EUB SuperHub

European Building Sustainability performance and energy certification Hub

Definition of common transnational indicators and assessment metrics for the E-Passport (D 2.2)

This project has received funding from the European Union's H2020 research and innovation programme under Grant Agreement No. 101033916.

Project no. 101033916

Project acronym: EUB SuperHub

Project title: European Building Sustainability performance and energy certification Hub

Call: H2020-LC-SC3-B4E-4-2020

Start date of project: 01.06.2021

Duration: 36 months

Deliverable title: D 2.2 - Definition of common transnational indicators and assessment metrics for the E-Passport

Due date of deliverable: August 31st, 2022

Organisation name of lead contractor for this deliverable:
CSTB (Centre Scientifique et Technique du Bâtiment) (partner #8)

1. table

Name	Organization
Letizia ROCCAMENA Sylviane NIBEL	*CSTB*
Cristina Di Maria, Elena Mocchio, Giacomo Riccio and Adriano Ferrara	*UNI*
Several experts involved in the writing and review of the KPIs description	*CSTB, IISBE, HM, EIHP, EIV*

2. table

Dissemination level		
PU	Public	X

3. table

History			
Version	**Date**	**Reason**	**Revised by**
01	01/09/2022	Draft for review	iiSBE, HM, EIHP, EIV
02	12/12/2022	Second Draft	CSTB
03	30/05/2023	Final Draft	iiSBE, HM, EIHP, EIV
04	29/06/2023	Final	GEO

Table of Contents

Executive summary

The current study defines and describes a core set of 21 transnational Key Performance Indicators (KPIs) for the next generation of assessment and certification framework of buildings energy performance (EPCs), complemented by other sustainability indicators, all of them forming a harmonized building passport.

Within the frame of Task 2.2, the EUB SuperHub project consortium was called upon to select these 21 KPIs covering all the relevant thematic areas suggested by the European Commission in the recent recast proposal for the Directive of the European Parliament and of the Council on the energy performance of buildings (EPBD), sustainability criteria, and smartness of buildings. The starting point was the list of 35 indicators previously identified in the frame of Task 1.2.

Once the set of the 21 indicators was selected (see Table 2), objectives and assessment methods were detailed for each indicator and reported in a specific description template defined for this task, as well as their calculations procedures, applicable life cycle phases, and levels of operation. For all introduced assessment methods and calculation procedures, it was ensured that they were fully compliant with the existing EU standards and current legislation framework (e.g., EPBD 2018, etc.), and applicable for various building types (residential, office, etc.).

In parallel, a transnational comparison of nationally used indicators and metrics regarding the KPIs was carried out to check the level of "readiness and maturity" of the partners' countries, showing the discrepancies in the familiarity and appropriation with the calculation of the indicators.

This document reports the filled description templates of all the selected KPIs as well as the result of the transnational comparison of the nationally used indicators and metrics regarding the KPIs. The description of the harmonized set of KPIs, along with the findings in Task 2.5, will be transformed into a CWA (CEN Workshop Agreement) in order to increase its legitimacy and to enlarge the audience of stakeholders, including more countries and experts.

1 Introduction and work methodology

The main objective of this Task 2.2 of EUB SuperHub is to provide a core set of transnational Key Performance Indicators (KPIs) for the next generation of assessment and certification framework of buildings energy performance (EPCs), complemented by other sustainability indicators, all of them forming a harmonized building passport. This Task took advantage of already operational indicators provided in the public national sustainability certification systems, European standards, and previous European R&D projects that were already collected during Task 1.2.

The selection of final common KPIs was carried out in two steps:

1. In the first step, a qualitative analysis with the aim to define an affordability rating for each indicator was carried out by each project partner (PP) on the 35 indicators selected in the frame of Task 1.2. The objective of this first step was to reduce the number of selected indicators (from 35 to about 20) by retaining only those offering the best ratings and guaranteeing at the same time the maximum reliability, enriching them with key information, so that they may unquestionably become KPIs.

2. In the second step, an exchange among the main experts of project partners took place during a workshop meeting, in order to make a selection of final KPIs consistent with the EPBD recast requirements, and to make more feasible their calculation according to the partners' experience and expertise.

These two steps are described more in detail later in this document.

Once the set of indicators is selected, objectives and assessment methods had to be described for each common indicator, as well as their calculations procedures, applicable life cycle phases and levels of operation. For all introduced assessment methods and calculation procedures, it had to be ensured that they were fully compliant with the existing EU standards and current legislation framework (e.g., EPBD 2018, etc.), and applicable for various building types (residential, office, etc.). A description template was especially set to allow a consistent and uniform description of all selected KPIs.

In parallel, another objective of the Task was to conduct a transnational comparison of nationally used indicators and metrics in order to check the level of "readiness and maturity" of the partners countries regarding the KPIs. This comparison was carried out by letting the project partners answer a few questions about the existence of defined calculation methods and assessment approaches in their national regulation or environmental certification/labelling, the existence of numerical calculation tools and the availability of qualified and experienced assessors to calculate these indicators. The results obtained are shown in chapter 4 and may be used in a future step of the EUB SuperHub project, for instance to determine the "mandatory" or "optional" status of each selected KPI. Progress is needed in the different EU countries, about half of the KPIs, in order to develop easy and mature assessment practice.

This deliverable D2.2 is the fourth version from September 2022, and is released in June 2023. for the main reasons hereinafter listed:

- The European context linked to the long process of EPBD recast (Energy Performance of Buildings Directive) led to an unsteady situation regarding most of KPIs. As the situation is not solved yet, some indicators will need adaptation or precision when EPBD recast will be finalised and adopted.
- The CEN standardisation under TC 350 was very active during 2022 and the 1st part of 2023, with the revision on EN 15978 on LCA methodology for the calculation of environmental performance of buildings, following the revision of EN 15804 on construction product LCA in 2019. This revision did not reach its objective in due time, leaving several methodological issues without a clear status, impacting the assessment method of energy and greenhouse gases related indicators. Currently a process of re-registration of a new work item (NWI) proposal is under way (June 2023), in order to continue the revision work. The consequence is a temporary inconsistency between EN 15804+A2(2019) at product scale and existing EN 15978(2011) for building LCA, relying on the old version of EN 15804. Another standard on data quality, EN 15941, linked to the two above mentioned, will enter in formal vote next September. Data quality is an important point for the validity and credibility of LCA indicators, and finally good-quality EPC and passport.
- The CEN Workshop initiated by UNI started officially at the end of April 2023 with a kick-off meeting. The 21 selected KPIs were submitted to a panel of experts and some interesting feedback was collected after 2 meetings, impacting (in the positive sense) the list of KPIs in a certain extent. It was preferable to publish D2.2 after this opportunity to share the KPIs list with experts.

This D 2.2 is an important step and also an important Milestone in EUB SuperHub project, with this list of 21 selected KPIs and their description. The deliverable D 2.5, adds new elements and precision of KPIs and the associated certification process and passport design. Later in autumn 2023 the CEN Workshop will release the CWA of harmonisation of KPIs. In addition, the test feedback in Work Package 5 will certainly bring important recommendations for KPIs implementation.

2 Criteria for KPIs selection

2.1 Results obtained from Task 1.2

Withing the frame of Task 1.2, the consortium investigated and analysed the available transnational set of indicators, related to the evaluation of the energy performance, sustainability and smartness of buildings. Transnational frameworks analysed are listed below, catalogued according to the belonging field.

Standardisation process:

- EN 15643:2021
- EN 15978:2011 (under revision in 2022)
- EN 16309:2014+A1:2014
- EN 16627:2015

EC initiatives:

- Smart Readiness Indicators
- Level(s)

EU projects:

- NewTREND (H2020)
- FASUDIR (FP7)
- OpenHouse (FP7)
- SuPerBuildings (FP7)
- CESBA MED (Interreg MED)
- LenSe (FP6-Policies)

International projects:

- SBTool (initially developed by Canada)
- SBA Common metrics (Sustainable Building Alliance, no more active)

The capitalisation of the results achieved by the European projects and the others mentioned above, in parallel with the investigation of short- and long-term goals identified by the European Commission in the recast proposal for the Directive of the European Parliament and of the Council on the energy performance of buildings (2021/12/15), were the main aspects deepened in the context of Task 1.2. Furthermore, it was strongly taken into account the analysis, carried out as part of Task 1.3, of the current needs of the market actors, a crucial aspect that guarantees the alignment of project outputs with market needs.

The final result of Task 1.2, delivered by EUB SuperHub project consortium, was a comprehensive list of indicators for evaluating the energy performance, sustainability and smartness of buildings in the next generation of Energy Performance Certificates and future Building Passports.

The following figure shows the interactions of the tasks T 1.x of WP1 contributing to the common transnational indicators of T 2.2.

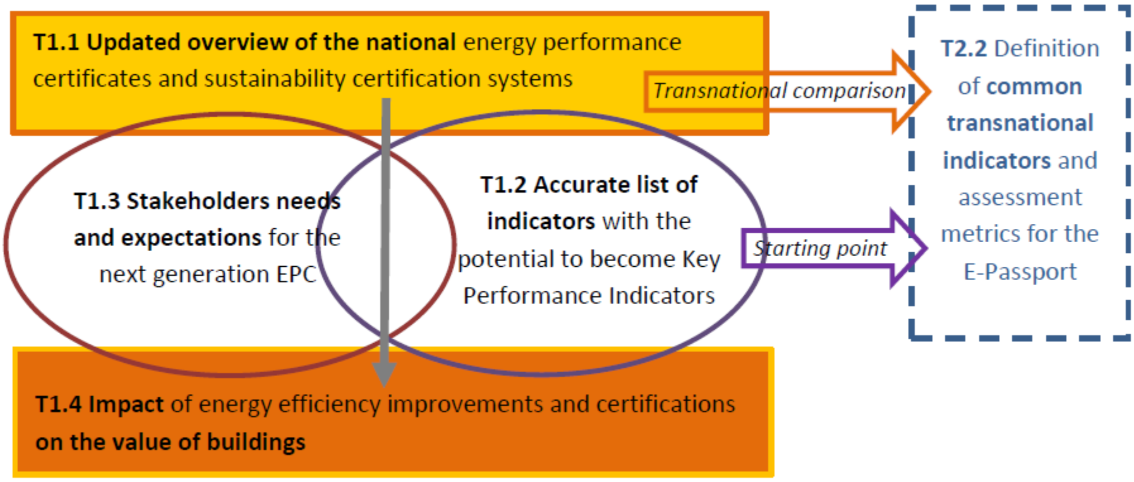


Figure 1 - Set of the WP1 tasks contributing to T2.2 objectives.

