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Level(s) indicator 1.1: Use stage energy performance

User manual: introductory briefing, instructions and guidance

(Publication version 1.2)

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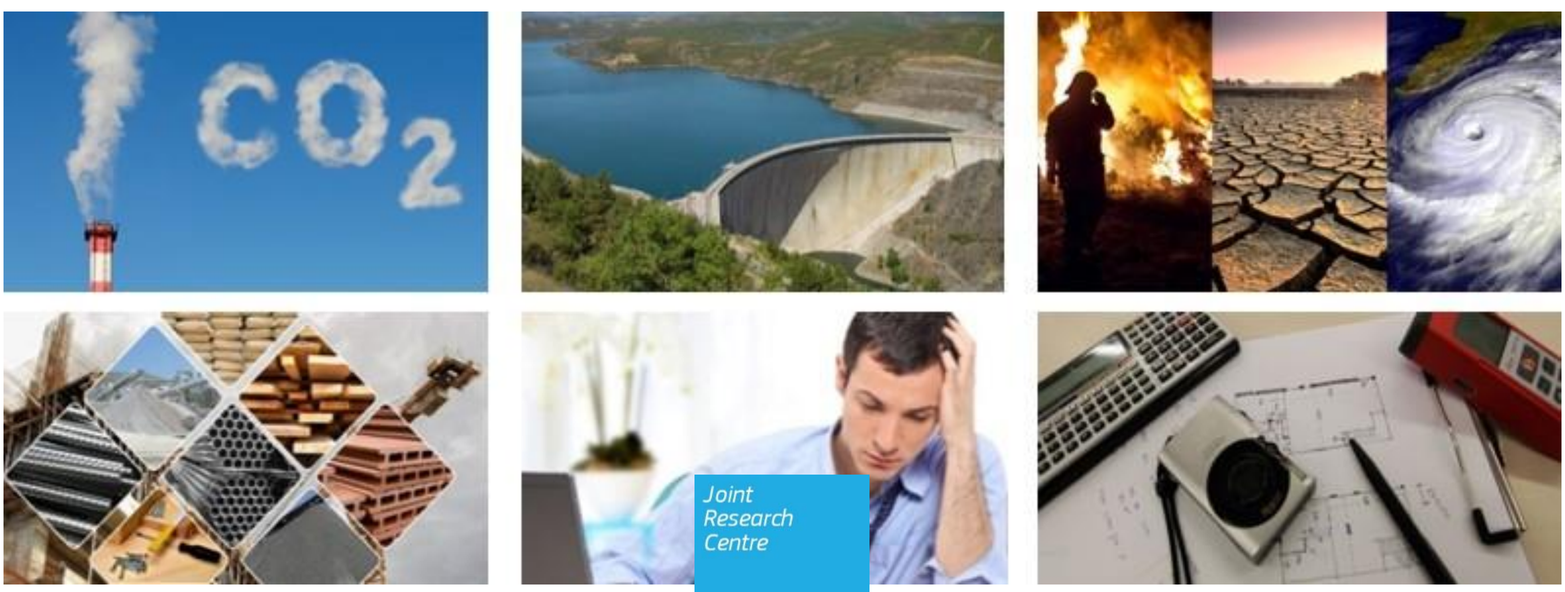

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Title
Level(s) indicator 1.1: Use stage energy performance user manual: introductory briefing, instructions and guidance (Publication version 1.2)

Abstract

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

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

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

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

Contents

The Level(s) document structure

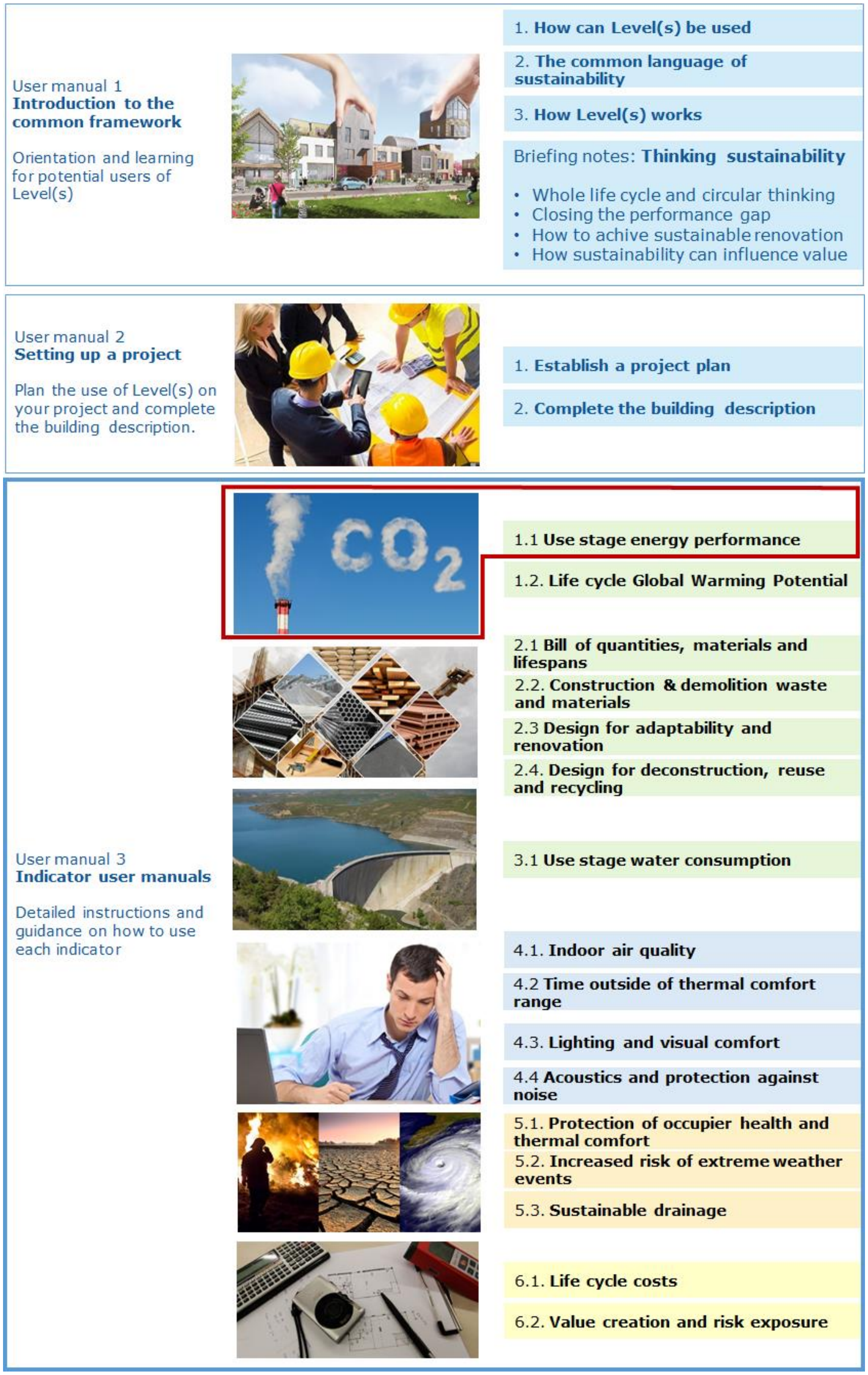

Figure 1. The Level(s) document structure

How this indicator user manual works

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

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

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

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

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

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

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

Technical terms and definitions used

Term	Definition (from EN ISO 52000-1.2017 or recast Energy Performance of Buildings Directive, 2018)
Assessment boundary	Boundary where the delivered and exported energy are measured or calculated
Delivered energy	Energy, expressed per energy carrier, supplied to the technical building systems through the assessment boundary, to satisfy the uses taken into account or to produce the exported energy (Note: delivered energy can be calculated for defined energy uses or it can be measured).
Energy carrier	Substance or phenomenon that can be used to produce mechanical work or heat or to operate chemical or physical processes
Energy need	For domestic hot water: heat to be delivered to the needed amount of domestic hot water to raise its temperature from the cold network temperature to the prefixed delivery temperature at the delivery point without the losses of the domestic hot water system. For heating or cooling: heat to be delivered to or extracted from a thermally conditioned space to maintain the intended space temperature conditions during a given period of time. For humidification or dehumidification: latent heat in the water vapour to be delivered to or extracted from a thermally conditioned space by a technical building system to maintain a specified minimum or maximum humidity within the space.
Energy source	Source from which useful energy can be extracted or recovered either directly or by means of a conversion or transformation process
Energy use*	For lighting: electrical energy input to a lighting system. For other services: energy input to appliances providing services not included in the EPB services For space heating or cooling or domestic hot water: energy input to the heating, cooling or domestic hot water system to satisfy the energy need for heating, cooling (including dehumidification) or domestic hot water respectively. For ventilation: electrical energy input to a ventilation system for air transport and heat recovery
Exported energy	Energy, expressed per energy carrier, supplied by the technical building systems through the assessment boundary. Note 1: It can be specified by generation types (e.g. combined heat and power, photovoltaic) in order to apply different weighting factors. Note 2: Exported energy can be calculated or it can be measured.
Nearly zero-energy building	Means, according to the Energy performance of Buildings Directive, a building that has a very high energy performance, as determined in accordance with Annex I. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby.
Non-renewable primary energy factor	Non-renewable primary energy for a given energy carrier, including the delivered energy and the considered energy overheads of delivery to the points of use, divided by the delivered energy.

