2.2 Outline methodology for making a Level 1 common performance assessment

Unit of measurement

The common unit of measurement is the **percentage of the time out of range of defined maximum and minimum temperatures during the heating and cooling seasons.** The performance is assessed for the useful floor area of the building and the projected pattern of use for the building. The performance of a building should always be assessed both with and without mechanical cooling. If energy modelling is carried out, an area weighted average shall be reported.

Boundary and scope

The scope of the indicator is the internal operating temperature and comfort condition of the occupiers within the building.

The assessment boundary is the building. Heat losses and gains that will affect the comfort conditions within the building, as well as the heating and cooling energy that may be required to maintain these conditions, are to be considered. The reported performance shall apply to 95% of the useful spaces assessed.

Calculation method and reference standards

Calculation of the reported performance shall be in accordance with the method described in Annex F of EN 15251 and/or an overheating assessment that forms part of a National Calculation Method. Buildings with and without mechanical cooling shall be assessed. Those buildings which have full or mixed mode mechanical cooling shall additionally assess the performance of the building fabric without mechanical systems such as Heating, Ventilation and Air Conditioning (HVAC).

If there is the intention to carry out post-occupancy evaluation of satisfaction/dissatisfaction with the thermal environment, the Predicted Percentage Dissatisfied (PPD) shall be estimated based on EN ISO 7730 (for mechanically cooled buildings) or the acceptable summer indoor temperature range (for buildings without mechanical cooling). The estimate PPD can then be compared with the results from an occupier survey.

Macro-objective 5: Adaptation and resilience to climate change

Definition:

The futureproofing of building performance against projected changes in the climate, in order to protect occupier health and comfort and to sustain and minimise risks to property values.

Intended scope and focus:

The initial priority focus of attention of macro-objective 5 is on the protection of health and comfort under projected future climate conditions. Assessment of future scenarios for the thermal comfort of the interior spaces of buildings shall be based on the same calculation methodology as for indicator 4.2.

In addition, and recognising that this first scenario represents only one potential aspect of this macro-objective, initial guidance is also provided on two further aspects that may be considered for potential future scenario development:

- Increased risk of extreme weather events, which may require consideration of the durability and resistance of building elements.
- An increased risk of flooding, which may require consideration of the capacity of drainage systems and the resilience of structures.

Users of the Level(s) framework will be encouraged to start to report on how they have addressed these two aspects. Initial guidance on design aspects to focus on and reference standards is provided in sections 5.2 and 5.3 of Part 3 of the Level(s) framework documentation.

The macro-objective 5 life cycle tool

Life cycle tool	Performance metric or reporting form
5.1 Life cycle tools: scenarios for projected future climatic conditions	*Scenario 1: Protection of occupier health and thermal comfort* Simulation of the building's projected time out of thermal comfort range for the years 2030 and 2050.

5.1 Life cycle scenarios: Projected future climatic conditions

5.1.1 What is a life cycle 'scenario'?

Scenarios are defined by EN 15978 as a *'collection of assumptions and information concerning an expected sequence of possible future events'*. They describe future events in the life cycle of a building for which changes in potential future performance can be analysed.

As such, they may describe time-related characteristics that can relate to any of the life cycle stages and which may have a significant influence on the environmental performance of the building. Examples for macro-objective 5 include the tolerance of the building fabric to heat waves, the resilience of elements of a building to weathering, and design measures that seek to minimise flood damage.

One scenario tool is provided for macro-objective 5. The scenario focusses on the modelling of buildings under future weather conditions in 2030 and 2050.

5.1.2 How can the life cycle scenario tool be used in building projects?

The design of more climate change proof buildings requires a focus on adaptation measures that can be incorporated into buildings now or, if necessary, are possible to incorporate at a future point in time.

By developing and evaluating future scenarios for the resilience of a building, and by using climatic projections carried out by recognised experts, designers can identify measures that have the potential to minimise future risks and liabilities.

The first life cycle scenario to be provided for this macro-objective focuses on extremes of temperature, with a focus on protecting the health and comfort of building occupants. This scenario has been selected to re-inforce the focus on the recast Energy Performance of Buildings (EPD) Directive 2010/31/EU on overheating potential, as well as reflecting its identification as an important aspect in the EU Strategy on adaptation to climate change[21].