The relevance and robustness of the selected indicators lies in the fact that they are:

- <u>Coherent</u> with European Commission directives and proposals
- <u>Representative</u> of the market needs
- <u>Exhaustive</u> in relation to the stakeholders demands
- <u>Harmonised</u> with the European Commission EPBD recast proposal
- <u>Effective</u> compared to the strategies for reducing energy consumption.

We also put some limits to this exercise. As Energy is the central topic, the KPIs must have a direct or indirect relation with the energy field. For example, acoustics is an important issue for many stakeholders and occupants, but this theme has no (or very little) connection with energy, this is the reason why acoustics is not included in the KPI list. This is the same with water use. Of course, domestic hot water (DHW) uses energy, but this energy is already included in the energy consumption indicators. The production of drinkable water and its distribution to buildings need some energy, but generally it is a small amount. So, the quantity of the water resource, in m^3, used for building operation and users' needs, is not considered as such in the selected KPIs. Nevertheless, the water consumption data may be accessible in the Digital Building Logbook (DBL) gathering all input data concerning the building information, characteristics and performances (see D 2.4).

2.2 Indicators affordability rating

As a first step in the selection of final common KPIs, a qualitative analysis was considered necessary for guaranteeing the maximum reliability of the indicators selected. This qualitative analysis was carried out with the aim to define an affordability rating for each indicator, and it focused on five key aspects, which represent five crucial aspects to be considered for the reliability and robustness of an indicator. To each of these aspects a score, ranging from 1 to 3, has been awarded with the purpose to get a final affordability rating for all the indicators selected. This affordability rating form was developed by the Italian partner iiSBE as part of Task 1.2, and it can be found the report D 1.2.

The five aspects considered for the taxonomy production of the indicators are the following:

1. Data availability: considers the easy of data retrieval and its availability to be used as it is to perform the calculation.

(score: 1 very difficult - 2 easy - 3 extremely easy)

2. Complexity of the calculation or measurement: considers the difficulty to perform the calculation necessary to get the result of the indicator.

(score: 1 very complicated - 2 easy - 3 extremely easy)

3. Level of competence required for the assessor: considers the level of knowledge and skill of the assessor, necessary to proper perform the calculation of the indicator.

(score: 1 high specialisation - 2 quite specialised - 3 basic)

4. Time to perform the calculation: considers the effort of the process of working, in terms of time, necessary to get the indicator result.

(score: 1 high - 2 medium - 3 low)

5. Cost of the evaluation: considers the real economic cost to be taken into account to get the result of the indicator. In this regard it's important to consider if any specific instrument, software, specific calculators are necessary to perform the calculation of the indicator.

(score: 1 high - 2 medium - 3 low)

The affordability rating (AF), obtained by each of the potential KPIs selected, outlines its reliability and robustness achieved through the five-parameter considered. The total AF comes from the sum of the individual items, the higher the score reached, the higher the trust in the indicator. The objective of this rating was to reduce the number of KPIs (from the 35 selected by partners under Task 1.2 to about 20) covering all the relevant thematic areas suggested by the European Commission in the recent recast proposal for the Directive of the European

Parliament and of the Council on the energy performance of buildings for evaluating the energy performance, sustainability and smartness of buildings.

Below is the table containing all the indicators (35) selected as potential KPIs, on which the qualitative analysis was performed, with the mean value of the AFs obtained for each of them from each project partner.

Table 1 – Affordability rating (AF) for each of the 35 indicators selected as potential KPIs within the frame of Task 1.2

Thematic area	Criterion	Indicator	Unit of measure	Reference framework	AF
Energy Consumption	1-Use stage energy performance	Primary energy demand per useful internal floor area	kWh/m²/yr kWh	1.1 Level(s)	12
	2-Use stage energy performance	Delivered final energy demand	kWh/m²/yr kWh	1.1 Level(s)	12
	3-Use stage energy performance	Non-renewable primary energy demand	kWh/m²/yr	1.1 Level(s)	12
	4-Embodied non-renewable primary energy	Total use of non-renewable primary energy resources (used in the life cycle of products)	MJ	EN 15978	7
	5-Electrical peak demand for building operations	Average of peak monthly electrical demand for one year	W/m²	B2.1 SBTool	11
Renewable Energy	6-Use stage energy performance	Renewable primary energy demand	kWh/m²/yr	1.1 Level(s)	12
	7-Energy from renewable sources in total primary energy consumption	Primary energy demand of the building that is met by renewable sources on total primary energy demand	%	B1.4 CESBA MED	9
	8-Embodied renewable primary energy	Total use of renewable primary energy resources (PERT)	MJ	B1.6 CESBA MED	12
Greenhouse Gas Emissions (in use stage)	9-Total GHG Emissions from energy used in building operations	CO_2 equivalent emissions per useful internal floor area per year	kg CO_2 eq./m²/yr	C 1.3 CESBA MED	6
Life-cycle Global Warming Potential	10-GHG emissions from energy embodied in construction materials	CO2 equivalent emissions per m² of gross area, as determined by calculations based on design documents and	kg CO_2 eq./m²/yr	C1.1 CESBA MED	8

Thematic area	Criterion	Indicator	Unit of measure	Reference framework	AF
		fuel emission values plus process-related emissions related to the region of production, and annualized according to the predicted lifespan of the building			
	11-Life cycle Global Warming Potential	Greenhouse gases emitted from the production of building materials to the end of the building's useful life and the subsequent demolition and recovery of the building materials per useful internal floor area	kg CO_2 eq/m^2/yr	1.2 Level(s)	10
Thermal comfort	12- Time outside of thermal comfort range	The proportion of the year when building occupiers are not comfortable with the thermal conditions inside a building	% of time out of range during the heating and cooling seasons	4.2 Level(s)	10
	13-Thermal comfort index	Predicted Percentage Dissatisfied (PPD)	%	D2.2 CESBA MED	9
Indoor Air Quality *	14-Indoor air quality conditions	Ventilation rate	L/s/m^2	4.1 Level(s)	9
	15-Indoor air quality conditions	CO_2 concentration	ppm	4.1 Level(s)	9
	16-Indoor air quality conditions	Relative humidity	%	4.1 Level(s)	9
	17-Target pollutants indoor sources	Total VOCs	µg/m^3	4.1 Level(s)	9
	18-Target pollutants indoor sources	CMR VOCs concentration	µg/m^3	4.1 Level(s)	11
	19-Target pollutants indoor sources	R value	Decimal ratio	4.1 Level(s)	11
	20-Target pollutants indoor sources	Formaldehyde concentration	µg/m^3	4.1 Level(s)	6
	21-Target pollutants outdoor sources	Benzene	µg/m^3	4.1 Level(s)	12

Thematic area	Criterion	Indicator	Unit of measure	Reference framework	AF
	22-Target pollutants outdoor sources	Radon concentration	Bq/m^3	4.1 Level(s)	8
	23-Target pollutants outdoor sources	Particulate matter < 2,5 μm	$μg/m^3$	4.1 Level(s)	9
	24-Target pollutants outdoor sources	Particulate matter < 10 μm	$μg/m^3$	4.1 Level(s)	9
Costs	25-Life Cycle Costs	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	€/m^2/yr	6.1 Level(s)	10
	26-Operational Energy Costs	Operational energy costs, aggregated annually, normalised by floor area	€/m^2	10.1 NewTREND	15
Smart Buildings	27-Smart readiness indicator	SRI (total)	%	SRI	9
	28-SRI Key Functionality	Energy saving and maintenance	%	SRI	14
	29-SRI Key Functionality	Comfort, ease and well-being	%	SRI	12
	30-SRI Key Functionality	Grid flexibility	%	SRI	12
Climate Change and Resilience	31-Protection of occupier health and thermal comfort	Proportion of the year when building occupiers are not comfortable with the summer thermal conditions inside a building	Projected % time out of range in the years 2030 and 2050	5.1 Level(s)	7
Electrical mobility	32-Installation of pre-cabling / number of recharging points in relation to the number of parking spaces			EPBD recast - art.12 (Infrastruc-ture for sustainable mobility)	12

Thematic area	Criterion	Indicator	Unit of measure	Reference framework	AF
Daylighting sufficiency	33-Daylight Factor (DF)	The ratio of horizontal indoor to outdoor illuminance by daylight under continuously overcast sky conditions expressed as a percentage	% (illuminan-ce)	BREEAM HQE certification (France)	9
	34-Daylight Provision	The ratio of time a target illuminance level is achieved across a fraction of the reference plane compared to the duration of daylit time	% (time)	EN 17037 (also BREEAM, HQE certification (France), etc.)	12
	35-Window ratio	Ratio of window area to the floor area	% (area)	HQE certification (France)	9

**: Some IAQ units of measurement have been corrected (µg/m³) compared to the previous version.*

The results collected showed that for some of the analysed indicators, the scores obtained by all partners were very similar, while for some of them the AFs were completely heterogeneous. This is due to the fact that not all indicators are commonly calculated and/or taken into account in national regulations / certification systems of all project partners. The analysis of this discrepancy in the familiarity with these indicators was carried out and it is shown in chapter 4.

2.3 Selection of final KPIs by the project partners

Starting from the AFs collected in the first step of this work, an exchange among all project partners took place during an online workshop meeting on May 3, 2022, in order to select final KPIs consistent with the EPBD recast requirements and make them more feasible to calculate according to the partners' experience and expertise.

The list of the 21 final KPIs of the EUB SuperHub project are presented in the table below.

Table 2 - List of the 21 selected KPIs

Thematic area	Indicator	Reference framework
Energy Consumption	1. Delivered annual final energy demand per useful floor area	1.1 Level(s)
	2. Total annual primary energy demand per useful floor area	1.1 Level(s)
	3. Non-renewable primary energy demand per useful floor area	1.1 Level(s)
	4. Embodied energy	EN 15978
Renewable Energy	5. Renewable annual primary energy demand per useful floor area	1.1 Level(s)
	6. Renewable energy ratio (on-site, nearby)	B1.4 CESBA MED
Greenhouse Gas Emissions (in use stage)	7. Annual use stage energy-related Global Warming Potential (GWP)	C 1.3 CESBA MED
Greenhouse Gas Emissions (on the life cycle)	8. Life Cycle Global Warming Potential (GWP)	1.2 Level(s)
Thermal comfort	9. Percentage of time outside of thermal comfort range	4.2 Level(s)
Indoor Air Quality	10. Ventilation rate	4.1 Level(s)
	11. CO_2 concentration	4.1 Level(s)
	12. Relative humidity	4.1 Level(s)
	13. Total VOCs	4.1 Level(s)
	14. CMR VOCs concentration	4.1 Level(s)
	15. R value	4.1 Level(s)
	16. Formaldehyde concentration	4.1 Level(s)
Costs	17. Operational Energy Costs	10.1 NewTREND
Smart Buildings	18. Smart Readiness Indicator	SRI
Resilience	19. Summer thermal discomfort in 2030 and 2050 - Percentage of time outside of thermal comfort range	5.1 Level(s)
E-mobility	20. Installation of pre-cabling / number of recharging points in relation to the number of parking spaces	EPBD recast - art.12 (Infrastructure for sustainable mobility)
Daylight sufficiency	21. Daylight Provision	EN 17037

Note 1: The names of the indicators #4 and #7 have been modified to better correspond to standardized indicators or to avoid inappropriate terms, while keeping the initial idea.