Term	Definition (from EN ISO 52000-1.2017 or recast Energy Performance of Buildings Directive, 2018)
Onsite (in the context of delivered energy)	Means energy produced on the premises and the parcel of land on which the building is located and the building itself. Note 1: onsite is defining a strong link between the energy source (localization and interaction) and the building.
Primary energy	Energy that has not been subjected to any conversion or transformation process Note 1: primary energy includes non-renewable and renewable energy. If both are taken into account it can be called total primary energy.
Renewable energy	Means energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases
Renewable primary energy factor	Renewable primary energy for a given distant or nearby energy carrier, including the delivered energy and the considered energy overheads of delivery to the points of use, divided by the delivered energy.
Technical building system	Means technical equipment for space heating, space cooling, ventilation, domestic hot water, built-in lighting, building automation and control, on-site electricity generation, or a combination thereof, including those systems using energy from renewable sources, of a building or building unit
Total primary energy factor	Sum of renewable and non-renewable primary energy factors for a given energy carrier.

*Energy use is similar to energy need, but energy use also accounts for any losses in the technical building system that occur within the assessment boundary.

Introductory briefing

Why measure performance with this indicator?

Primary energy use is the required metric for reporting on the energy performance of buildings across the EU. The energy performance of a building, expressed in primary energy, is used for both compliance with minimum energy performance requirements and for the Energy Performance Certificates (EPCs), which can be based on either design or as-built input data[1].

Broadly speaking, for buildings constructed before 2010, use stage primary energy demand will account for the most significant life cycle impacts. For newer buildings[2], the production stage and other use stages related to material use, such as replacement and refurbishment, assume greater importance. This is because proportionately they use less energy in the use stage and the materials used for their construction are more energy intensive. In this case, the use stage is potentially responsible for as little as 30% of life cycle energy use, depending on the building type, form and specification.

In addition, reporting on this indicator can provide useful insights on the building's total emissions of air pollutants to the ambient air. Whereas an overall reduction in primary energy consumption will generally have a positive effect on air quality[3], a fuel switch may also lead to an increase of emissions of specific ambient air pollutants[4].

What does it measure?

The indicator measures the energy performance of a building, on the basis of the calculated or actual energy that is consumed, in order to meet the different energy needs associated with its typical use. In practice, this equates to the energy required to heat and cool spaces, to supply hot water, to light spaces and to run the technical building systems. - This requires energy carriers, such as electricity, natural gas and biomass, which are directly used in the building to provide power, heat and hot water. If energy is exported from the building, this should also be considered.

The primary energy use is calculated based on the quantities of energy carriers required and the primary energy factors associated with each energy carrier. The primary energy factors may be based on national or regional annual weighted averages or a specific value for on-site production. At the design stage, the starting point is to calculate energy needs which, after accounting for the efficiency of the relevant technical building system <u>inside the assessment boundary</u>, are converted into the required quantity of delivered energy. Then it is a case of defining the energy carrier that is delivered to the system and multiplying by the primary energy factor, which accounts for any losses and inefficiencies <u>outside of the assessment boundary</u>. Upon completion of the building, measured (metered) fuel and electricity consumption can be converted into primary energy by applying the same primary energy factors.

Apart from heating, cooling, ventilation, hot water and lighting systems, the primary energy use may relate to the energy use of other technical building systems or to the use of appliances that are plugged into the buildings electricity circuit – such as computers, ovens, washing machines etc..

With the increasing installation of renewable energy technologies on or near buildings, the indicator also enables reporting on how much of the primary energy demand is supplied by renewable energy generation – either on-site or connected to the building – as well as how much renewable primary energy is exported as a surplus from what the building consumes.

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1 See Annex I of Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency

2 Dodd et al, Identifying indicators for the life cycle environmental performance, quality and value of EU office and residential buildings, July 2016, Technical Report, Joint Research Centre

3 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.

4 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

At what stage of a project?

Level	Activities related to the use of indicator 1.1
1. Conceptual design (following design principles)	✓ Design, material selection and detailing according to principles for cost-optimal minimum requirements and Nearly-Zero Energy Buildings (NZEB). ✓ Selection of tailored solutions for major renovation works.
2. Detailed design and construction (based on calculations, simulations and drawings)	✓ Calculated building permitting assessment: design or tailored ✓ Calculated EPB assessment sub types: as built
3. As-built and in-use (based on commissioning, testing and metering)	✓ Construction quality testing: air tightness and building fabric integrity ✓ Commissioning, functional performance testing and seasonal testing. ✓ Measured EPB assessment sub types: climate corrected, use corrected or standard

The unit of measurement

The common unit of measurement for non-renewable primary energy in the use stage of a building is **kilowatt hours per square metre per year (kWh/ m^2 / yr)**. This unit is common to any specific indicator used (e.g. total primary energy for EPBD services, total non-renewable energy for EPBD services etc.) The full set of indicators (mandatory and optional ones for Level(s) is provided in the last tables in sections L2.7 and L3.5.

The performance is assessed for the total useful floor area of the building, which is recorded in the Level(s) building description. National rules may in addition define zones of a building that are to be included or excluded from the reporting.

System boundary

The assessment boundary is set at the point(s) where delivered and exported energy are measured or calculated. Although energy can be imported or exported from/to the building from on-site, nearby and distantsources, the assessment boundary does not change (see blue line in Figure 2). Outside the assessment boundary, primary energy factors shall apply to all forms of energy transformation that supply the delivered energy to the building, as well as any exports[5]. Inside the assessment boundary, the energy losses are taken into account by technical building system efficiency factors and thus are already accounted for in delivered energy values.

Scope

The minimum scope of the indicator reflects those energy uses (i.e. delivered energy plus losses related to the whole energy chain outside the assessment boundary) defined by the Energy Performance of Building Directive - heating, cooling, ventilation, domestic hot water and (built-in) lighting and optionally other technical building systems. In a life cycle approach, these energy uses are referred to as 'operational energy consumption' and are reported under Module B6 in EN 15978.

The design principles and calculations shall also take into account thermal performance characteristics of the building included in thermal modelling according to the local climatic conditions – including insulation, thermal bridging, passive solar gain and thermal capacity – and the benefits of daylighting.

Calculation method and reference standards

The calculation method should be the national or regional calculation method for energy performance laid down in the Member State where the building is located. If other calculation methods are used, they must be compliant with the EN ISO 52000 series and standards developed under mandate 480[6]. The calculation method and assessment type used (as defined by the EN ISO series) shall be reported in all cases.

[5] Primary energy factors are, in most cases, provided in each national calculation method as defined by Member Stated. If not, default factors can be found in the reference EN standards series. The Primary energy factors may be different for delivered and exported energy.

[6] See here: https://epb.center/documents/

Instructions on how to use the indicator at each level

Instructions for Level 1

L1.1. The purpose of this level

This level is for those users who would like to:

- Understand the energy uses associated with the type of building they are working on, and
- Know where they can focus attention in order to reduce the non-renewable primary energy use associated with the building's delivered energy during the use stage.

L1.2. Step-by-step instructions

These instructions should be read in conjunction with the accompanying Level 1 technical guidance and supporting information (see page 20).

1. Make sure to have completed the Level(s) building description, as some of the information may be needed to check the relevance of design concepts.
2. Consult the checklist under L1.4 of energy design concepts and read the related sections of the Level 1 technical guidance.
3. Within the design team, review and identify how the energy design concepts can be introduced into the design process.
4. Once the design concept is finalised with the client, record the energy design concepts that were taken into account using the L1 reporting format.

L1.3. Who should be involved and when?

Actors involved at the conceptual design stage should be led by the concept architect and engineers. The energy design concepts can be further explored once professionals such as service engineers, energy auditors, energy/sustainability consultants and quantity surveyors become involved in the project.

L1.4. Checklist of relevant design concepts

The following energy design concepts have been identified from best practice and literature reviewed by the Joint Research Centre as proxies for achieving better performance. Although all new buildings in the EU are required to comply with minimum energy performance requirements, and although there are also requirements on existing buildings or building components (depending on Member State), the checklist can still be used to inform design concepts and to improve performance without necessarily having to make more advanced assessments of the building's energy requirements.