Development of this scenario also allows users to explore the potential positive influence of 'green infrastructure' at the building level, for which there is evidence that certain features can moderate temperatures around a building.

5.1.3 The focus of attention of the scenarios

One initial scenario tool is provided as a priority initial focus. Two further potential future scenarios, which address other aspects of building resilience and adaptability, and which may be included in later versions of the Level(s) framework, are briefly mentioned in Part 3 for guidance purposes only.

[21] COM(2013)216, Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions, *An EU Strategy on Adaptation to Climate Change*

The options for reporting on results from modelling of the scenario are given. These provide users with qualitative and quantitative ways of reporting on how far the building addresses the potential future risk of overheating.

Overheating could in turn result in greater discomfort for occupants and an increase in cooling energy use, so the potential to compare the results of a building energy performance assessment carried out according to indicator 1.1 is also emphasised.

Initial guidance is provided for the following two potential future scenarios, which are associated with:

- An increased risk of flooding in some areas.
- More frequent occurrence of extreme weather events.

Each scenario, in turn, has the potential to have an impact on a building's projected future performance under other indicators – for example, in relation to the service life (life cycle scenario tools 2.2), water consumption (indicator 3.1) and energy demand (indicators 1.1 and 6.1).

5.1.4 Scenario development for the Level 1 common performance assessment option

The rules for calculation and reporting at the common performance level 1 allow for a simplified assessment of the scenario 'Protection of occupier health and thermal comfort' to be carried out. The rules are as follows:

- Use of the same calculation method and indicator metrics as for indicator 4.2
- Extension of the thermal simulation used to report on indicator 4.2 in order to calculate the performance using weather projections for 2030 and 2050.
- The future performance shall be calculated using the same operative temperature range as for indicator 4.2
- If suitable future projections are not available at national, regional or local level, weather files derived from heat wave events in the last 20-30 years may be used.

Further detailed guidance is provided in Part 3, sections 5.1.1 and 5.1.2.

Macro-objective 6: Optimised life cycle cost and value

Definition: Optimisation of the life cycle cost and value of buildings to reflect the potential for long term performance, inclusive of acquisition, operation, maintenance, refurbishment, disposal and end of life.
Intended scope and focus: Life Cycle Costing (LCC) is particularly relevant to achieving an improved environmental performance as higher initial capital costs may be required to achieve lower life-cycle running costs, higher residual property values and improved workforce productivity. It therefore represents a method for making effective, long-term investment decisions. LCC is an important tool during the project definition, concept design and detailed design stages, where it can be used to select and value engineer the design that will provide the lowest overall cost (and highest residual value) along the life cycle of the asset. It may also take into account so-called 'intangible' benefits, which may include factors that influence the users' comfort and productivity. European standards on life cycle cost also address the concept of property value and the potential for the improved environmental performance of buildings to have a positive influence on value, lettings and stability in the property market. Professional valuation bodies working at European level have sought to integrate environmental performance into their value appraisal and risk rating criteria, but there is still some way to go before the true value of better performing buildings is reflected in appraisals. The potential of property valuation and risk rating methods to fully capture the benefits of more sustainable buildings has received less attention than life cycle costs, but has wider potential to support long term investment decisions. This is because better performance can be equated with not just reduced overheads (by minimising operational costs), but also increased revenues and more stable investments (by making properties more attractive) and reduced risk (by anticipating potential future exposure).

The macro-objective 6 indicators

Indicators	***Performance metrics***
6.1 Life cycle costs	Euros per square metre of useable floor area per year (€/m^2/yr)
6.2 Value creation and risk factors	Reliability ratings of the data and calculation methods for the reported performance of each indicator and life cycle scenario tool.

6.1 Indicator on life cycle costs

The focus of indicator 6.1 is on the life cycle elemental costs of a building, including the cost of construction, operation, maintenance, refurbishment and disposal[22].

Users are encouraged to report on costs for all the life cycle stages. However, the minimum scope of reporting required is for the following stages:

- Use stage energy and water costs (life cycle stages B6 and B7)
- Construction and long-term maintenance, repair and replacement costs (life cycle stages A1-3/B2–4)

The minimum scope forms an important part of the overall life cycle costs of a building. They are intended to provide information that is of direct use to those operating or investing in a building.