Note 2: Following some experts' comments during a recent CEN Workshop meeting on harmonisation of KPIs in May 2023 (see the setting of this CW in chapter 5), indicators 1 and 2 have been reversed for logical reason, and some limited changes in the KPIs titles, units or references were made, for clarification. The suggestions made about grouping or adding indicators are not reported here, because they need deeper discussion in the coming months.

The reasons behind the choice of each of these indicators are described below:

- **Indicator 1 "Delivered annual final energy demand per useful floor area"**

The 'delivered energy' is generally the one metered by the utilities.

Tracking the evolution of energy consumption at the assessment boundary (in the form of delivered energy) by each energy carrier and by EPB service can help to understand which building element uses the most energy. Then, it is possible to apply many well-proven active and passive energy efficiency measures to reduce delivered final energy demand.

NOTE: Building element means a technical building system or an element of the building envelope.

- **Indicator 2 "Total annual primary energy demand per useful floor area"**

The energy performance of a building expressed by a numeric indicator of primary energy in kWh/(m^2.a), is included in the energy performance certificate (EPC) in order to make it possible for owners and tenants of the building or building unit to compare and assess its energy performance. This indicator represents the metric used for building energy ratings in most EU countries. Except for energy performance certificates (EPCs) a numeric indicator of primary energy is used to comply with minimum energy performance standards for existing buildings. Primary energy is also important for meeting mandatory regulations for new and renovated buildings.

The goal is to reduce the overall energy consumption of buildings in all areas, considering the chain processes from the beginning.

- **Indicator 3 "Non-renewable annual primary energy demand per useful floor area"**

It is of utmost importance to reduce the EU's dependence on fossil fuels.

Tracking non-renewable energy demand outside the assessment boundary is important to reduce the non-renewable primary energy use associated with the building's delivered energy for energy performance of buildings services (EPB services) during the use stage. In addition, reporting on this indicator can provide useful insights on the building's total emissions of air pollutants to the ambient air.

- **Indicator 4 "Embodied energy"**

This indicator intends to promote construction products and services with low embodied energy over their life cycle.

Embodied energy refers to the non-renewable primary energy resources for manufacturing the products or services used in the project, for the initial construction or renovation, and during its lifetime (replacements), for the transportation to the site, construction, maintenance, and for the removal and disposal or recycling of materials, and restoration of the site at the end of its life.

An energy optimum can be calculated, associating building-scale embodied energy and operational energy on a certain horizon of time.

- **Indicator 5 "Renewable annual primary energy demand per useful floor area"**

The objective of energy-efficient buildings is to cover the building's energy demand with renewable energy sources. The energy demand is commonly expressed with the primary energy demand in kWh/(m².a). Tracking renewable primary energy demand is important to incentive the consumption and production of renewable energy.

- **Indicator 6 "Renewable energy ratio (on-site, nearby)"**

This KPI aims to measure the share of renewable primary energy demand in total primary energy demand. Its tracking is important to maximise the use of renewable energy sources.

The renewable energy ratio *RER* states how much of total primary energy demand is marked as renewable primary energy.

- **Indicator 7 "Annual use stage energy-related Global Warming Potential (GWP)"**

This indicator aims to quantify the contribution of use stage energy systems to Global Warming Potential.

EPBD is clearly focused on the reduction of GHG emissions, and this indicator is essential in an Energy Performance Certificate.

This indicator can measure progress towards EU climate objectives, which can be reached mainly by applying energy-efficient measures, using decarbonized energy sources, and adapting users' behaviour.

- **Indicator 8 "Life Cycle Global Warming Potential (GWP)"**

In recent and new buildings, considering the high energy performance achieved by regulated uses, the embodied GWP is higher than the operational one. So, building design must consider low-carbon elements (construction products and technical services) on their life cycle (from cradle to grave). Combined with decarbonised energy sources for building operation, low-carbon elements contribute to the European Union climate objectives.

- **Indicator 9 "Percentage of time outside of thermal comfort range"**

Because of a combination of factors including poor insulation, low-quality windows, cold bridging through the building fabric, high levels of air infiltration, and insufficient or poorly maintained heating systems, a significant portion of the housing stock in the EU is unable to provide adequate levels of thermal comfort. The control of thermal comfort is an important factor to consider in all buildings because uncomfortable circumstances can put more vulnerable residents at risk from illnesses, reduce the productivity level of the occupants, and/or may necessitate the usage of additional cooling/heating energy. As the control of overheating is specifically addressed by the Energy Performance of Buildings Directive 2010/31/EU (EPBD), this indicator primarily focuses on summertime thermal comfort, but it also considers residents' capacity to maintain a comfortable indoor temperature in winter.

- **Indicator 10 "Ventilation rate"**

Since most of the Europeans spend more than the 90% of their time inside buildings, indoor air quality (IAQ) is a highly important influence on human health. Ventilation rate is one of the most effective strategies to control air changes, CO_2 and humidity. Indeed, the ventilation rate involves filtering out harmful pollutants that could enter via intakes of outdoor air. It also includes the provision of a minimum air exchange rate to prevent unhealthy levels of CO_2, humidity and pollutants arising from indoor materials in the indoor.

- **Indicator 11 "CO_2 concentration"**

Indoor air quality can have multiple effects on the human health. The quality of the indoor air depends on multiple variables that are closely related to pollutant levels and air conditions (e.g. CO_2 and humidity). To ensure suitable Indoor Air Quality (IAQ) level, a number of different performance aspects must be addressed to ensure that the CO_2 concentration are within the safe limits.

It's fundamental to limit the CO_2 concentration level in indoor air for occupants' well-being. Furthermore, the measurement of the CO_2 concentration is an indirect measure that allows to understand if the mechanical ventilation works properly and if there are anomalies.

- **Indicator 12 "Relative humidity"**

The level of relative humidity is an important influencing factor on occupant comfort. Excessively high humidity (> 90%) increases the intensity of hot or cold temperatures, while excessively low humidity (< 20%) can cause irritation of the eyes, nose and throat. Poor control of humidity from outdoor air or from kitchen and bathroom areas can create ideal conditions for mould growth, which in turn can provoke respiratory or allergenic health issues[1].

Studies relating to homes suggested that around 17% of the EU population (approximately 80 million people) live in homes in which damp and associated mould growth may provoke health effects[2].

- **Indicator 13 "Total VOCs"**

---

1 Level(s) indicator 4.1: Indoor air quality, European Commission - Joint Research Centre, January 2021.

2 Grun G., Urlaub S., Foldbjerg P., Towards an identification of European indoor environments' impact on health and performance – Mould and dampness. Frauhofer-Institut fur Bauphysik IBP

People are spending an increasing amount of time indoors. There they are exposed to pollutants generated outdoors that penetrate to the indoor environment and also to pollutants produced indoors, for example as a result of space heating, cooking and other indoor activities, or emitted from products used indoors. Multiple variables of indoor air quality (IAQ) impact human health and several are closely related to Volatile Organic Compounds (VOCs).

The TVOC emissions can be limited through the careful selection of VOC free construction products and materials, or at least very low-emission ones.

- **Indicator 14 "CMR VOCs concentration"**

People are spending an increasing amount of time indoors. There they are exposed to pollutants generated outdoors that penetrate to the indoor environment and also to pollutants produced indoors, for example as a result of space heating, cooking and other indoor activities, or emitted from products used indoors. Multiple variables of IAQ impact on the human health and several are closely related to CMR VOCs. CMRs entering routes into organisms include inhalation (of dust, fumes, gas, vapours), ingestion (by eating, drinking, smoking with dirty hands or by accidental ingestion) and penetration through (intact or damaged) skin and mucous membranes.

In addition to Total VOCs estimation, a value for total CMR VOCs is necessary to separately identify the more hazardous substances that may be emitted.

- **Indicator 15 "R Value"**

Since each individual VOC has its own potential toxicity upon exposure to humans, the R value has been developed, trying to translate data from total VOC measurements into potential human health risks. The LCI concept was first developed by the European Collaborative Action on Indoor Air Quality and its Impact on Man when considering the best way to evaluate emissions from solid flooring materials. Nowadays, the European Commission subgroup on EU-LCI values task is to derive and recommend EU-wide harmonised health-based reference values for the assessment of product emissions, based on the so-called "lowest concentration of interest" (LCI) concept[3].

Indeed, the R value normalises each individual VOC concentration against a specific LCI value for that individual VOC. This creates a coefficient for each VOC and, when coefficients for individually identified VOCs in the same sample are summed up together, the overall R value can be generated.

An R value > 1 would then suggest that the VOC content in indoor air is a concern for human health impacts[4].

---

3 https://ec.europa.eu/growth/sectors/construction/eu-lci-subgroup_en

4 Level(s) indicator 4.1: Indoor air quality, European Commission - Joint Research Centre, January 2021.

- **Indicator 16 “Formaldehyde concentration”**

Indoor exposure to formaldehyde pollutant through inhalation is a dominant contributor to cause adverse health effects. The lowest concentration reported to cause sensory irritation of the eyes in humans is 0.36 mg/m3 for four hours. Increases in eye blink frequency and conjunctival redness appear at 0.6 mg/m3. There is no indication of accumulation of effects over time with prolonged exposure. The perception of odour may result in some individuals reporting subjective sensory irritation.

Due to its serious health risk, as it is classified as carcinogenic, it is necessary to prevent human health from exposure to the contaminant; in that sense, it is preferable the use of low-emitting building materials and products. Preventing exposure to environmental tobacco smoke and other combustion emissions, will minimize exposure-related risk. In addition, ventilation can reduce indoor exposure to formaldehyde.