Level 1 design concept	Brief description
1. Minimum energy performance **requirements** and Near Zero-Energy Building (NZEB) **design**	• Minimise the heating, cooling and lighting energy use of the building by: - *For **new** buildings*, designing and specifying a high performance and air-tight building fabric. - Designing and specifying high performance heating, ventilation, cooling and (fixed) lighting systems. - *For **major** renovations*, detailing and specifying high performance improvements to the existing building fabric. - Designing and specifying high performance heating, ventilation, cooling and (fixed) lighting systems. • Using renewable energy technologies to, as far as possible, supply energy to the building.
2. **Site** specific **design**	In designing a new building, or in planning a major renovation of an existing building, **take into account:**

Level 1 design concept	Brief description
	• The **climatic conditions of the site** in order to minimise heating, cooling, domestic hot water, ventilation and lighting needs and to inform the specification of non-combustion renewable energy technologies. Steps that can be taken include: - Reference to **local weather data** in order to understand better the distinct seasonal, monthly, weekly and diurnal conditions. - Reference to information about any localised microclimate conditions, such as prevailing winds, the urban heat island effect and air pollution levels. In this way, the physical design, elevations and servicing can be designed to respond to the local climate, including the potential for passive heating/cooling, intelligent structures, high yield renewables and use of daylighting. *This aspect has a strong interaction with indicators 4.2 and 4.3, which address thermal comfort and lighting respectively.*
3. **Renovation** specific design	In seeking to renovate a building, use information gathered in a baseline survey to adapt the improvements to the performance and conditions of the existing building, taking into account: • The construction of the original building, including the building envelope and structure. • Existing technical services, including heating, cooling, domestic hot water, ventilation and lighting. • How the orientation and floor layout influences patterns of climatic exposure, daylighting and ventilation. Information obtained from prior occupants may also yield useful information about the buildings performance.
4. High quality building fabric and services	Minimise the potential for gaps between design and actual performance by ensuring that the building fabric and technical services are designed, specified, constructed and installed with the necessary attention to detail and quality. This could include a focus on: • The air tightness and thermal integrity of the building envelope, including the continuity of insulation and junctions with windows, doors and balconies. • The functional performance of HVAC[7] systems, including the design of distribution systems and the setup of equipment.
5. Smart monitoring and control systems	Identify opportunities to install intelligent systems that can: • Provide users and building managers with timely information about the buildings energy use, whilst also allowing them to learn how to meet occupier energy needs with less energy. • Be used to maximise the potential for self-consumption of renewable energy generated by the building.

L1.5. Reporting format

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

Energy design concept	**Addressed?** *(yes/no)*	**How has it been incorporated into the building design concept?** *(provide a brief description)*
1. Minimum energy performance requirements and Near Zero-Energy Building (NZEB) design		
2. Site specific design		

[7] HVAC stands for Heating, Ventilation and Air-Conditioning

Energy design concept	**Addressed?** *(yes/no)*	**How has it been incorporated into the building design concept?** *(provide a brief description)*
3. Renovation specific design		
4. High quality building fabric and services		
5. Smart monitoring and control systems		

Instructions for Level 2

L2.1. The purpose of this level

This level is for those users who are at the stage of needing to **calculate** the delivered energy and primary energy consumptio of a building for the purpose of **design comparisons, building permitting** or **tendering**.

L2.2. Step-by-step instructions

These instructions should be read in conjunction with the accompanying Level 2 technical guidance and supporting information (see page 23).

1. Identify the type of energy performance assessment that is required, the calculation method to be used and the software tools that will be used.
2. Complete the supporting information table with the type of energy performance assessment, the calculation method and the scope of energy uses addressed by the method.
3. Identify and gather the input data that will be required to make the calculation of energy needs. This may need to be obtained from different members of the design team - for example, building material insulation values, heating and cooling system's design performance values.
4. If relevant, obtain **calculated** values for the contribution of on-site or nearby renewable energy sources to meet the building's energy uses.
5. *For renovation projects,* ensure that the baseline building survey will provide the necessary information about the existing building structure and fabric.
6. Use the input data and efficiencies of building technical systems to calculate the energy uses of the building (i.e. the quantities of delivered energy for each energy carrier).
7. *Optional step:* where the national calculation method used does not provide a calculation route for estimating other, non-EPBD building services, estimates may be made at this point.
8. Apply primary energy factors to the energy carriers used for the calculated delivered energy in order to obtain the primary energy consumption.
9. Continue with design iterations and improvements until the final design that will be used for building permitting or the tendering process has been obtained.
10. *Optional step:* If the intention in the Level(s) project plan is to report on the performance of the completed building, the monitoring and metering strategy should be developed.
11. Develop specifications and designs for the energy monitoring systems and metering that will be used to obtain data on the energy uses of the completed and occupied building.
12. Complete the supporting information table on energy uses, entering the figures obtained for each fuel or energy carrier.
13. Complete the main reporting table with the non-renewable primary energy figure obtained for EPBD services, as well as estimates of exported renewable energy. Optionally, estimates for total primary energy use (renewable and non-renewable combined) and any use related to non-EPBD services can be reported separately.

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

The main items needed are as follows:

- ✓ A completed Level(s) building description.

- ✓ An appropriate calculation software tool that is compliant with the national or regional calculation method for the relevant Member State or compliant options based on CEN standards developed under mandate M/480[8].
- ✓ A building design that is sufficiently advanced to provide the input data required to make the calculations using the compliant calculation software tool.
- ✓ Estimations of occupier related energy needs, in the case that a method for their estimation is not provided within the national calculation method.

L2.4. Who should be involved and when?

Actors involved at the detailed design stage should led by the architect and engineers. Input data may be obtained from, amongst others, the architect, energy auditors, service engineers and quantity surveyors. Simulations may be carried out by the service engineers or by the energy/sustainability consultants.

L2.5. Ensuring the comparability of results

Comparative performance assessments can be made on the basis of:

- The assessment type: by the calculation method (i.e. national, regional or other compliant options based on CEN standards developed under mandate M/480), and by the purpose (i.e. for building permitting and/or an Energy Performance Certificate).
- Primary energy factors: The choices related to primary energy factors associated with extraction/generation and transport of the energy carried to the building should be reported according to EN 17423.
- Weather data: The design winter and summer years for the local area or region, following the method in EN 52000-1.
- Standard input data: Data provided at national level as part of national or regional calculation methods or the default data provided in Annex G of EN ISO 13790 shall be used. This shall include the use of standard occupancy data (see Annex G.8).
- Calculation time step: The choice of a quasi-steady state or hourly dynamic method as described in EN ISO 13790.

The conditions of use will have been fixed according to national or regional requirements. It is recommended that further steps are taken to ensure the quality and suitability of third party input data.

L2.6. Going a step further

The following steps can be taken in order to optimise the energy simulations carried out in order to design a high performance NZEB building. This represents a 'tailored' calculation that is representative of the site conditions and occupier energy use:

- Representative input data: The use of input data that is representative of:
  - the conditions of use and occupancy patterns associated with the building.
  - the certified performance of construction products and energy systems.
  - In the case of major renovations, the actual construction details of the existing building. This could include existing EPCs or other studies that have been used to demonstrate compliance with minimum energy performance requirements.
- Site specific weather data: The use of weather files that are as representative as possible of the location of the building.

[8] See here: https://epb.center/documents/

- Dynamic simulation: The use of a 'dynamic' method of simulating the energy performance of a building, meaning that it has an hourly time interval.

Other ways of going further can mean providing more information about the energy carriers that would help provide useful information for other Level(s) indicators:

- Adding carbon emission factors to each of the energy carriers to allow for the conversion of use stage energy consumption into carbon emissions (linking to Level(s) indicator 1.2).
- Adding cost factors for energy carriers to allow for the estimation of operation costs (linking to Level(s) indicator 6.1).

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

Supporting information

Level 2 reporting item	**Information to provide** **(select/delete as appropriate)**
Type of assessment	*Building permit, as-built (calculated) EPC or tailored assessment*
Calculation method	*Specify the method and any software tools used*
	The time step for the data used by the method e.g. monthly, daily, hourly

Delivered energy use assessment for the building

Building service	***Energy need***	***System efficiency*** [1]	***Energy carrier*** [2]	***Delivered energy per energy carrier***	***Non renewable primary energy factor*** [3]		***Renewable primary energy factor*** [3]		***Total primary energy factor*** [3]	
	kWh/yr	Decimal	Free text	kWh/yr	Decimal factor	kWh/yr	Decimal factor	kWh/yr	Decimal factor	**kWh/yr**
Heating										
Cooling										
Ventilation										
Hot water										
Lighting										
Other (please specify) [4]										
Exported renewable energy [5]	*n/a*	*n/a*								
Total										

1. The efficiency with which delivered energy is converted into needed energy. For example, if a boiler converts 85% of the calorific value of a fuel into heat in water coming out of the tap or shower, the system efficiency would be 0.85. Dividing the energy need by the system efficiency will produce the delivered energy result (delivered energy can never be lower than the energy needed).

2. For example, energy carriers from distant sources: solid, liquid or gaseous fossil fuels; solid, liquid or gaseous biofuels or grid electricity. From nearby sources: district heating or district cooling. From onsite sources: electricity from PV panels, electricity from wind turbines, heat from solar thermal, geothermal or aerothermal. In cases where more than one energy carrier is used for the same building system (e.g. hot water from a gas boiler and from onsite solar thermal) two rows should be made for hot water, one for each energy carrier. There must always be a dedicated row for each energy carrier for any given service. 3. Any given energy carrier may have a non-renewable factor and a renewable factor, or just one of the two. These factors may be greater than, equal to, or less than 1, although the combined total of non-renewable and renewable primary energy factors for a given energy carrier cannot be less than 1. 4. If the methodology requires other energy needs to be accounted for, or the user simply wants to do this, then one row should be used for each "other" energy service. 5. When making the entry for delivered energy for any exported renewable energy from the building, a negative number should be used.