6.1.1 Overview of the indicator

What does the indicator measure?

The indicator measures all building element costs incurred at each life cycle stage of a project for the reference study period and, if defined by the client, the intended service life. The life cycle stages are presented in Part 1, section 2.2 of the Level(s) framework and the building element list is presented in Part 3, section 1.1.2. The life cycle stages reflect those used as the basis for the reference standards EN 16627 and ISO 15686-5.

The following life cycle stages may be reported on as a minimum scope in order to provide information to investors, asset managers and occupiers:

- Use stage energy and water costs (life cycle stages B6 and B7): The utility costs associated with occupation of a building, inclusive of communal costs of operating a building and the costs associated with occupier energy and water use.
- Construction, maintenance, repair and replacement costs (life cycle stages A1-3/B2-4): This shall include the elemental cost of constructing the building asset, exclusive of land costs. This shall comprise:

  - Enabling works to prepare the site for construction (or a building for renovation).
  - Construction of the building (on and off site activities).
  - Fit out in preparation for occupation.

The future cost assumptions relating to maintenance, repair and replacements shall also be accounted for. This shall include reactive, cyclical and major planned activities.

These costs will be strongly influenced by the decisions and calculated performance of the following indicators in the Level(s) framework:

- 1.1a Use stage delivered energy use
- 2.2a building and elemental service life planning
- 3.1 Efficient use of water resources.

[22] In the reference standard EN 15978 the relevant module of the use stage is B6 'Operational energy use'

Why measure performance with this indicator?

These costs provide important information to investors, asset managers and occupiers. The latter includes homeowners, who may wish to understand the costs associated with maintaining and running a home for the duration of a full mortgage term, and residents' organisations responsible for the communal costs of maintaining apartment blocks.

As well as encouraging clients and designers to consider the relationship between upfront capital costs and use stage costs, they can provide a more informed basis for understanding future performance, value and liabilities associated with a building.

Savings associated with energy and water efficient buildings can be cash flowed in order to capitalise the value of the savings and reflect this in property valuations and investment decisions. This may be in comparison with benchmarks of performance in a local market, across a portfolio or the performance prior to a major renovation.

The development of a medium to long term maintenance and replacement plan can support more cost effective management of assets. This can include decisions relating to the service life and durability of key elements and components, as well as predictions of potential future costs and liabilities that may be associated with the early failure of components.

How can this indicator be used in building projects?

Reporting can be based on estimated performance at the design stage or on as-built performance following completion and after monitoring of performance during occupation. This means they can be used by a range of project actors, including during the design stage, to estimate future performance and performance following occupation so as to check how the building is actually performing against projected short, medium and long term cost schedules.

The potential for gaps and variances between design and actual cost performance may depend on:

- the quality and representativeness of the cost estimates used, which may be based on a range of sources.
- the assumptions that form the basis for modelled projections of potential future operational costs and potential future maintenance, replacement and refurbishment costs.

Part 3, Section 6.1.2.2 provides more guidance on both of these aspects, and level 3 reporting may be based on a more detailed assessment of the quality of cost data and projections.

Table 6.1.1 Project stages during which indicator 6.1 can be used

Project stage	**Activities related to the use of indicator 6.1**
1. Design stage (based on estimates and assumptions)	✓ Cost estimates and modelling: Based on the client's requirements and detailed designs.
2. Completion stage (based on as-built drawings)	✓ Verification of as-built costs: Based on the final cost and the as-built specifications.
3. Post-completion (based on commissioning and testing)	n/a

4. Occupation (based on measured performance)	✓ Metered utility costs: Real energy and water cost performance data. ✓ Monitoring of maintenance and replacement costs: Refinement of projections over time as real performance data comes in.

6.1.2 Outline methodology for making a Level 1 common performance assessment

Unit of measurement

The common unit of measurement for each life cycle stage is **euros per square metre of useable floor area per year (€/m²/yr).**

The common unit shall be based on the net present cost of each life cycle stage. This shall be calculated by applying a discount rate to the costs incurred for each year of the reference study period.