- **Indicator 17 “Operational Energy Costs”**

The energy cost is the one of the largest if not the largest operating expense in non-residential buildings. In residential building the energy cost can be so high that over 10% of the household income is spent on heating cost alone. Indeed, it is estimated that about 8% of the EU population are unable to keep their home adequately warm due to high energy cost and thus suffering from energy poverty. Energy poverty therefore remains a major challenge and lifting vulnerable citizens out of it is an urgent task for the EU and its members. Moreover, there is a strong correlation between the building energy efficiency performance, its environmental footprint and its operational energy cost. Hence, the indicator encourages the uptake of energy efficient buildings and renovation actions.

- **Indicator 18 “Smart Readiness Indicator”**

One of the main objectives of the Energy Performance of Buildings Directive (EPBD) is to leverage on the potential of smart technologies in the building sector to support creating healthy and comfortable buildings with lower energy consumption and carbon impact. Moreover, the smart technologies can also facilitate the integration of renewable energy sources in energy systems. Therefore, the EPBD sets out provisions to establish a “Smart Readiness Indicator” (SRI) as an instrument for rating the smart readiness of buildings.

- **Indicator 19 "Summer thermal discomfort in 2030 and 2050 - Percentage of time outside of thermal comfort range "**

The climate is set to change in the future and the heat waves, as well as tropical nights, are expected to become more frequent and sever in the years 2030 and 2050, which can pose a significant health risk to vulnerable groups. Given the longevity of buildings, this indicator is intended to help identify and implement climate adaptation measures that can minimize the risk of overheating and maintain an acceptable degree of thermal comfort in the summer. The indicator follows basically the same methodology as Indicator 9 (percentage of time outside of thermal comfort range), except that it uses projections for future climate in 2030 and 2050 to measure the thermal performance of the building instead of past weather data.

- **Indicator 20 "Installation of pre-cabling / number of recharging points in relation to the number of parking spaces"**

Electric vehicles combined with an increased share of renewable electricity production play a crucial role for reducing greenhouse gas emissions and decarbonisation of the electricity system by providing flexibility, balancing and storage services.

The number of available purpose-built recharging points is crucial for the establishment of electric vehicles. Electric vehicles park regularly and for long periods, giving the opportunity to recharge. Buildings, especially those where people park for reasons of residence or employment, therefore play a crucial role in providing the necessary infrastructure for re-charging. Moreover, the installation of recharging points at building's parking lots is not only a useful service to the users but can also provide energy storage to the related building.

The (pre-) equipping of parking spaces provides a rapid and cost-efficient installation of recharging points for individual owners and ensures the required access to recharging points.

- **Indicator 21 "Daylight provision"**

Daylight can contribute significantly to the lighting needs of any type of building and accordingly, in improving the energy performance of buildings. This means that daylight openings should have appropriate areas to provide sufficient daylight throughout the year.

Moreover, it is important not to overlook the fact that light impacts human health and performance by enabling performance of visual tasks, controlling the body's circadian system, affecting mood and perception, and by enabling critical chemical reactions in the body.

3 KPIs description

3.1 Design of the description template

Once all the KPIs selected, it was decided to set a description template allowing the consistent and uniform description of selected KPIs. To do this, a review of descriptive formats already used in other European projects was carried out so as to select all the information to be added about each indicator. In particular, the templates analysed were those of the European projects SuPerBuildings, Level(s) and ALDREN. More information about these projects can be found in Deliverable D 1.2.

At first, the commonalities between the different templates were highlighted and added to the SuperHub KPIs describing template when deemed consistent with the objectives of the project. Subsequently, other information found to be of interest were picked up from the different templates that already exist or were added based on the project partners' expertise. Below, the information required for describing the indicators in each project are listed. Following them, the EUB SuperHub description template final version is shown with the questions to be answered by the information entered by the project partners in red, in parentheses. The common points in the templates were highlighted using the same reference colours.

3.1.1 SuPerBuildings

1. Indicator
Name – Definition / description
Definition / description of sub-indicators
Units
Principles of classification
Weighting and aggregation
2. Validity
Issue of concern
Explanation
Justification
3. Object of assessment
Building
Site
Location
Other
4. Characterization
Directly impact-related / Building-performance or site-performance based / Process-based
Status of the indicator
5. Assessment
Design phase:
Calculation / assessment method,
Data needed and data availability,
Applicability
Operation phase:
Measurement / assessment method
Data needed and data availability,
Applicability
6. Comparability
Requirements for comparability
7. Sources of information
Source / Bibliography / Web links
Free comments
Writer and date (last update)

3.1.2 Level(s)

1. Introduction briefing
Why measure performance with this indicator?
What does it measure?
At what stage of a project?
Conceptual design (following design principles)
Detailed design and construction (based on calculations, simulations and drawings)
As-built and in-use (based on commissioning, testing and metering)
The unit of measurement
System boundary
Scope
Calculation method and reference standards
2. Instructions on how to use the indicator at each level
2.1 Instructions for Level 1
The purpose of this level
Step-by-step instructions
Who should be involved and when?
Checklist of relevant design concepts
Reporting format
2.2 Instructions for Level 2
The purpose of this level
Step-by-step instructions
What do you need to make an assessment?
Who should be involved and when?
Ensuring the comparability of results
Going a step further
Reporting format of an assessment
2.3 Instructions for Level 3
The purpose of this level
Step-by-step instructions
What do you need to make an assessment?
Who should be involved and when?
Format for reporting the results of an assessment
3. Guidance and further information for using the indicator
For using level 1
For using level 2
For using level 3

3.1.3 ALDREN

EX: Module 2 (Energy Performance)
Main outcomes of the task
Objectives
The methodology and protocol
Mid-term outcomes and future steps needed
Description of the current status
Existing buildings definition as the baseline for impact assessment
Numerical indicators of energy performance and targets
Consultation of indicators with existing voluntary certification schemes
Energy performance targets towards NZEB
Typical technologies and solutions for existing and NZEB
Protocol for Aldren European Voluntary Certificate (EVC) procedures
Input Data collection (Subject, Steps / actions / explanation / examples, Source of information)
Steps towards energy rating and ALDREN European Voluntary Certificate – ALDREN methodology
Conclusions
Conclusions from setting and testing the scale and reference
Conclusions on the methodological integration of the EVC in ALDREN procedures

3.1.4 EUB SuperHub

Name
Reference framework
Definition and description (What does this indicator measure?)
Objectives/Justification (Why measure performance with this indicator?)
Unit of measurement
System boundary (Where is the system boundary set? Building? Site? Location?)
Certification case (New buildings? Existing buildings (in use)? Under major renovation buildings? In which form?)
Scope (Residential buildings? Non-residential buildings*? Both?)
Reference standards
Assessment protocol (Instructions on how to calculate/assess the indicator at each stage)
Calculation method/Assessment approach (Step-by-step instructions)
Data requirements (Data needed and data availability)
Assessors' required qualifications (Who should be involved and when? What are the necessary competences/skills to carry out the assessment?)
Comparability (How to compare the indicator value to the equivalent national values or benchmarks? How to compare the results for buildings with different functions? What are the conditions and limits of comparability?)

**** Non-residential buildings:*** *all types of tertiary buildings in all sectors of activity: offices, shops, warehouses, hotels, nurseries, schools, colleges, high schools, campuses, museums, media libraries, etc.*

3.2 Filled description templates

This section shows the completed description templates of the 21 selected KPIs for EUB e-Passport.

Note 1: Under the template item "Assessors' required qualifications", we have chosen, following iiSBE suggestion, to use the competence framework defined in the H2020 **Train4Sustain** project[5], formalised in October 2022 into a CEN Workshop Agreement (CWA) after a public consultation[6] (ref. 17939, document of 212 pages[7]). This CWA is based on a Competence Quality Standard (CQS) in sustainable buildings, developed by Train4Sustain partners, facilitating transnational recognition of learning outcomes and competence levels of existing qualifications and vocational trainings. In the following forms, the Train4Sustain competence levels are not filled yet. It will be done during task 2.5, under the supervision of iiSBE, which was actively involved in the Train4Sustain project.

Note 2: Following some experts' feedback during a recent CEN Workshop meeting on harmonisation of KPIs in May 2023 (see the setting of this CW in chapter 5), the initial order of presentation of the two first indicators has been reversed in this last version, so as to have final energy presented before primary energy.

3.2.1 Indicator 1 "Delivered annual final energy demand per useful floor area":

Name	**Delivered annual final energy demand per useful floor area**
Reference framework	Level(s) indicator 1.1: Use stage energy performance (Publication version 1.2 – July 2021)
Definition and description	Definitions from the proposal for EPBD revision (published in December 2021) or EN ISO 52000-1 (published in August 2017) **Delivered energy** means energy, expressed per energy carrier, supplied to the technical building systems through the system boundary, **to satisfy the uses** taken into account or **to produce the exported energy**. An energy carrier is a substance or phenomenon that can be used to produce mechanical work or heat or to operate chemical or physical processes. Energy can be delivered to the building and exported from the building through the system boundary. It is important to differentiate between: • Delivered final energy demand and • Net delivered final energy demand. The delivered final energy demand is used for satisfying the uses taken into account or to produce the exported energy.

[5] https://train4sustain.eu/
[6] https://www.cencenelec.eu/news-and-events/news/2022/workshop/2022-08-08-train4sustain/
[7] https://standards.cencenelec.eu/dyn/www/f?p=CEN:110:0::::FSP_PROJECT,FSP_ORG_ID:75704,3070781&cs=126033BD3BC453C2FD4F7A44F94665A38

<table>
<tr><td></td><td>Net delivered final energy demand, required to meet the energy demand of considered energy performance of buildings services (EPB services) of the assessed building only, represents delivered minus exported energy, both expressed per energy carrier.