Energy performance assessment results

	kWh/m²/yr
L2.1 EPBD services [1] non-renewable primary energy self-used [2] (mandatory)	
L2.2 EPBD services [1] renewable primary energy self-used [2] (optional)	
L2.3 EPBD services [1] total primary energy self-used [2] (optional)	*L2.1 + L2.2*
L2.4 Exported renewable primary energy (mandatory)	
L2.5 EPBD services [1] non-renewable primary energy balance [3] (mandatory)	*L2.1 – L2.4*
L2.6 Non-EPBD services non-renewable primary energy self-used [2] (optional)	
L2.7 Non-EPBD services renewable primary energy self-used [2] (optional)	
L2.8 Non-EPBD services [1] total primary energy self-used [2] (optional)	*L2.6 + L2.7*
L2.9 Total primary energy self-used [2] (optional)	L2.3 + L2.8
L2.10 Total primary energy balance [2] (optional)	*L2.9 – L2.4*

1. For the purposes of comparability, EPBD services in Level(s) reporting should be considered as: heating, cooling, ventilation (including any humidification and dehumidification), hot water and lighting.

2. Self-used means energy delivered to the building as part of the building operation. This includes all energy delivered from all sources, including onsite sources for EPBD services, such as PV panels and solar thermal installations and ignores any excess of renewable energy from onsite sources that is exported.

3. Primary energy "balance" means the subtracting any exported renewable primary energy from the total "self-used" energy.

Instructions for Level 3

L3.1. The purpose of this level

This level is for those users who would like to:

- Collect metered data in order to understand the energy use associated with the building they are working on, and
- Carry out testing of the building in use in order to identify any performance issues with the building fabric and building technical systems.

L3.2. Step-by-step instructions

These instructions should be read in conjunction with the accompanying Level 3 technical guidance and supporting information (see page 33).

Building fabric and technical services testing

1. Prior to handover of the building, the testing for air tightness and thermal integrity shall take place.
2. Prior to handover of the building, functional performance testing (i.e. commissioning) of the HVAC, as well as low or zero carbon energy systems, shall take place.
3. The reports obtained from the tests carried out shall be reviewed to identify any remedial actions that can be undertaken by the construction contractors.

Monitoring and metering strategy

4. Prior to handover, the setting up of monitoring or metering systems shall be completed. This shall include the correct calibration of meters and the recompilation of sub-meter readings (if installed) with the main meters and the logs of Building Automation and Control Systems and/or Building Energy Management Systems (if installed).
5. Following handover and prior to occupation, responsibility shall be assigned for obtaining and compiling the data provided by the installed meters and systems.
6. Data shall be collected after a defined minimum period of occupation time following completion of the building and be collected for at least a minimum defined duration of time.
7. If the data is to be used to compare performance with other buildings, the performance shall be corrected in relation to the conditions of use and the test reference year for the local area or region, following the method in the national calculation method or EN ISO 52000-1.
8. Complete the supporting information table on energy needs, entering the metered figures obtained for each fuel or energy carrier.
9. To obtain the total primary energy use, apply the primary energy factors stipulated in the relevant calculation method to the delivered energy quantities for each fuel or energy carrier.
10. Complete the main reporting table with the mandatory fields and, if desired, some or all of the optional fields for primary energy consumption. If they can be disaggregated, non-EPBD service primary energy use shall be entered separately. Methods for collecting and assessing measured energy use specifically for heating and domestic hot water are provided in EN 15378-3.
11. *Optional step:* Identify and attempt to diagnose the reason for any significant deviations from the calculated figures reported at Level 2.

L3.3. What do you need to make an assessment?

The main items needed are as follows:

✓ A completed Level(s) building description.

- ✓ Certifications and results from air tightness, thermal integrity and functional performance testing.
- ✓ Measured data obtained from meters and sub-meters, or from a building management system.

L3.4. Who should be involved and when?

Those actors involved in handover of the building and in subsequent facilities management. Analysis may be carried out by the same service engineers, energy auditors or energy/sustainability consultants who made the design assessment, or by consultants appointed by the building owner/operator.

L3.5. Format for reporting the results of an assessment

Supporting information

Level 3 reporting item	**Information to provide** **(select/delete as appropriate)**
Type of assessment	*Measured EPC or other type of corrected (measured) assessment*
Sampling period	*How long after completion of the building and for how many years?*
Corrections applied	*Please detail any corrections applied to the data and according to which standard.*
Primary energy factors	*Please identify the calculation method from which the factors used are taken*

Measurements of delivered energy to the building

Building service	***Energy carrier*** [1]	***Delivered energy per energy carrier***	***Non renewable primary energy factor*** [2]		***Renewable primary energy factor*** [2]		***Total primary energy factor*** [2]	
	Free text	kWh/yr	Decimal factor	kWh/yr	Decimal factor	kWh/yr	Decimal factor	**kWh/yr**
Heating								
Cooling								
Ventilation								
Hot water								
Lighting								
Other (please specify) [3]								
Exported renewable energy [4]								
Total								

1. For example, energy carriers from distant sources: solid, liquid or gaseous fossil fuels; solid, liquid or gaseous biofuels or grid electricity. From nearby sources: district heating or district cooling. From onsite sources: electricity from PV panels, electricity from wind turbines, heat from solar thermal, geothermal or aerothermal. In cases where more than one energy carrier is used for the same building system (e.g. hot water from a gas boiler and from onsite solar thermal) two rows should be made for hot water, one for each energy carrier.

2. Any given energy carrier may have a non-renewable factor and a renewable factor, or just one of the two. These factors may be greater than, equal to, or less than 1, although the combined total of non-renewable and renewable primary energy factors for a given energy carrier cannot be less than 1. 3. If the methodology requires other energy needs to be accounted for, or the user simply wants to do this, then one row should be used for each "other" energy service. 4. When making the entry for delivered energy for any exported renewable energy from the building, a negative number should be used.

Energy performance assessment results

	kWh/m²/yr
L3.1 EPBD services [1] non-renewable primary energy self-used [2] (mandatory)	
L3.2 EPBD services [1] renewable primary energy self-used [2] (optional)	
L3.3 EPBD services [1] total primary energy self-used [2] (optional)	*L2.1 + L2.2*
L3.4 Exported renewable primary energy (mandatory)	
L3.5 EPBD services [1] non-renewable primary energy balance [3] (mandatory)	*L2.1 – L2.4*
L3.6 Non-EPBD services non-renewable primary energy self-used [2] (optional)	
L3.7 Non-EPBD services renewable primary energy self-used [2] (optional)	
L3.8 Non-EPBD services [1] total primary energy self-used [2] (optional)	*L3.6 + L3.7*
L3.9 Total primary energy self-used [2] (optional)	L2.3 + L2.8
L3.10 Total primary energy balance [2] (optional)	*L2.9 – L2.4*
1. For the purposes of comparability, EPBD services in Level(s) reporting should be considered as: heating, cooling, ventilation (including any humidification and dehumidification), hot water and lighting. 2. Self-used means energy delivered to the building as part of the building operation. This includes all energy delivered from all sources, including onsite sources for EPBD services, such as PV panels and solar thermal installations and ignores any excess of renewable energy from onsite sources that is exported. 3. Primary energy "balance" means the subtracting any exported renewable primary energy from the total "self-used" energy.	

Guidance and further information for using the indicator

For using level 1

Additional background guidance and explanations are provided for two key concepts introduced in the Level 1 use stage energy design concept checklist, namely:

- L1.4. Checklist design concept 1a: Understanding the energy use associated with a building.
- L1.4. Checklist design concept 1b: The minimum energy performance and the requirements for Nearly Zero-Energy Building (NZEB), according to the national/regional building codes.

L1.4. Checklist design concept 1a: Understanding the energy use associated with a building

Directive 2010/31/EU on the energy performance of buildings (hereafter referred to as 'the EPBD') as amended by Directive (EU) 2018/844, states that reporting on the energy performance of a building shall include 'an energy performance indicator and a numerical indicator of primary energy use'. Moreover, the calculation methodology should follow the national annexes of the overarching standards, namely EN ISO 52000-1, 52003-1, 52010-1, 52016-1 and 52018-1.

Annex I of the Directive lays down a common framework for the calculation of a building's energy performance. This describes the minimum scope for the performance aspects to be modelled within a national or regional calculation method, as indicated in the table below. These equate to heating, hot water, cooling, ventilation and built-in lighting. Passive and internal heat gains, for example from appliances and heating pipes, shall also be taken into account.