The net present costs should generally be calculated using real costs, i.e. excluding inflation. However, assumptions about inflation may also be included within the discount rate if nominal costs are required for the purpose of detailed financial planning.

Boundary and scope

The system boundary shall encompass all the life cycle stages illustrated in Part 1, section 2.2. For renovated existing buildings, the system boundary shall encompass all life cycle stages that relate to the extended service life.

The minimum scope of the indicator shall include the building parts and elements identified in Part 3, section 1.1, table 1.1.

A simplified approach may be followed that focuses on a reduced number of life cycle stages, but if this is done the reporting rules described in Part 3, section 6.1.1.2 must be followed, as the results will not be representative of the full life cycle.

Calculation method and data requirements

The method for the common performance assessment requires reporting on the costs by life cycle stage. As-built cost data, and the emerging picture of use stage life cycle costs post-occupation, can then be reported at a later stage.

The reference standard for calculating the life cycle costs of each life cycle stage shall be ISO 15686-5 and EN 16627. The reference standard ISO 15686-8 provides a methodology for calculating and estimating the design life of elements and components.

Development of a life cycle cost plan for a building will require the collection of a range of cost data, which may vary in quality according to its source and age. Further guidance on cost data collection is provided in Part 3, section 6.1.2.2.

6.2 Indicator on value creation and risk factors

The focus of indicator 6.2 is on those aspects of a more sustainable building performance that have the potential to create financial value or to expose owners and investors to risks and liabilities in the future.

The indicator also intends to provide information on the reliability of the underlying data and calculation methods on which a reported performance is based, to those involved in the appraisal of a buildings value.

In this way, the indicator will support property valuers and investors by supplementing their existing data and knowledge, thereby allowing them to better take into account the potential influence of sustainability aspects on value and risk.

6.2.1 Overview of the indicator

What does the indicator measure?

The indicator is designed to support valuation and risk rating processes in two ways:

- Comprehensiveness of the valuation or risk rating: By identifying the potential for a Level(s) performance assessment to influence a property valuation appraisal or risk rating. This potential is to be checked for each indicator reported on. This checking process includes a specific focus on the criteria followed by valuation professionals and the assumptions they make about the market influence of improved sustainability performance.
- Reliability of the reported performance assessments: By rating the reliability of a Level(s) performance assessment. This comprises the rating of the data and calculation method, the professional capability of the those carrying out the performance assessment, and the extent to which there is independent verification of the results.

By following this approach, it is anticipated that project actors will be encouraged to focus attention on how the use of Level(s) may influence value and risk, as well as the precision and accuracy of performance assessments carried out.

Table 6.2.1 Identified or emerging influence of Level(s) framework indicators on property value and risk

EU Level(s) framework indicator or scenario	**Potential influence on value and risk**		
	1. Increased revenues due to market recognition and lower voids	**2. Reduced operational, maintenance, repair and replacement costs**	**3. Future risk of increased overheads or loss of income**
1.1 Use stage energy performance	✓	✓	
1.2 Life cycle Global Warming Potential			✓
Life span, adaptability and deconstruction scenario 1: Building and elemental service life			✓

Life span, adaptability and deconstruction: scenario 2 Design for refurbishment and adaptability		✓	✓
Life span, adaptability and deconstruction scenario 3: Design for deconstruction, reuse and recyclability			✓
2.3 Construction & demolition waste and materials		✓	✓
3.1 Efficient use of water		✓	✓
4.1 Indoor air quality	✓		
4.2 Time out of thermal comfort range	✓		
Projected future climate conditions scenario 1 5.1 Protection of occupier health and thermal comfort			✓
6.1 Life cycle costs		✓	✓
Cradle to cradle Life Cycle Assessment (LCA)	✓		✓

Why assess value and risk with this indicator?

The reporting format is intended to ensure that sustainability is integrated into risk rating and value appraisal processes and that it is done on as informed and transparent a basis as possible. This in turn should improve confidence in the assertions that can be made about present and future performance, as well as focussing attention on the need for more data on how costs, revenues and values are influenced in practice.