NOTE: For defined energy uses, delivered energy can be calculated or measured.</td></tr>
<tr><td>Objectives /Justification</td><td>The ‘delivered energy’ is generally the one metered by the utilities. Tracking the evolution of energy consumption at the system boundary (in the form of delivered energy) by each energy carrier and by EPB services can help to understand which building element uses the most energy. Then, it is possible to apply many well-proven active and passive energy efficiency measures to reduce delivered final energy demand.
NOTE: Building element means a technical building system or an element of the building envelope.</td></tr>
<tr><td>Unit of measurement</td><td>Delivered annual final energy demand per useful floor area for EPB services E_{del} in kWh/(m²y)
Delivered energy can be calculated ($E_{del,calc}$) or it can be measured ($E_{del,meas}$).
Useful floor area A_{use} in [m^2] for EPB assessments is the total internal floor area of a building where energy for space heating/cooling is consumed to condition the space measured up to the internal wall surfaces (see Table B.20 – Specifications of the useful floor area within the EN ISO 52000-1:2017).
Useful floor area is used in EPCs for expressing annual energy (e.g., primary, delivered energy) and carbon emissions per unit of conditioned area.</td></tr>
<tr><td>System boundary</td><td>Calculation or measurement of the energy flows (delivered and exported energy) is performed at the system boundary. Inside the system boundary, the energy losses are taken into account by technical building system efficiency factors and thus are already accounted for in delivered energy values.
NOTE: The system 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 distant sources, the system boundary does not change.</td></tr>
<tr><td>Certification case</td><td>1. New buildings after construction – new buildings ‘as built’ (without long-term use data)
In the case of new buildings after construction, only the calculated (asset) method can be applied to calculate this indicator.
2. Existing buildings in the use phase (with long-term use data of at least three years)
In the case of existing buildings in the use phase, both methods, calculated (asset) and measured (operational) methods can be applied for the calculation of this indicator.
3. Existing buildings after major renovation (without long-term use data)
In the case of existing buildings after a major renovation, only the calculated (asset) method can be applied to calculate this indicator.</td></tr>
<tr><td>Scope</td><td>The scope of the indicator includes both residential and non-residential buildings with the following building services (also called EPB services) considered (informative default choices taken from Table B.18 of EN ISO 52000-1):
<table>
<tr><td rowspan="2">Building service (or EPB service)</td><td colspan="2">Building service considered in the calculation of indicator (Yes/No)</td></tr>
<tr><td>Residential buildings</td><td>Non-residential buildings</td></tr>
<tr><td>Heating</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Cooling</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Ventilation</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Humidification</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Dehumidification</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Domestic hot water</td><td>Yes</td><td>Yes</td></tr>
</table></td></tr>
</table>

Lighting	No	Yes
External lighting	No	No
People transport (elevators…)	No	No
Appliances	No	No
Others	No	No

NOTE: When calculating this indicator, the building services considered must always be clearly declared if they differ from default choices.

Reference standards

The energy calculation method for energy performance available across the EU include:

- use of **national or regional calculation methods** and associated software tools (which must comply with Annex I of the EPBD) or
- use of **calculation methods** compliant with the EN **ISO 52000** series and standards developed under mandate 480.

The majority of national or regional calculation methods are currently based on EN 15603[8] and its associated standards (EN 15316 series). It is anticipated that, over time, these methods will be updated to reflect the new EN ISO 52000-19 series.
According to EN ISO 52000, there are two types/methods of the energy performance of building assessment:

- calculated (asset) assessment method,
- measured (operational) assessment method.

The assessment type used (as defined by the EN ISO 52000 series) **should be reported in all cases** for the purposes of comparability.

Type	Sub-type	Input data		
		Use	Climate	Building
Calculated (asset)	Design	Standard	Standard	Design
	As built	Standard	Standard	Actual
	Tailored	Depending on purpose		
Measured (operational)	Climate corrected	Actual	Corrected to standard	Actual
	Use corrected	Corrected to standard	Actual	Actual
	Standard	Corrected to standard	Corrected to standard	Actual

Energy performance of building assessment types

Assessment protocol

Calculated (asset) assessment method for calculating the delivered annual final energy demand per useful floor area:

1. calculate energy needs (e.g., for space heating, cooling, domestic hot water preparation),
2. calculate annual delivered energy to the building site through the assessment boundary <u>for each energy carrier</u> (*cr*) required to meet the energy demand of considered uses and to generate the exported energy,
3. calculate the **delivered annual final energy demand per useful floor area** $E_{del,calc}$ in **kWh/(m²y)** to the building site by summing up the calculated annual delivered energy for each energy carrier (*cr*) (from step 2) and then dividing by useful floor area.

EN 15603:2008 Energy performance of buildings – Overall energy use and definition of energy ratings

EN ISO 52000-1 Energy performance of buildings – Overarching EPB assessment – Part 1: General framework and procedures

	Calculated (asset) assessment method for calculating the net delivered annual final energy demand per useful floor area: 1. calculate energy needs (e.g., for space heating, cooling, domestic hot water preparation), 2. calculate annual delivered energy to the building site through the assessment boundary for each energy carrier (cr) required to meet the energy demand of considered uses and to generate the exported energy, 3. calculate the total annual delivered final energy demand to the building site by summing up calculated annual delivered energy for each energy carrier (cr) (from step 2), 4. calculate annual exported energy from the building site through the assessment boundary for each energy carrier (cr), 5. calculate the total annual exported energy from the building site by summing up calculated annual exported energy for each energy carrier (cr) (from step 4), 6. calculate the **net delivered annual final energy demand** per useful floor area $E_{del,net,calc}$ in kWh/(m^{2}y) by subtracting the total annual exported energy from the total annual delivered energy and then dividing by useful floor area. **Measured (operational) assessment method - delivered annual final energy demand per useful floor area:** 1. measure annual delivered energy to the building site through the assessment boundary for each energy carrier (*cr*) required to meet the energy demand of considered uses and to generate the exported energy, 2. calculate the **delivered annual final energy demand per useful floor area $E_{del,meas}$** in **kWh/(m^{2}y)** to the building site by summing up measured annual delivered energy for each energy carrier (*cr*) (from step 1) and then dividing by useful floor area. **Measured (operational) assessment method – net delivered annual final energy demand per useful floor area:** 1. measure annual delivered energy to the building site through the assessment boundary for each energy carrier (*cr*) required to meet the energy demand of considered uses and to generate the exported energy, 2. calculate the total annual delivered energy to the building site by summing up measured annual delivered energy for each energy carrier *(cr)* (from step 1), 3. measure annual exported energy from the building site through the assessment boundary for each energy carrier (*cr*), 4. calculate the total annual exported energy from the building site by summing up measured annual exported energy for each energy carrier (*cr*) (from step 3), 5. calculate the **net delivered annual final energy demand per useful floor area $E_{del,net,meas}$** in **kWh/(m^{2}y)** by subtracting the total annual exported energy from the total annual delivered energy and then dividing by useful floor area.
Calculation method /Assessment approach	A building generally uses more than one energy carrier delivered to the technical building system through the assessment boundary to satisfy the energy performance of buildings services (EPB services). Amounts of all energy carriers need to be aggregated using the same units (kWh). Energy carriers can be used for covering: • EPB services, • non-EPB services.

	The quantities of fuels used as energy carriers (e.g., liquid fuels, solid fuels, etc.), which are sometimes expressed in various units (e.g., Liters, kg, stacked m^3, bulk m^3), need to be expressed in kWh by multiplying the amount of fuel by its gross calorific value. Delivered energy can be expressed based on gross or net calorific values. The choice between net and gross calorific value shall be maintained without mixing net and gross values. The following table gives the conversion factors between net and gross calorific values. <table><tr><th>Energy carrier</th><th>Conversion factor $f_{GCV/NCV}$</th></tr><tr><td>Oil</td><td>1,06</td></tr><tr><td>Gas</td><td>1,11</td></tr><tr><td>LPG</td><td>1,09</td></tr><tr><td>Coal</td><td>1,04</td></tr><tr><td>Lignite</td><td>1,08</td></tr><tr><td>Wood</td><td>1,08</td></tr></table>**Calculated (asset) assessment method** The calculation direction goes from the needs (for space heating/cooling, domestic hot water preparation) to the delivered energy. **Calculated delivered annual final energy demand per useful floor area** for EPB services $\boldsymbol{E_{del,calc}}$ in **kWh/(m².a)** through the assessment boundary required to meet the energy demand of considered uses and to generate the exported energy: $$E_{del,calc} = \frac{\sum E_{del,cr,calc}}{A_{use}}$$ where: $E_{del,cr,calc}$ is the calculated annual delivered energy for energy carrier (*cr*) [kWh/a] A_{use} – is the useful floor area [m²] **Calculated net delivered annual final energy demand per useful floor area** for EPB services $\boldsymbol{E_{del,net,calc}}$ in **kWh/(m².a)** through the assessment boundary: $$E_{del,net,calc} = \frac{\sum E_{del,cr,calc} - \sum E_{exp,cr,calc}}{A_{use}}$$ where: $E_{del,cr,calc}$ is the calculated annual delivered energy for energy carrier (*cr*) [kWh/a] $E_{exp,cr,calc}$ is the calculated annual exported energy for energy carrier (*cr*) [kWh/a] A_{use} – is the useful floor area [m²] **Measured (operational) assessment method** NOTE: The measured delivered annual final energy demand per useful floor area to meet the energy demand of considered EPB services $\boldsymbol{E_{del,meas}}$ in kWh/(m².a) to meet the energy demand of considered uses and to generate the exported energy is calculated in the same way as the calculated delivered annual final energy demand per useful floor area $E_{del,calc}$ in kWh/(m²y) using the measured delivered energy amount $E_{del;cr,meas}$ instead of the corresponding calculated amounts $E_{del;cr,calc.}$: $$E_{del,meas} = \frac{\sum E_{del,cr,meas}}{A_{use}}$$ where: $E_{del,cr,meas}$ is the measured annual delivered energy for energy carrier (*cr*) [kWh/a] A_{use} – is the useful floor area [m²]