Table 1. Common general framework for calculation of a building's energy performance as laid down by the EPBD (recast)

Type of performance aspect	Performance aspects
Minimum aspects of thermal characteristics to take into consideration	(a) the following actual thermal characteristics of the building including its internal partitions: (i) thermal capacity; (ii) insulation; (iii) passive heating; (iv) cooling elements; and (v) thermal bridges; (b) heating installation and hot water supply, including their insulation characteristics (c) air-conditioning installations (d) natural and mechanical ventilation which may include air-tightness (e) built-in lighting installation (mainly in the non-residential sector) (f) the design, positioning and orientation of the building, including outdoor climate (g) passive solar systems and solar protection (h) indoor climatic conditions, including the designed indoor climate (i) internal loads
Aspects whose 'positive influence' shall be taken into account	(a) local solar exposure conditions, active solar systems and other heating and electricity systems based on energy from renewable sources; (b) electricity produced by cogeneration; (c) district or block heating and cooling systems; (d) natural lighting.

Source: European Commission (2010)

L1.4. Checklist design concept 1b: The concept of a Nearly Zero Energy Building (NZEB)

Under the EPBD, Member States must ensure that all new buildings are 'nearly zero-energy' (NZEB) from the 31st December 2020 – meaning that an NZEB building effectively becomes the minimum energy performance requirement for new buildings from that date onwards. According to Article 2(2) of the EPBD, an NZEB

> '*…means a building that has a very high energy performance, as determined in accordance with Annex I. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby*'.

This definition does not differentiate between new and existing buildings. However, action is encouraged across the EU to *facilitate the cost-effective transformation of existing buildings into nearly zero-energy buildings*, which would translate into major refurbishment that allows energy performance requirements of an NZEB level to be met.

The exact definition of an NZEB in terms of primary energy use varies between Member States. However, in 2016 [9] the Commission published possible benchmarks by climate zone for an NZEB performance (see the table below).

Table 2. Indicative numeric benchmarks for the performance of an NZEB

Climate zone	***Office buildings***			***Single family house***		
	Total primary energy (kWh/m^2)	***On-site renewable energy contribution (kWh/m^2)***	***"Net" primary energy (kWh/m^2)***	***Total primary energy (kWh/m^2)***	***On-site renewable energy contribution (kWh/m^2)***	***"Net" primary energy (kWh/m^2)***
Mediterranean	*80-90*	*60*	*20-30*	*50-65*	*50*	*0-15*
Oceanic	*85-100*	*45*	*40-55*	*50-65*	*35*	*15-30*
Continental	*85-100*	*45*	*40-55*	*50-70*	*30*	*20-40*
Nordic	*85-100*	*30*	*55-70*	*65-90*	*25*	*40-65*

Source: European Commission (2016)

The climate zones referred to below can be cross-referenced to the heating and cooling degree days reference table included in the supporting guidance to the building description (see the table from Level(s) user manual 2 - reproduced here below for convenience).

Table 3. Climate zones and corresponding heating and cooling degree-day ranges[10]

Climate zone	**Parameters**		**Representative cities**
	Heating degree days	**Cooling degree days**	
Zone 1	<1500	>1200	Athens - Larnaca - Luga - Catania – Seville - Palermo
Zone 2	<1500	>800 - 1200	Lisbon - Madrid - Marseille - Rome
Zone 3	>1500-3000	400-800	Bratislava - Budapest - Ljubjana - Milan - Vienna
Zone 4	>1500-3000	<400	Amsterdam - Berlin – Brussels - Copenhagen - Dublin - London - Macon - Nancy - Paris - Prague - Warszawa
Zone 5	>3000	<400	Helsinki - Riga - Stockholm – Gdansk - Tovarene

The first part of the definition establishes energy performance as the defining element that makes a building an 'NZEB'. This energy performance should be achieved by minimising energy needs and by focussing on the design concepts identified in the L1.4 checklist, which focus on the building envelope and technical building systems. The

[9] Commission Recommendation (EU) 2016/1318 of 29 July 2016 on guidelines for the promotion of nearly zero-energy buildings and best practices to ensure that, by 2020, all new buildings are nearly zero-energy buildings

[10] From Ecofys (2013) and JRC (2018)

second part of the definition provides guiding principles to achieve this very high performance by covering the resulting low amount of energy to a very significant extent by energy from renewable sources, on or off site.

The concept of NZEB reflects the fact that renewable energy and energy efficiency measures work together. When placed on a building, renewable energy technologies such as on-site solar photovoltaic modules will reduce non-renewable delivered energy used in the building and, when exported, will reduce the overall primary energy use. Figure 2 illustrates the assessment boundary (blue line) for calculating primary energy according to EN 52000-1. In many cases, on-site renewable energy will not be sufficient to bring energy use close to zero, at least without further energy efficiency measures. In these cases renewable energy sources **located nearby** can contribute towards meeting a building's energy use. A distinction between onsite, nearby and distant locations of energy sources is illustrated by the red lines in the Figure below.

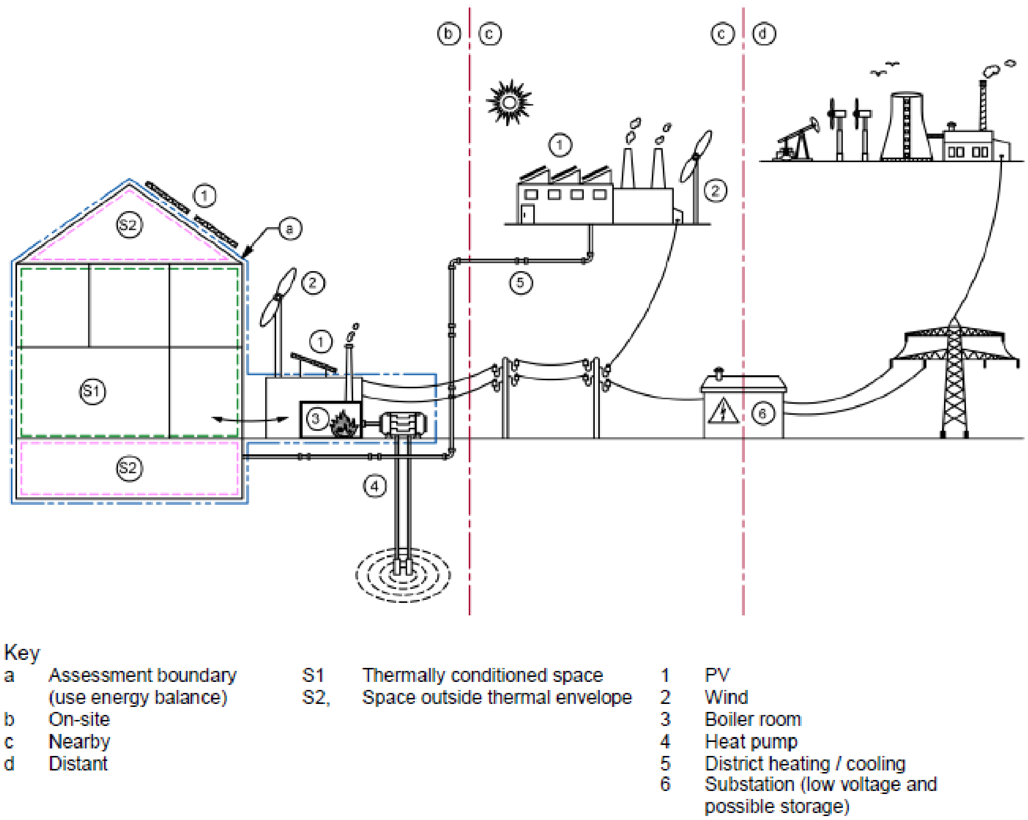

Figure 2. Building assessment boundary and energy balance locations

Source: CEN (2017)

The Figure above illustrates how PV panels can be counted as onsite, nearby or distant energy sources via the electricity energy carrier, depending on where the panels are located relative to the building. The same goes for wind turbines and electricity. The Figure also shows that district heating (or cooling) would be considered as a nearby energy source, but any geothermal or aerothermal heat pumps will be onsite energy sources if located on the building site.

Another distinction that has to be made in the Figure above is the assessment boundary. It is clearly illustrated that a boiler (for hot water and/or space heating) would be considered as a building technical system and thus **inside** the assessment boundary but that PV panels, even if they are on the roof of the building, are considered as **outside** the assessment boundary.

Consequently, all electricity coming into the building shall be considered as delivered energy, because it has to cross the assessment boundary before it reaches the building technical systems.

For using level 2

Additional background guidance and explanations are provided to support the estimation of total primary energy at Level 2. The specific topics covered are as follows:

- L2.2. Steps 1 and 2: The calculation methodology to be used,
- L2.2. Steps 1 and 2: Accounting for non-EPBD building service energy use,
- L2.2. Step 3a: Requirements for input data to the calculation method,
- L2.2. Step 3b: The selection of weather data sets,
- L2.2. Step 4: Ensuring the quality of the input data used,
- L3.2. Steps 1 and 2: Checking and testing the quality of construction and installation,
- L3.2. Steps 10 and 11: Monitoring of occupied performance.