The risk rating and valuation standards of the Royal Institute of Chartered Surveyors (RICS), the European Group of Valuer's Associations (TEGoVA) and the International Valuation Standards Council (IVSC) integrate sustainability as an aspect to take into account and highlight the possibility to make 'special assumptions' about its future impact on value, and calling upon 'relevant expertise, certifications and reports' to supplement their professional skills.

In terms of specific guidance, RICS in its 'Red Book' Valuation Practice Statement (VPS) number 2 advises valuers to:

> *'collect and record appropriate and sufficient sustainability data, as and when it becomes available, for future comparability, even if it does not currently impact on value'*

Moreover, the importance of the 'inputs and assumptions' made in reaching a judgement are also highlighted, with the 2017 edition of the International Valuation Standard stating that:

> *'The process of valuation requires the valuer to make impartial judgements as to the reliability of inputs and assumptions. For a valuation to be credible, it is important that those judgements are made in a way*

that promotes transparency and minimises the influence of any subjective factors on the process.'

The integration of sustainability valuation and risk considerations will by necessity encourage the client and their professional team to learn about the sustainability characteristics of his property. Feedback from practitioners suggests that, in the process, they tend to learn things about the property that they may not have focused on otherwise. As a result, the additional value and quality that sustainability aspects can contribute to building designs and specifications becomes better understood.

How can the reliability rating be used in building projects?

Reliability rating scales are provided throughout the Level(s) framework for each indicator. For each indicator, the rating is made based on the quality, representativeness and precision of a performance assessment. The formal capability of the professionals carrying out the assessment and the extent to which the result is independently verified is also taken into account. This means that the building professionals carrying out the performance assessments for a specific indicator will, at the same time, have the possibility to generate a reliability rating.

It is likely, as a result, that the ratings would be largely produced at the design and construction stage. They would, in parallel, be used by clients and their valuers as information to inform the risk rating and valuation of a building. In addition, focus is given to the valuation and risk rating criteria that they use to make an appraisal, and the extent to which the assumptions used may be influenced by a Level(s) assessment.

Table 6.2.2 illustrates the information feeding into ratings at each project stage. It shows that the information about performance may be updated over time. This includes feedback from the testing of the building and systems.

Table 6.2.2 The project stages at which indicator 6.2 can be used from a project management and a financial perspective

a. Design, construction and facilities management related stages

Project stage	**Activities related to use of indicator 6.2**
1. Design stage (based on calculations)	✓ Rating of the input data, calculation methods and simulation tools used. ✓ Information to inform design stage appraisals of the viability/profitability of the project.
2. Completion stage (based on as-built drawings)	✓ Validation of input data based on as-built drawings and specifications. ✓ Commissioning and quality testing: Feedback from functional performance testing of systems, building fabric testing.
3. Post-completion (based on commissioning and testing)	✓ In situ testing: Feedback from health and comfort aspects to validate design choices.
4. Occupation (based on measured performance)	✓ Measured (metered) energy and water data: Potential to diagnose differences between design and actual performance.

b. Valuation and investment appraisal related stages

Project stage	Activities related to use of indicator 6.2
1. Outline appraisal	✓ Early stage identification of potential design influences on the appraisal of value and risk
2. Detailed appraisal and risk rating	✓ To support detailed evaluation and value engineering of design decisions ✓ To develop more informed scenarios for the performance of the property in the market
3. Financial approvals and due diligence	✓ To provide greater insight into the reliability of performance assessments ✓ To demonstrate how performance aspects have been taken into account in the value engineering of the project
4. Cost control on site	✓ To more clearly distinguish specifications that are important from a value and risk perspective
5. Asset management and leasing	-

6.2.2 Outline methodology for making a reliability rating

The methodology for making a rating is provided in Part 3, section 6.2.1.

Unit of measurement

The indicator combines checklists and ratings. The ratings provide a semi-quantitative score. The higher the score, the greater the reliability of the performance assessment made for that indicator. Checklists are used to identify aspects of value creation and risk management that have been addressed, and the appraisal criteria used.

One of the ratings evaluates the reliability of data, calculation methods, professional capabilities and independent verification. The reliability scores can be determined for each indicator in the Level(s) framework. The scoring is based on a semi-quantitative evaluation of the representativeness and precision of the data and calculation methods used to make a performance assessment.