	The measured net delivered annual final energy demand per useful floor area $\boldsymbol{E_{del,net.meas}}$ in kWh/(m²·a), required to meet the energy demand of considered EPB services, are calculated in the same way as the calculated net delivered annual final energy demand per useful floor area $E_{del,net,calc}$ in kWh/(m².a) <u>using the measured delivered and exported energy</u> amounts $E_{del;cr,meas}$ and $E_{exp;cr,meas}$ instead of the corresponding calculated amounts $E_{del;cr,calc}$ and $E_{exp;cr,calc}$: $E_{del,net,meas} = \frac{\sum E_{del,cr,meas} - \sum E_{exp,cr,meas}}{A_{use}}$ where: $E_{del,cr,meas}$ is the measured annual delivered energy for energy carrier (*cr*) [kWh/a] $E_{exp,cr,meas}$ is the measured annual exported energy for energy carrier (*cr*) [kWh/a] A_{use} – is the useful floor area [m²]
Data requirements	**Calculated (asset) assessment method** For the calculation of the **calculated delivered annual final energy demand per useful floor area $\boldsymbol{E_{del,calc}}$** in **kWh/(m².a)**, the following values are required: • $SE_{del,cr,calc}$ is the sum of all <u>calculated</u> annual delivered energy to the building site for energy carrier (*cr*) to meet the energy demand of considered uses and to generate the exported energy in [kWh/a] • A_K is useful floor area in [m²] For the calculation of the **calculated net delivered annual final energy demand per useful floor area $\boldsymbol{E_{del,net,calc}}$** in **kWh/(m².a)**, the following values are required: • $SE_{del,cr,calc}$ is the sum of all <u>calculated</u> annual delivered energy to the building site for energy carrier (*cr*) to meet the energy demand of considered uses and to generate the exported energy in [kWh/a] • $SE_{exp,cr,calc}$ is the sum of all <u>calculated</u> annual exported energy from the building site for energy carrier (*cr*) in [kWh/a] • A_K is useful floor area in [m²] **Measured (operational) assessment method** For the calculation of the **measured delivered annual final energy demand per useful floor area $\boldsymbol{E_{del,meas}}$** in **kWh/(m².a)**, the following values are required: • $SE_{del,cr,meas}$ is the sum of all <u>measured</u> annual delivered energy to the building site for energy carrier (*cr*) to meet the energy demand of considered uses and to generate the exported energy in [kWh/a] • A_{use} is useful floor area in [m²] For the calculation of the **measured net delivered annual final energy demand per useful floor area $\boldsymbol{E_{del,net,meas}}$** in **kWh/(m²y)**, the following values are required: • $SE_{del,cr,meas}$ is the sum of all <u>measured</u> annual delivered energy to the building site for energy carrier (*cr*) to meet the energy demand of considered uses and to generate the exported energy in [kWh/a] • $SE_{exp,cr,meas}$ is the sum of all <u>measured</u> annual exported energy from the building site for energy carrier (*cr*) in [kWh/a] A_{use} is useful floor area in [m²]

Assessors' required qualifications	The level of competence of the assessor must be in compliance with the competence levels defined in the CEN Workshop Agreement (CWA) of TRAIN4SUSTAIN, n° 17939 (October 2022).
Comparability	The results of this indicator are comparable between the buildings: • If the buildings are of the same building type, located in the same climatic zone, • If the same assessment methods (either calculated or measured) and subtypes are used, • if the same building services are considered when calculating this indicator.

3.2.2 Indicator 2 "Total annual primary energy demand per useful floor area"

Name	**Total annual primary energy demand per useful floor area**
Reference framework	Level(s) indicator 1.1: Use stage energy performance (Publication version 1.2 – July 2021)
Definition and description	**Primary energy** is the energy found in nature from renewable and non-renewable sources, which has not undergone any conversion or transformation process, such as sunlight, wind, biomass, coal, crude oil, natural gas, or uranium. The term total primary energy is used when both non-renewable and renewable sources are considered. This indicator measures the total energy performance of a building. The total primary energy takes into account the actual energy demand for the building itself and the energy needed to deliver this energy to the building, such as extraction, refining and transportation. Hence it provides a more holistic view of the energy performance of the building. The total primary energy is measured by assigning the correct primary energy factor per energy carrier to the actual metered or calculated energy that is consumed, to meet 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. <u>If energy is exported from the building, this should also be considered</u>. The primary energy use is calculated based on the quantities of energy carriers required and the primary energy factors associated with each energy carrier. It is important to differentiate between: • **Total** primary energy demand and • **Net** primary energy demand. **<u>The total primary energy demand</u>** is the energy found in nature and used <u>to satisfy the energy performance of buildings services (EPB services) or to produce the exported energy</u>. **The net primary energy demand** means subtracting any exported renewable primary energy from the total primary energy demand.
Objectives / Justification	The energy performance of a building expressed by a numeric indicator of primary energy in kWh/(m^2.yr), is included in the energy performance certificate (EPC) in order to make it possible for owners and tenants of the building or building unit to compare and assess its energy performance. This indicator represents the metric used for building energy ratings in most EU countries. Except for energy performance certificates (EPCs) a numeric indicator of primary energy is used to comply with minimum energy performance standards for existing buildings. Primary energy is also important for meeting mandatory regulations for new and renovated buildings. The goal is to reduce the overall energy consumption of buildings in all areas, considering the chain processes from the beginning.

<table>
<tr><td>Unit of measurement</td><td>Total annual primary energy demand per useful floor area E_{Ptot} in kWh/(m²·a) to satisfy the energy performance of buildings services (EPB services) or to produce the exported energy.
The total primary energy demand is calculated based on the quantities of energy carriers which can be calculated or measured.
Useful floor area A_{use} in [m²] for EPB assessments is the total internal floor area of a building where energy for space heating/cooling is consumed to condition the space measured up to the internal wall surfaces (see Table B.20 – Specifications of the useful floor area within the EN ISO 52000-1:2017). Useful floor area is used in EPCs for expressing annual energy (e.g., primary, delivered energy) and carbon emissions per unit of conditioned area.</td></tr>
<tr><td>System boundary</td><td>The system boundary is the building. Delivered and exported energy from or to the building are calculated or metered (measured) at the system boundary. Multiplying <u>total primary energy factors</u> with the delivered/exported energy to calculate total primary energy demand follows <u>outside the system</u> <u>boundary</u>.
<u>NOTE</u>: The system 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 distant sources, <u>the system boundary does not change</u>.</td></tr>
<tr><td>Certification case</td><td>1. New buildings after construction – new buildings 'as built' (<u>without long-term use data</u>)
In the case of new buildings after construction, only the calculated (asset) method can be applied to calculate this indicator.
2. Existing buildings in the use phase (<u>with long-term use data of at least three years</u>)
In the case of existing buildings in the use phase, both methods, calculated (asset) and measured (operational) methods can be applied for the calculation of this indicator.
3. Existing buildings after major renovation (<u>without long-term use data</u>)
In the case of existing buildings after major renovation, only the calculated (asset) method can be applied to calculate this indicator.</td></tr>
<tr><td>Scope</td><td>The scope of the indicator includes both residential and non-residential buildings with the following building services considered (default choices taken from Table B.18 of EN ISO 52000-1):
<table>
<tr><th rowspan="2">Building service (or EPB service)</th><th colspan="2">Building service considered in the calculation of indicator (Yes/No)</th></tr>
<tr><th>Residential buildings</th><th>Non-residential buildings</th></tr>
<tr><td>Heating</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Cooling</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Ventilation</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Humidification</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Dehumidification</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Domestic hot water</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Lighting</td><td>No</td><td>Yes</td></tr>
<tr><td>External lighting</td><td>No</td><td>No</td></tr>
<tr><td>People transport (e.g., elevators)</td><td>No</td><td>No</td></tr>
<tr><td>Appliances</td><td>No</td><td>No</td></tr>
<tr><td>Others</td><td>No</td><td>No</td></tr>
</table>
<u>NOTE</u>: When calculating this indicator, the building services considered must always be clearly declared if they differ from default choices.</td></tr>
<tr><td>Reference standards</td><td>The energy calculation method for energy performance available across the EU include:
• use of national or regional calculation methods and associated software tools (which must comply with Annex I of the EPBD) or</td></tr>
</table>

<table>
<tr>
<td></td>
<td>

- use of **calculation methods** compliant with the **EN ISO 52000** series and standards developed under mandate 480.

The majority of national or regional calculation methods are currently based on EN 15603[10] and its associated standards (EN 15316 series). It is anticipated that, over time, these methods will be updated to reflect the new EN ISO 52000-1[11] series.
According to EN ISO 52000, there are two types / methods of the energy performance of building assessment:

- calculated (asset rating method),
- measured (operational rating method).

The assessment type used (as defined by the EN ISO 52000 series) **should be reported in all cases** for the purposes of comparability.

<table>
<tr><th rowspan="2">Type</th><th rowspan="2">Sub-type</th><th colspan="3">Input data</th></tr>
<tr><th>Use</th><th>Climate</th><th>Building</th></tr>
<tr><td rowspan="3">Calculated (asset)</td><td>Design</td><td>Standard</td><td>Standard</td><td>Design</td></tr>
<tr><td>As built</td><td>Standard</td><td>Standard</td><td>Actual</td></tr>
<tr><td>Tailored</td><td colspan="3">Depending on purpose</td></tr>
<tr><td rowspan="3">Measured (operational)</td><td>Climate corrected</td><td>Actual</td><td>Corrected to standard</td><td>Actual</td></tr>
<tr><td>Use corrected</td><td>Corrected to standard</td><td>Actual</td><td>Actual</td></tr>
<tr><td>Standard</td><td>Corrected to standard</td><td>Corrected to standard</td><td>Actual</td></tr>
</table>

Energy performance of building assessment types

</td>
</tr>
<tr>
<td>Assessment protocol</td>
<td>

The total annual primary energy demand per useful floor area E_{Ptot} in **kWh/(m²·a)** to satisfy the energy performance of buildings services (EPB services) or to produce the exported energy represents the sum of non-renewable and renewable primary energy demand.

The net annual primary energy demand per useful floor area for energy performance of buildings services (EPB services) **$E_{Ptot,net}$**, in **kWh/(m².a)**, represents the total primary energy demand subtracted by the exported renewable primary energy demand.

</td>
</tr>
<tr>
<td>Calculation method / Assessment approach</td>
<td>

The total annual primary energy demand per useful floor area E_{Ptot} in **kWh/(m².a)** to satisfy the energy performance of buildings services (EPB services) or to produce the exported energy, represents the sum of non-renewable and renewable primary energy demand:

$$E_{Ptot} = E_{Pnren} + E_{Pren}$$

where:

E_{Pnren} - is non-renewable primary energy demand per useful floor area per year for EPB services [kWh/(m².a)] → see indicator (KPI 3) named *Non-renewable annual primary energy demand per useful floor area.*

E_{Pren} - is renewable primary energy demand per useful floor area per year for EPB services [kWh/(m².a)] → see indicator (KPI 5) named *Renewable annual primary energy demand per useful floor area.*

The formula used for calculating total primary energy demand is the same for both calculated (asset) and measured (operational) rating methods.