L2.2. Steps 1 and 2: The calculation methodology to be used

The underlying calculation method for each component of a building's energy demand is provided by the EN ISO 52000 series of standards, which were developed in support of Directive 2010/31/EU for the Energy Performance of Buildings, as amended by Directive (EU) 2018/844. However, Member States are not obliged to use this standard and they can apply their own calculation methodologies (which must comply with Annex I of the EPBD) according to national or regional circumstances.

This means that national calculation methods used in order to calculate the energy performance of buildings, for the purpose of obtaining building permits or to issue Energy Performance Certificates (EPCs), could be used as reference methods for reporting.

The Concerted Action website on the Energy Performance of Buildings website[11] provides information on the different approaches defined for 34 different countries/regions in Europe (namely: Austria, Belgium-Brussels, Belgium-Flemish region, Belgium-Walloon region, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, UK-England, UK-Northern Ireland, UK-Scotland and UK-Wales).

Learn more about:

Options for ensuring the consistency of the energy calculation method used

The majority of national or regional calculation methods are currently based on EN 15603 and its associated standards. It is anticipated that, over time, these methods will be updated to reflect the new EN ISO 52000-1 series. In any case, according to the EPBD, Member States shall describe their national calculation methodology following the national annexes of the overarching standards, namely ISO 52000-1, 52003-1, 52010-1, 52016-1, and 52018-1, which have been developed under mandate M/480 given to the European Committee for Standardisation (CEN). **Compliant options** available to users of the Level(s) framework across the EU include:

- Use of a national calculation method and associated software tools developed according to one of the reference CEN standard series;
- Use of independently developed and validated software tools developed according to one of the reference CEN standard series;
- Direct use of the calculation method laid down within one of the reference CEN standard series.

[11] https://epbd-ca.eu/database-of-outputs

In each of these cases, it shall be indicated alongside the reporting on the indicator result whether a method developed according to a relevant CEN standard has been used. If a method is not available, the CEN standard itself (or its nationally adopted equivalent) can be used.

In addition to the calculation method, the exact type of energy assessment, according to the classification made by EN ISO 52000-1, shall be identified for the purposes of comparability. The table below classifies the assessment types available to users.

Table 4. Energy Performance of Building assessment types

Type	Sub-type	Input data			Type of application
		Use	Climate	Building	
Calculated (asset)	Design	Standard	Standard	Design	Building permit, certificate under conditions
	As built	Standard	Standard	Actual	Energy performance certificate, regulation
	Tailored	Depending on purpose			Optimisation, validation, retrofit planning, energy audit
Measured (operational)	Climate corrected	Actual	Corrected to standard	Actual	Monitoring, or energy audit
	Use corrected	Corrected to standard	Actual	Actual	Monitoring
	Standard	Corrected to standard	Corrected to standard	Actual	Energy performance certificate, regulation

Source: ISO organisation (2018)

The primary energy use of a building is derived from the calculation of the delivered energy entering the building across the assessment boundary. There are therefore two main steps in the calculation routine that are important to understand at a general level:

1. **Model the delivered final energy demand**: Delivered energy is the energy delivered to the building in the form of electricity, heat and fuel in order to satisfy energy needs within the building (heating, cooling, ventilation, domestic hot water, lighting, appliances, etc.). The starting point for most energy calculation methods is on the thermal performance of the building envelope:
   - The building envelope (energy need): This is the starting point for calculation methods developed according to EN ISO 13790 and EN ISO 52016. Orientation, control of solar gains and daylighting, thermal inertia and zoning are key factors to be considered in the method;

Derive the total non-renewable primary energy demand: In order to derive the primary energy demand of a building, primary energy factors must be applied to the calculated or measured delivered energy . These factors are provided within each national calculation method but default values can also be found in EN 52000-1. The primary energy factors represent the efficiency of the energy chain outside the assessment boundaries. For more transparency, EN 17423 provides a reporting table on the hypothesis taken into account by defining the primary energy factors. It is important to note that exported renewable energy is to be reported separately. This is because the Level(s) framework takes a life cycle approach and, according to reference standard EN 15978, exported energy is reported as a benefit beyond the building's system boundary, under Module D. The precise conventions adopted concerning the exported energy can completely alter the indicator result (namely whether exported renewable electricity is considered as avoiding onsite produced renewable electricity elsewhere or whether it avoids grid produced electricity being used elsewhere). The latter would give a greater influence of exported renewable electricity on the final result than the former.

L2.2. Steps 1 and 2: Understanding the scope and framework for assessing building energy performance

There are dozens of standards relating to the energy performance of buildings and it is vital to understand how they sit within the overall framework for assessing the energy performance of buildings, which is shown in the table below.

Table 5. Modular framework for energy performance of buildings

			EPBD services									Non-EPBD services	
Sub-modules	Module 1: Overarching	Module 2: Building	Module 3: Heating	Module 4: Cooling	Module 5: Ventilation	Module 6: Humidification	Module 7: Dehumidification	Module 8: Domestic hot water	Module 9: Lighting	Module 10: Building automation and control	Module 11: electricity production (onsite)	Module 12: Other	Module 13: Other
1. General													
2. Common terms and definitions													
3. Applications													
4. Ways to express energy performance													
5. Building categories and building boundaries													
6. Building occupancy and operating conditions													
7. Aggregation of energy services and energy carriers													
8. Building zoning													
9. Calculated energy performance													
10. Measured energy performance													
11. Inspection													
12. Ways to express indoor comfort													
13. External environment conditions													
14. Economic calculation													

Each cell in the table above will, now or in the future, have one or more EN, ISO or EN ISO standards. The cells have been left blank to avoid the table becoming too complex.

It is recommended that readers familiarise themselves with the content available at the EPC center website (https://epb.center/) which contains lots of useful information. The Figure below attempts capture the core of the EPC assessment in a single image.

Figure 3. Map of energy considerations and related standards for energy performance assessments of buildings

There are 5 main modules: (i) cooling; (ii) ventilation; (iii) heating; (iv) domestic hot water and lighting (v) lighting. The calculation starts with estimating the energy needs based on the building envelope (i.e. heat gains, heat losses, climatic conditions and indoor temperature and air quality requirements). This will provide results for energy needs for building technical systems for heating, cooling and ventilation. Any humidification or dehumidification should already be considered in estimates for these three systems. The blue arrows indicate the direct relationship of the heating, cooling and ventilation modules with the building envelope characteristics - and also how ventilation strategies affect calculations for heating and cooling energy needs. The domestic hot water module does not have a direct relationship to the building envelope characteristics but the lighting module does.

As building technical systems have become more sophisticated, as wireless networks and smart controls have become reality, and as onsite renewables have become an increasingly attractive option, the benefits of building automation system and control become more evident. This is where EN 15232-1 comes in and requires a general description of each building technical system (or in this case, EPBD service, to use Level(s) terminology). EN 15232-1 also requires any relevant information about emissions, distribution throughout the building, any energy storage and any energy carrier transfer or combination taking place in the relevant EPBD service modules. For example, domestic hot water may be a combination of solar thermal and a gas-fired boiler and to achieve optimum performance, would require the storage of water heated by solar radiation for later use by occupants.

It is necessary to convert energy needs into delivered energy for each energy carrier. To do this, the efficiency of the building technical system needs to be accounted for. Total delivered energy to a building technical system cannot be less than the energy need, as the system cannot be more than 100% efficient (a specific example of geothermal heat pumps is provided later in the guidance).

All of the delivered energy needs to then be converted into primary energy, and this will depend on the primary energy factors that are assumed for each energy carrier. EN ISO 52000-1 provides some default primary energy (renewable and non-renewable) factors in Table B.16 of the standard. National and regional methods can specify their own primary energy factors as well.

There are lots of choices for how the final result of the energy performance of a building can be reported (e.g. total primary energy, total non-renewable primary energy (self-used), total non-renewable primary energy (balance) etc. and whether these include non-EPBD services or not). The final indicator(s) would be specified by the national or regional method. However, the underlying calculations, if carried out in line with the overarching series of EN ISO 52000 standards, would provide the basic information to report in all of indicators mentioned in the Level(s) reporting format, at least for EPBD services.

L2.2. Steps 1 and 2: Declaring the approach for dealing with any exported renewable energy

As requirements for new buildings to be NZEB come into force and increasing attention is paid to energy efficiency benefits from building renovation, the installation of onsite renewable electricity has gained more attention. If the scope of the energy performance assessment is on EPBD services only, then it may be necessary to consider the "export" of renewable electricity to non-EPBD services in the same building – which might seem strange. There is also the possibility to consider the export of renewable electricity to other buildings. In both cases, there are two ways in which exported renewable energy from onsite sources can be considered[12]:

- Based on the primary energy used to generate it (i.e. $K_{exp} = 0$)
- Based on the avoided primary energy from the grid (i.e. $K_{exp} = 1$)

An illustrated example is shown for a system with an air-source or ground-source heat pump, grid electricity and onsite electricity as energy carriers crossing the assessment boundary.