Overarching assessment tool 7: Cradle to cradle Life Cycle Assessment (LCA)

Users of the Levels(s) framework will learn more about how to conduct an LCA. This is because Level(s) has been designed to help users to understand and model the building life cycle stages as described in the reference standard EN 15978:

- Raw material extraction and manufacturing of construction products (A1-3)
- Construction of the building (A4-5)
- Occupation and use of the building (B1-7)
- The end of life and deconstruction of the building (C1-4)
- Benefits and loads beyond the system boundary from the recovery of materials and products from a building (D)

Users can first learn about how the different steps in conducting an LCA work (see Part 2) and, once they are more skilled, they can move on to conduct an LCA (see Part 3, section 7).

7.1 A simplified approach to conducting an LCA

A brief overview is provided of the LCA method in this section. The full simplified methodology for conducting an LCA can then be found in Part 3 of the Level(s) documentation, section 7.

7.1.1 What does it measure?

LCA is a method to assess the environmental performance of a building throughout its entire life cycle, as described in the reference standards ISO 14040/10444 (2006) and EN 15978 (2011). The environmental impacts of a building shall be assessed through quantification and reporting on the following environmental impact category indicators.

- Global warming potential (GWP_{100})
- Depletion potential of the stratospheric ozone layer (ODP)
- Acidification potential of land and water (AP)
- Eutrophication potential (EP)
- Formation potential of tropospheric ozone photochemical oxidants (POCP)
- Abiotic Resource Depletion Potential for elements (ADP element)
- Abiotic Resource Depletion Potential for fossil fuels (ADP fossil).

In addition, the use of renewable biotic resources and non-metallic minerals for construction materials shall be reported.

7.1.2 Units of measurement

The environmental impacts of a building's bill of materials shall be quantified and reported with reference to **the use of 1 m² of useful internal floor area per year for each life cycle stage** (i.e. 1 m²/yr which corresponds to the "reference flow", using LCA terminology).

Environmental impacts are expressed with the units used in the associated calculation methods (e.g. kg CO_2 eq for GWP, kg CFC-11 eq for ODP, kg SO_2 eq for AP, kg $(PO_4)^{3-}$ eq for EP, kg C_2H_4 eq for POCP, kg Sb eq for ADP elements, MJ for ADP fossil fuels), MJ for renewable primary energy resources used as raw material, kg for non-metallic minerals.

The building to be assessed shall be described according to the guidance in Part 3, section 1 ('goal and scope definition'). This includes:

- Building type and expected use(s), function(s) and service(s);
- Period of use and extent of use (e.g. number of users);

- Geographical context and climatic conditions;
- Technical, functional and qualitative properties of the building;
- The reference study period.

Calculations shall be adapted if the intended service life of the building is expected to be shorter or longer than the reference study period, as defined in Part 3, section 1.4. The reference study period may be the same as the intended service life of the building.

7.1.3 Why measure performance with this method?

LCA is a holistic approach that allows for a comprehensive overview of the environmental impacts that may be the result of different building types, design choices and medium to long term scenarios. It can be used as a tool by professionals for:

- Understanding the order of magnitude of the impacts due to a building and its components, and identifying the hot-spots in the life cycle;
- Defining and analysing improvement options for the reduction of the environmental impacts of a building and identifying any trade-offs;
- Avoiding that impacts are shifted from a life cycle stage to another one (e.g. decreased consumption of energy in the use stage by the introduction of more efficient materials, which results in increased energy use during material production) without improving the entire environmental performance of the building.

7.1.4 How can it be used in building projects?

Conducting an LCA brings together different elements of the framework (i.e. inventory data, life cycle scenarios, environmental impacts). The method can thus be used either as:

1. A holistic tool for the comprehensive assessment of the building's environmental impacts and the optimisation of designs (tending towards expert/advanced use), and/or
2. A learning tool to promote better understanding and quantification of the building’s environmental impacts (educational purpose, for professionals who are not familiar with LCA).

LCA on its own can be used as a tool to analyse different materials, components and options at the different project phases. Three different ways of working with LCA are presented, depending on which of the three levels of the framework is used, and depending on the project's objectives.