</td>
</tr>
</table>

EN 15603:2008 Energy performance of buildings – Overall energy use and definition of energy ratings

EN ISO 52000-1 Energy performance of buildings – Overarching EPB assessment – Part 1: General framework and procedures

	The net annual primary energy demand per useful floor area for EPB services ***E*Ptot,net**, in **kWh/(m².a)**, represents the total primary energy demand subtracted by the exported renewable primary energy demand: $E_{Ptot,net} = E_{Ptot} - E_{Pren,exp}$ E_{Ptot} - is the total annual primary energy demand per useful floor area to satisfy the EPB services or to produce the exported energy [kWh/(m².a)] $E_{Pren,exp}$ - is the exported renewable annual primary energy demand per useful floor area [kWh/(m².a)]
Data requirements	Data required for the calculation of **the <u>total</u> annual primary energy demand per useful floor area E_{Ptot}** in **kWh/(m².a)** to satisfy the EPB services or to produce the exported energy: • E_{Pnren} - is non-renewable primary energy demand per useful floor area per year for EPB services [kWh/(m².a)] → see indicator (KPI 3) named *Non-renewable annual primary energy demand per useful floor area for EPB services* **E_{Pnren}** in kWh/(m².a) • E_{Pren} - is renewable primary energy demand (on-site, nearby) per useful floor area per year for EPB services [kWh/(m².a)] → see indicator (KPI 5) named *Renewable annual primary energy demand (on-site, nearby) per useful floor area for EPB services* **E_{Pren}**, *in kWh/(m².a)* Data required for the calculation of **<u>net</u> primary energy demand per useful floor area per year** for EPB services **$E_{Ptot,net}$**, in **kWh/(m².a)**: • E_{Ptot} - is the total annual primary energy demand per useful floor area to satisfy the EPB services or to produce the exported energy [kWh/(m².a)] • $E_{Pren,exp}$ - is the exported renewable annual primary energy demand per useful floor area [kWh/(m².a)] Primary energy factors (total, non-renewable, renewable) are defined at a national level.
Assessors' required qualifications	The level of competence of the assessor must be in compliance with the competence levels defined in the CEN Workshop Agreement (CWA) of TRAIN4SUSTAIN, n° 17939 (October 2022).
Comparability	The results of this indicator are comparable between the buildings: • If the buildings are of the same building type, located in the same climatic zone, • If the same assessment methods (based on either calculated or measured delivered energy) and subtypes are used, • if the same building services are considered when calculating this indicator.

3.2.3 Indicator 3 "Non-renewable annual primary energy demand per useful floor area":

Name	**Non-renewable annual primary energy demand per useful floor area**
Reference framework	1.1 Level(s) indicator 1.1: Use stage energy performance (Publication version 1.2 – July 2021)
Definition and description	**Non-renewable primary energy** means energy from non-renewable sources which has not undergone any conversion or transformation process. The indicator uses non-renewable primary energy factors defined for different fuels to calculate the non-renewable primary energy demand based on the delivered final energy demand, which is obtained either through a calculation or from metered data.

<table>
<tr><td>Objectives /Justification</td><td>It is of utmost importance to reduce the EU's dependence on fossil fuels. Tracking non-renewable energy demand outside the assessment boundary is important to reduce the non-renewable primary energy use associated with the building's delivered energy for energy performance of buildings services (EPB services)_during the use stage. In addition, reporting on this indicator can provide useful insights on the building's total emissions of air pollutants to the ambient air.</td></tr>
<tr><td>Unit of measurement</td><td>Non-renewable annual primary energy demand per useful floor area for EPB services E_{Pnren} in kWh/(m²a)
Useful floor area A_{use} in [m²] for EPB assessments is the total internal floor area of a building where energy for space heating/cooling is consumed to condition the space measured up to the internal wall surfaces (see Table B.20 – Specifications of the useful floor area within the EN ISO 52000-1:2017). Useful floor area is used in EPCs for expressing annual energy (e.g., primary, delivered energy) and carbon emissions per unit of conditioned area.</td></tr>
<tr><td>System boundary</td><td>Delivered and exported energy are calculated or metered (measured) at the system boundary. Multiplying <u>non-renewable primary energy factors</u> with the delivered/exported energy to calculate non-renewable primary energy demand follows <u>outside the system boundary</u>.
NOTE: The system 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 distant sources, <u>the system boundary does not change</u>.</td></tr>
<tr><td>Certification case</td><td>1._New buildings after construction – new buildings 'as built' (<u>without long-term use data</u>)
In the case of new buildings after construction, only the calculated (asset) method can be applied for the calculation of this indicator.
2._Existing buildings in the use phase (<u>with long-term use data of at least three years</u>)
In the case of existing buildings in the use phase, both methods, calculated (asset) and measured (operational) methods can be applied for the calculation of this indicator.
3._Existing buildings after major renovation (<u>without long-term use data</u>)
In the case of existing buildings after major renovation, only the calculated (asset) method can be applied to calculate this indicator.</td></tr>
<tr><td>Scope</td><td>The scope of the indicator includes both residential and non-residential buildings with the following building services considered (default choices taken from Table B.18 of EN ISO 52000-1):
<table>
<tr><td rowspan="2">Building service
(or EPB service)</td><td colspan="2">Building service considered in the calculation of indicator (Yes/No)</td></tr>
<tr><td>Residential buildings</td><td>Non-residential buildings</td></tr>
<tr><td>Heating</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Cooling</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Ventilation</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Humidification</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Dehumidification</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Domestic hot water</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Lighting</td><td>No</td><td>Yes</td></tr>
<tr><td>External lighting</td><td>No</td><td>No</td></tr>
<tr><td>People transport (e.g., elevators)</td><td>No</td><td>No</td></tr>
<tr><td>Appliances</td><td>No</td><td>No</td></tr>
<tr><td>Others</td><td>No</td><td>No</td></tr>
</table>
<u>NOTE</u>: When calculating this indicator, the building services considered must always be clearly declared if they differ from default choices.</td></tr>
</table>

<table>
<tr>
<td>Reference standards</td>
<td>
The energy calculation method for energy performance available across the EU include:

use of national or regional calculation methods and associated software tools (which must comply with Annex I of the EPBD) or
use of calculation methods compliant with the EN ISO 52000 series and standards developed under mandate 480.

The majority of national or regional calculation methods are currently based on EN 15603[12] and its associated standards (EN 15316 series). It is anticipated that, over time, these methods will be updated to reflect the new EN ISO 52000-1[13] series.
According to EN ISO 52000, there are two types/methods of the energy performance of building assessment:

calculated (asset rating method),
measured (operational rating method).

The assessment type used (as defined by the EN ISO 52000 series) should be reported in all cases for the purposes of comparability.
<table>
<tr><th rowspan="2">Type</th><th rowspan="2">Sub-type</th><th colspan="3">Input data</th></tr>
<tr><th>Use</th><th>Climate</th><th>Building</th></tr>
<tr><td rowspan="3">Calculated (asset)</td><td>Design</td><td>Standard</td><td>Standard</td><td>Design</td></tr>
<tr><td>As built</td><td>Standard</td><td>Standard</td><td>Actual</td></tr>
<tr><td>Tailored</td><td colspan="3">Depending on purpose</td></tr>
<tr><td rowspan="3">Measured (operational)</td><td>Climate corrected</td><td>Actual</td><td>Corrected to standard</td><td>Actual</td></tr>
<tr><td>Use corrected</td><td>Corrected to standard</td><td>Actual</td><td>Actual</td></tr>
<tr><td>Standard</td><td>Corrected to standard</td><td>Corrected to standard</td><td>Actual</td></tr>
</table>
Energy performance of building assessment types
</td>
</tr>
<tr>
<td>Assessment protocol</td>
<td>Non-renewable primary energy demand represents delivered energy plus losses related to the whole energy chain outside the assessment boundary. The non-renewable primary energy demand is calculated based on the delivered quantities of non-renewable energy carriers and the non-renewable primary energy factors for each non-renewable energy carrier.
Non-renewable energy carrier/s is/are delivered to the technical building system as delivered final energy and multiplied by the non-renewable primary energy factor to calculate non-renewable primary energy demand.
Non-renewable primary energy factors account for any losses and inefficiencies outside the assessment boundary.
<u>NOTE</u>: Delivered final energy can be <u>calculated</u> for defined energy uses or it can be <u>measured</u>. See indicator (KPI 1) named delivered annual final energy demand per useful floor area E_{del} in kWh/(m^2y)</td>
</tr>
<tr>
<td>Calculation method /Assessment approach</td>
<td>The formula for calculating non-renewable primary energy demand is the same for both the calculated (asset) and measured (operational) assessment methods.
The calculated non-renewable primary energy demand is calculated using the calculated amounts of delivered energy carriers, whereas the measured non-renewable primary energy demand is calculated using the measured amounts of delivered energy carriers instead of calculated ones.</td>
</tr>
</table>

EN 15603:2008 Energy performance of buildings – Overall energy use and definition of energy ratings

EN ISO 52000-1 Energy performance of buildings – Overarching EPB assessment – Part 1: General framework and procedures

Calculated (asset) assessment method

Non-renewable annual primary energy demand per useful floor area for EPB services E_{Pnren} in **kWh/(m²y)** is calculated by multiplying <u>calculated delivered energy</u> for each energy carrier (*cr*) with the <u>non-renewable primary energy factors</u> corresponding to each energy carrier and then dividing by useful floor area:

$$E_{Pnren} = \frac{\sum\left(E_{del,cr,calc} \cdot f_{Pnren,del,cr}\right)}{A_{use}}$$

where:

$E_{del;cr,calc}$ – is the calculated annual delivered energy for energy carrier (*cr*) [kWh/y]

$f_{Pnren:del;cr}$ – non-renewable primary energy factor for the delivered energy carrier (*cr*) [–]

A_{use} – useful floor area [m²]

Format for reporting the results of an assessment using the calculation method:

Building service	***Energy need***	***System efficiency*** [1]	***Energy carrier*** [2]	***Delivered energy per energy carrier***	***Non renewable primary energy factor*** [3]	
	kWh/yr	Decimal	Free text	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						

Measured (operational) assessment method

Non-renewable annual primary energy demand per useful floor area for EPB services E_{Pnren} in **kWh/(m²y)** is calculated by multiplying <u>measured delivered energy</u> for each energy carrier (*cr*) with the <u>non-renewable primary energy factors</u> corresponding to each energy carrier and then dividing by useful floor area:

$$E_{Pnren} = \frac{\sum\left(E_{del,cr,meas} \cdot f_{Pnren,del,cr}\right)}{A_{use}}$$

where:

$E_{del,cr,meas}$ – is the measured annual delivered energy for energy carrier (*cr*) [kWh/y]

$f_{Pnren,del;cr}$ – non-renewable primary energy factor for the delivered energy carrier (*cr*) [–]

A_{use} – useful floor area [m²]

Format for reporting the results of an assessment using the measured (operational) assessment method:

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

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.