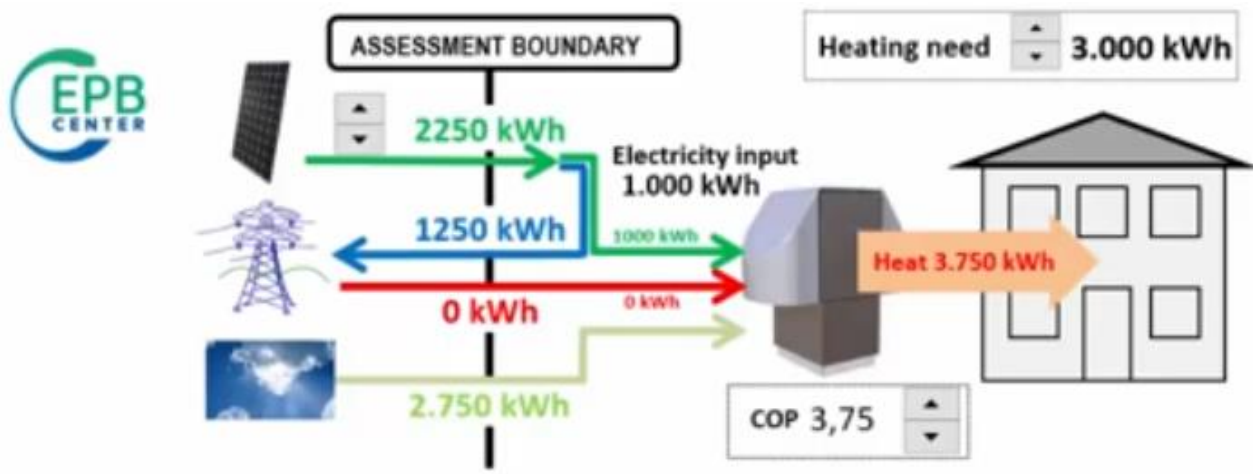

Figure 4. Example with exported renewable energy.

Source: EPB Center

In the example above, an air-source or ground-source heat pump uses renewable heat and 1000 kWh of onsite generated electricity from PV panels to meet the heating energy needs. Because of the oversizing of the PV panels system, an excess of 1250 kWh of renewable electricity is produced, which is exported to the grid.

Let´s assume that the primary energy factors for onsite PV and grid electricity are as follows:

- Onsite PV: renewable primary energy factor = 1.0, non-renewable primary energy factor = 0,0 (total = 1,0)
- Grid electricity: renewable primary energy factor = 0.5, non-renewable primary energy factor = 2.0 (total = 2.5).

[12] K_{exp} is a factor that determines which part of exported energy is included in the energy performance of a building, it is mentioned specifically in tables A.17 and B.17 of EN ISO 52000-1.

Independently of the K_{exp} used, the calculation is the same (i.e. delivered energy used in the building + excess renewable energy generated onsite – exported energy). However, depending on the K_{exp} used, the value for exported energy, and thus for total primary energy consumption would then vary as follows:

- Using K_{exp} = 0, the exported PV electricity simply cancels out the excess production of onsite PV electricity, so the total primary energy consumption would be 3750 kWh (i.e. 3750 + 1250 – (1250x1.0)) and have a renewable energy ratio of 1.00 (i.e. 100% renewable).
- Using K_{exp} = 1, the exported PV electricity has a bigger benefit, because each kWh exported is avoiding the need to consume 2 kWh of non-renewable energy sources and 0.5 kWh of renewable energy sources. In this case, the total primary energy consumption would drop to 1875 kWh (i.e. 3750 + 1250 – (1250x2.5)) and have a renewable energy ratio of 2.32 (i.e. 232% renewable).

It might seem confusing that a system can be more than 100% renewable and this is part of the reason why Level(s) does not currently require reporting of the renewable energy ratio.

L2.2. Steps 1 and 2: Accounting for non-EPBD building service energy use

Electricity loads associated with energy use, such as, for example, appliances or computers that are plugged into power sockets, are not specifically covered in most national or regional calculation methods. This effectively means that they are non-EPBD building service energy uses (i.e. modules M12 and M13). It should be clearly noted how they are treated in Level(s) reporting (i.e. omitted completely, partially included or fully included) and, if included, the relevant calculations and assumptions used

L2.2. Step 3a: Requirements for input data to the calculation method

An important first step is to identify the input data that will be required. The table below summarises the main data items and potential sources. Each method will provide guidance on where real values can substitute default values. For a tailored assessment, real values shall be used as far as possible.

Table 6. Specification of the main data requirements and potential sources

Data item	Potential source	
	Default EU values	National, regional or locally specific values
Conditions of use and occupancy	EN ISO 13790 (Annex G8) EN ISO 52000-1 ISO/TR 52000-2 EN ISO 52016-1	National or regional calculation method
Thermal envelope description	EN ISO 13790 (Annex G) EN ISO 52016-1	National or regional calculation method: certified products and details
Building services description	EN ISO 13790 (Annex G) EN ISO 52016-1	National or regional calculation method: certified products
Reference year climate file	Three climate zones (EN 15265 test cases)	National or regional calculation method Member State Meteorological Offices
Primary energy factors	EN 15603 (Annex E) EN 52000-1 (Annex B.10)	National or regional calculation method
Internal temperature set points	EN ISO 13790 (Annex G) EN ISO 52016-1	National or regional calculation method

Data item	Potential source	
	Default EU values	National, regional or locally specific values
Ventilation and infiltration rates	EN 15241 EN 15242	National or regional calculation method
Internal gains as heat flows	EN ISO 13790 (Annex J) EN ISO 52016-1	National or regional calculation method
Heating/cooling system characteristics and capacity	-	National or regional calculation method: certified products [13]

L2.2. Step 3b: The selection of weather data sets

It is recommended to use a test reference year derived from the medium term (20 or 30 year) time series of a standard local weather station. The length of this time series will ensure that the reference year is representative of climatic variations in the short to medium term. If it is difficult to access hourly local weather files, the Joint Research Centre's open access weather file database may be used for sites across the EU[14].

The Urban Heat Island (UHI) effect

Where possible, it is important to take into account the Urban Heat Island (UHI) effect, as this can have a significant effect on localised external temperatures. In some EU towns and cities, work has been done to interpolate weather datasets to take into account the UHI effect. This is particularly important in major cities and locations where the urban design, commuting patterns and topography can exacerbate winter or summer conditions.

Learn more about:

Determining the extent of the urban heat island effect

The Urban Heat Island (UHI) effect is an additional factor to take into account when modelling the external air and radiative temperatures around a building. This is because the temperature in an urban area can be elevated compared to rural areas due to a combination of:

- vehicle exhaust,
- building air conditioning heat rejection,
- street canyon geometry,
- reduced evapotranspiration by vegetation and,
- absorption and re-radiation of heat by roads, paving and structures.

The effect can be generalised across an urban area or, where there are combinations of factors, it can be very localised within a district or at specific points.

Recognising the significance of this effect, a number of cities have put in place initiatives to support designers to take it more into account. Examples include London[15], Stuttgart[16] and Zaragoza[17].

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[13] This may include reference to product characteristics laid down in Ecodesign Implementing Measures, Energy Labelling legislation or other relevant harmonised standards.

[14] Joint Research Centre, Photovoltaic Geographical Information System (PVGIS) – TMY generator https://ec.europa.eu/jrc/en/PVGIS/tools/tmy

[15] London's urban heat island, https://data.london.gov.uk/dataset/london-s-urban-heat-island---average-summer

[16] Climate ADAPT case study of Stuttgart,http://climate-adapt.eea.europa.eu/metadata/case-studies/stuttgart-combating-the-heat-island-effect-and-poor-air-quality-with-green-ventilation-corridors

[17] José M. Cuadrat Prats, Sergio M. Vicente-Serrano y Miguel A. Saz Sánchez, *Los efectos de la urbanizacion en el clima de Zaragoza (España): La isla de calor y sus factores condictiontes*, Boletín de la A.G.E. N.º 40 - 2005, págs. 311-327

L2.2. Step 4: Ensuring the quality and representativeness of the input data used

It is recommended that where third party input data is used, special attention be paid to its quality and compliance. For example, input data may also be available that has been checked and certified for use – for example, performance data for architectural details that can minimise thermal bridging.

Use of certified input data may be a requirement of a national calculation method in order to ensure comparability. Its use may therefore help ensuring that calculations are compliant with national calculation methods. The QUALICHeCK project provides further orientation on ensuring the quality and compliance of input data (see the box below).

Learn more about:

Ensuring the quality and compliance of the input data used in an performance assessment

The Intelligent Energy Europe funded project, QUALICHeCK, has sought to identify how the quality and compliance of input data can be ensured[18]. Examples of sources of compliant input data include:

- Pre-calculated values for certain technologies/aspects;
- Procedures for generating reliable data for innovative products;
- Databases of product characteristics;
- Rules for consistent declarations of product performance.

These sources may also be subject to third party verification.

Although input data may comply with standards or calculation method requirements, it is important to note that it might not result in a more accurate simulation of the as-built performance, however it will help ensure a comparable performance assessment.

Greater precision can be achieved by calculating or obtaining input data for the performance of specific building details or, in the case of building renovations, calculating or obtaining input data for the performance of specific construction details identified from condition surveys.

The performance of technologies such as renewable energy generation can be modelled separately in order to provide more representative input data.

It is also important to define, in as a representative way as possible, input data that is influenced by occupancy patterns. The starting point shall be predicted occupancy patterns and occupation density for the building and the conditions of use with respect to how areas will be heated and cooled. This shall then be used as the basis for defining:

- Internal temperature set points.
- Ventilation and infiltration rates.
- Internal gains and heat flows.

In the case of building renovations, surveys of the existing occupants of a building or a building stock can provide additional refinement to the understanding of occupancy patterns and user behaviour. It is important to consider user behaviour because evidence has shown that, particularly in residential building renovations, there can be a 'rebound effect' whereby the efficiency improvements are offset by greater energy use by occupants.

[18] QUALICHeCK (2016) *Compliant and Easily Accessible EPC Input Data,* http://qualicheck-platform.eu/results/reports/

L2.2. Step 8: Understanding primary energy factors

To convert the quantities of delivered energy crossing the assessment boundary and reaching the building technical systems into primary energy, it is necessary to understand how primary energy factors can vary, depending on the type of energy carrier and other upstream considerations.

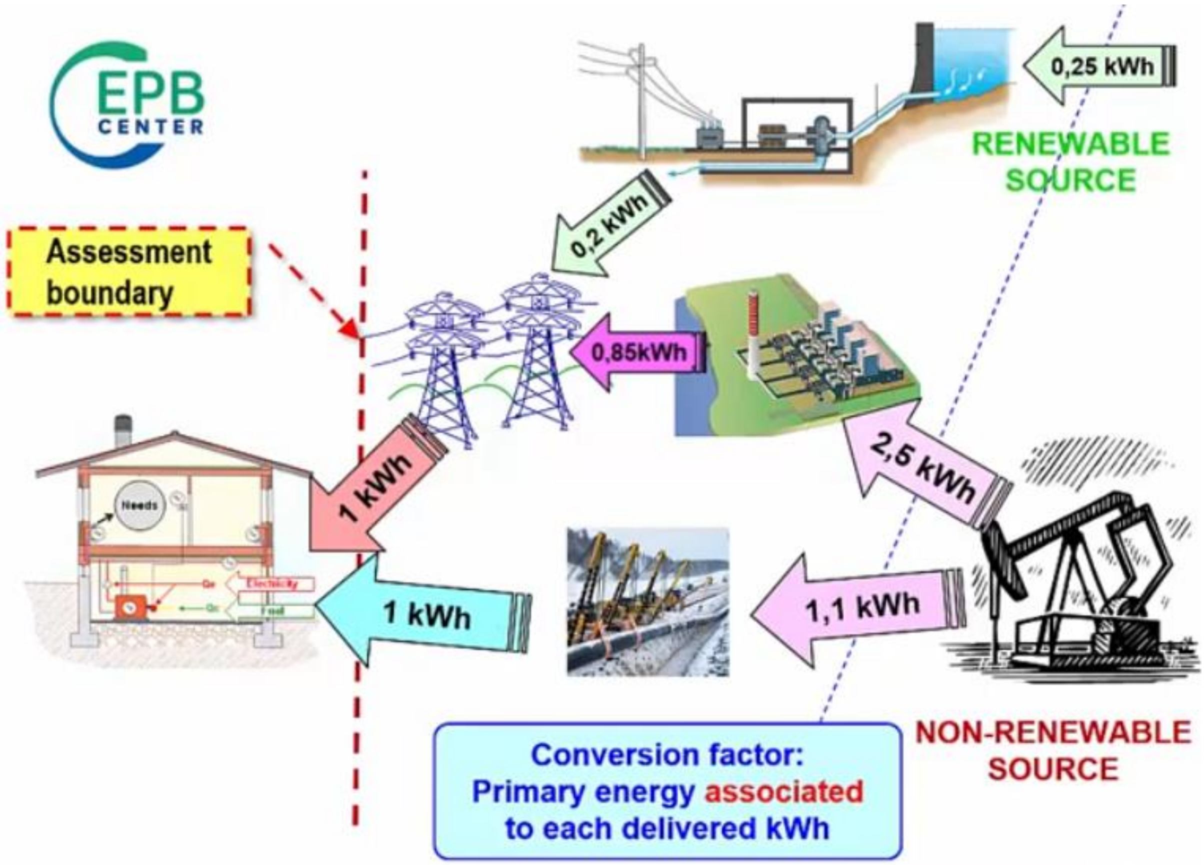

Figure 5. Illustration of different primary energy sources and potential conversion factors.

Source: EPB Center

In the above Figure, the supply of the following three types of energy is shown:

- renewable electricity via the grid from hydropower (top)
- non-renewable electricity via the grid from fossil fuel power station (middle)
- natural gas fuel.

Starting with the simplest example, and working backwards from the building, it can be seen that for every 1.0 kWh of natural gas fuel consumed in the building, 1,1 kWh of natural gas needs to be extracted from the gas well. The extra energy is needed in order to compensate for leaks in extraction, leaks in the infrastructure and any pumps to move gas throughout the network under pressure. These losses are often referred to as "overheads".

For grid electricity, this is more complex because there are two different sources of primary energy. In the example, for every 1.0 kWh of electricity consumed in the building, 1,05 kWh of electricity needs to pass through the grid in order to account for distribution losses (e.g. heat and noise). The relative contributions of the two primary energy sources are: 0.20 kWh from hydropower and 0.85 kWh from the gas power station. It is clear that the overheads are much less significant for hydropower (ca. 20%) than for the natural gas power station (ca. 66%).

Because of the differences in energy overheads, even though the delivered grid electricity suggests a split of around 81% non-renewable (i.e. 0.85 of 1.05), if we go back to primary energy, the non-renewable share would increase to around 91% (2.5 of 2.75).

For the purposes of Level(s) reporting with the above example, each kWh of grid electricity used as an energy carrier to building technical systems (EPBD or non-EPBD services) would have the following primary energy factors: (i) renewable primary energy factor = 0.25; non-renewable primary energy factor = 2.5.

For using level 3

Additional background guidance and explanations are provided to support the measurement of total primary energy at Level 3. The specific topics covered are as follows:

- L3.2. Steps 1 and 2: Checking and testing the quality of construction and installation.
- L3.2. Steps 10 and 11: Monitoring of occupied performance.

L3.2. Steps 1 and 2: Checking and testing the quality of construction and installation

Evidence shows that a commitment to carry out building envelope quality testing and the functional performance testing of HVAC systems for a completed building can ensure that performance more closely approximates to estimations by focussing the attention of design teams and contractors on:

- Design and in particular building envelope details.
- Construction quality.
- Correct installation of services.

Performance targets and objectives can be laid down which can later be checked on site during completion of the building. For offices, this may be applied to the whole building or only a part of it. For multi-unit residential building projects, these may be applied to a sample of properties. Reference test procedures that can be used are identified in the guidance note below.

Learn more about:

Reference standards for checking and testing the as built and completed energy performance of a building

Quality and functional performance testing requirements can be specified with reference to specific tests, routines and standards:

- Testing of the quality and integrity of the building envelope, with reference standards to include:
  - Air tightness using a fan pressurisation test (EN ISO 9972).
  - Integrity by thermal imaging survey (EN 13187).
- Commissioning of Heating, Ventilation and Air Conditioning (HVAC) systems, with reference standards to include:
  - Functional performance testing of the system operating characteristics (EN 12599).
  - Checking of the integrity of ventilation duct work (EN 15727).
- Commissioning of low or zero carbon energy generation technologies, with reference to best practice for each technology.

The Intelligent Energy Europe funded project QUALICHeCK provides further guidance on ensuring the quality of works, including a range of case studies from across the EU [19].

L3.2. Steps 10 and 11: Monitoring of occupied performance

A metering strategy is essential to ensure accurate measurement of a building's energy use. This is also important in buildings supplied with of heating, cooling and domestic hot water services from a centralised source, since as the 2018 amended version of the Energy Efficiency Directive [20] requires consumption data to be provided to energy

[19] QUALICHeCK (2016) *Source book on Guidelines for better enforcement of quality of the works*, www.qualicheck-platform.eu

[20] Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency

consumers. Care should be taken to ensure that meters are installed as specified, with due attention to calibration and placement, as well as to how the data will be collated and analysed, and by whom. Further guidance on the process is provided below.

Where installed, there is an important role for Building Automation and Control Systems or Building Energy Management Systems in monitoring performance. The revised Energy Performance of Buildings Directive requires that Member States require, where technically and economically feasible, that non-residential buildings with an effective rated output for heating systems or systems for combined space heating and ventilation of over 290 kW are equipped with building automation and control systems by 2025.

Learn more about:

The role of metering in Building Performance Evaluation

The setting up of meters and monitoring systems should be addressed during the commissioning process for building services. This shall include the recompilation 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 building handover, the metering and BEMS 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)