Data requirements	**Calculated (asset) assessment method** For the calculation of the **non-renewable annual primary energy demand per useful floor area** for EPB services $\boldsymbol{E_{Pnren}}$ in **kWh/(m²y)** the following values are required: • $E_{del,cr,calc}$ – the calculated annual delivered energy for energy carrier (*cr*) [kWh/y] • $f_{Pnren,del,cr}$ – non-renewable primary energy factor for the delivered energy carrier (*cr*) [–] • A_{use} – useful floor area [m²] **Measured (operational) assessment method** For the calculation of the **non-renewable annual primary energy demand per useful floor area** for EPB services $\boldsymbol{E_{Pnren}}$ in **kWh/(m²y)** the following values are required: • $E_{del,cr,meas}$ – is the measured annual delivered energy for energy carrier (*cr*) [kWh/y] • $f_{Pnren,del,cr}$ – non-renewable primary energy factor for the delivered energy carrier (*cr*) [–] • A_{use} – useful floor area [m²]
Assessors' required qualifications	The level of competence of the assessor must be in compliance with the competence levels defined in the CEN Workshop Agreement (CWA) of TRAIN4SUSTAIN, n° 17939 (October 2022).
Comparability	The results of this indicator are comparable between the buildings: • If the buildings are of the same building type, located in the same climatic zone, • If the same assessment methods (either calculated or measured) and subtypes are used, • if the same perimeters (on-site, nearby, distant) are used when calculating this indicator, • if the same building services are considered when calculating this indicator.

3.2.4 Indicator 4 "Embodied energy"

Name	Embodied energy
Reference framework	EN 15978, Sustainability of construction works - Assessment of environmental performance of buildings – Calculation method (2011) (under revision in 2022-2023)
Definition and description	**The part of the EN 15978 indicator "Total use of non-renewable primary energy resources" limited to the life cycle of products** is frequently called **embodied energy** and is a commonly specified environmental impact indicator used in Life Cycle Assessment. Note: This indicator is not as such among the EN 15978 tables of indicators, it is a sub-indicator. This indicator measures the embodied non-renewable primary energy of materials, products and services used for the building construction, its service life, until its end-of-life, considering the life cycle of these materials, products, and services. According to **ISO 6707-3:2022** (Buildings and civil engineering works - Vocabulary - Part 3: Sustainability terms), **embodied energy** is defined as follows: "*total of all the energy used in the processes associated with the extraction, production, transportation, installation, use, refurbishment, replacement and disposal at the end of life of products and services, but excluding the energy used for operation*". So, embodied energy is not limited to the "cradle-to-gate" perimeter of products life cycle, but it includes all the processes until their end-of-life. It supposes to have an EPD database compliant with **EN 15804:2012+A2:2019**, but in certain countries, environmental product data is limited to "cradle-to-gate". Embodied energy considers all the products during the reference study period of the building (RSP, 50 years by default), including the initial construction and the replacement of products having a service life shorter than the RSP.
Objectives /Justification	This indicator intends to promote construction products and services with low embodied energy over their life cycle. Embodied energy refers to the non-renewable primary energy resources for manufacturing the products or services used in the project, for the initial construction or renovation, and during its lifetime (replacements), for the transportation to the site, construction, maintenance, and for the removal and disposal or recycling of materials, and restoration of the site at the end of its life. An energy optimum can be calculated, associating building-scale embodied energy and operational energy on a certain horizon of time.
Unit of measurement	kWh / m^2 or MJ (net calorific value) The EN 15978 standard mentions MJ for all energy indicators, but for ensuring homogeneity with the other energy KPIs, it is preferable to use kWh / m^2 (per useful floor area and for building RSP = 50 years). *RSP = reference study period*
System boundary	All the construction elements are theoretically considered: from foundations to finishings. The **minimum scope / perimeter** of the indicator includes the following building parts and elements:

Building parts	Related building elements
Shell (substructure and superstructure)	
Foundations (substructure)	• Piles • Basements • Retaining walls
Load-bearing structural frame	• Frame (beams, columns, and slabs) • Upper floors • External walls • Balconies
Non-load bearing elements	• Ground floor slab • Internal walls • Partitions and doors • Stairs and ramps
Facades	• External wall systems • Cladding and shading devices • Façade openings (including windows and external doors) • External paints, coatings, and renders
Roof	• Structure • Weatherproofing
Parking facilities	• Above ground and underground

The elements defined in Level(s), including also technical services / equipment, and external works on the plot of land, should be included, and if not, replaced by default values.

The boundary for calculating this indicator covers the "cradle to grave" processes (raw materials extraction, transport to manufacturing facilities and manufacturing processes), for all the construction materials, products, components, and services used in the construction of the building, its service life and end-of-life. The rules for determining their impacts and aspects are defined in EN 15804 and EN 15978.

Theoretically, the full life cycle of the building and its immediate surroundings on its site (curtilage), including all the components, have to be considered. Are excluded: operational energy use (B6), operational water use (B7) and building related users' activities not covered in B1-B7 modules (B8).

If module D exists for products in terms of embodied energy, module D1 captures net embodied energy beyond the system boundary and must be reported separately as additional information.

Transparency and details are recommended in result presentation, in order to facilitate results understanding and comparability.

Certification case

1. **New buildings after construction – new buildings 'as built'** (<u>without long-term use data</u>)

   In the case of new buildings after construction, the indicator must be calculated considering all the materials used for the building construction, and potential replacements of products in the future. It may be useful, according to the objective of the assessment, to separate results for the initial building construction and for the building service life .

	2. **Existing buildings in the use phase** (with long-term use data of at least three years) In the case of existing buildings in the use phase, this indicator is not applicable because the existing data for old materials used for the building construction, components and transport are unreliable, and there is often a lack of information on the actual embodied material. 3. **Existing buildings after major renovation** (without long-term use data) In the case of existing buildings after major renovation, the indicator must be calculated considering the life cycle of materials, products and services newly installed for their renovation. For those retained in-situ, pre-existent processes are ignored, while future processes are considered. For removed existing elements, only the end-of-life and module D are included. The future replacements of products, etc., during the reference study period (RSP) after renovation, should be included (to be checked / updated after EN 15978 revision). Note : Different approaches or methods might be used for this 3rd case. The chosen one should be clearly identified/described.
Scope	Both **residential** and **non-residential** buildings. This indicator supposes a good knowledge of construction products and services attached to the building. So, it is adapted to **new** construction and to **recently renovated** buildings.
Reference standards	**EN 15978** Sustainability of construction works - Assessment of environmental performance of buildings – Calculation method (November 2011) (under revision in 2022-2023) **EN 15804:2012+A2:2019**, Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products
Assessment protocol	Embodied energy is obtained through a **calculation process,** not a measurement process. The starting point is the compilation of a precise, strutured and if possible exhaustive **Bill of Quantities** (**BoQ**) which specifies the elements of a building (e.g., foundations, columns, etc. until finishes), with their quantities (mass, volume, dimensions…), lifespans and replacement rates. Then **the assessment protocol differs according to the existence or not of a national EPD database**, leading to 2 assessment methods. **Method 1** is based on the compilation of a Bill of Materials (**BoM**), drawn from the BoQ. The BoM describes a mass-based inventory of the different materials (kg) (e.g., concrete, steel, aluminium) contained in the various building elements. **Method 2** is using **EPDs** (environmental product declarations) compliant with **EN 15804**, to be associated with the **BoQ** and replacement numbers.
Calculation method / Assessment approach	According to the existence or not of a national database of EPDs of construction products with sufficient data quality and availability, the calculation method is based on a Bill of Materials (BoM) (method 1) or based on EPDs compliant with EN 15804 (method 2). **Method 1 - Use of a Bill of Materials** (see Level(s) framework) The following steps should be followed to compile the BoM: • Compile the Bill of Quantities: A BoQ comprises the building elements accounting for at least 99% of the mass of the building.

	• Identify the basic components of each building element. A breakdown of its constituent materials has to be carried out. The mass of each constituent material has to be determined. • Aggregation by material: The mass for each constituent material should thereafter be aggregated to obtain the total mass for each type of material. • Once the BoM has been compiled, it is possible to calculate the indicator associating to each constituent material the relative embodied primary non-renewable energy by multiplying the specific mass (i.e., kg) with its corresponding embodied energy coefficient (i.e., MJ/kg or kWh/kg). • The results are then aggregated at the building scale. • A reporting format with sufficient detailed interim figures is recommended. **Method 2 - Use of a database of EPDs compliant with EN 15804** (calculation at the building scale, compliant with EN 15978) • Compile the Bill of Quantities: A BoQ comprises the building elements accounting for at least 99% of the mass of the building. • Identify in the database the EPDs corresponding to the products put in place. • Estimate the number of replacements of each product during the RSP (reference study period = 50 years) • Take the primary non-renewable energy indicator • Multiply the quantities and the value of the primary non-renewable energy for each product • Aggregate at the scale of the building, keeping available interim results (e.g. per life cycle module and per family of products)
Data requirements	**Data source:** - Building project documents, especially the Bill of Quantities - Bill of Materials (for method 1) - EPDs database (for method 2) - Embodied energy coefficients for all materials (method 1) - Realistic products service lives (for both) **Data quality:** - See data quality requirements of the European Level(s) framework - Refer to **prEN 15941** Data quality (formal vote in september-november 2023)
Assessors' required qualifications	The level of competence of the assessor must be in compliance with the competence levels defined in the CEN Workshop Agreement (CWA) of TRAIN4SUSTAIN, n° 17939 (october 2022).
Comparability	The results of this indicator are comparable between the buildings: • If the buildings are of the same building category, located in the same climatic zone, • If the same life cycle modules are taken into account, • If the same method is used (1 or 2) • If the data quality and the completeness of building description are comparable

3.2.5 Indicator 5 "Renewable annual primary energy demand per useful floor area"

Name	**Renewable annual primary energy demand per useful floor area**

Reference framework	Level(s) indicator 1.1: Use stage energy performance (Publication version 1.2 – July 2021)
Definition and description	**Renewable primary energy** means energy from renewable non-fossil sources (e.g., wind, solar thermal and solar photovoltaic, geothermal energy, ambient energy, tide, wave, hydropower, biomass, biogas, etc.) which has not undergone any conversion or transformation process. Renewable energy can be produced: • On-site (e.g., PV panels, wind turbines, solar panels on the building roofs, heat pumps located on the building site) • Nearby (e.g., renewable energy from district heating systems, PV panels, solar panels, wind turbines) • Distant (e.g., renewable electricity from the electricity grid, PV panels, solar, panels, wind turbines) It is noteworthy that PV or solar panels can be counted as onsite, nearby, or distant energy sources, depending on where the panels are located relative to the building. The same goes for wind turbines. To avoid double-counting of renewable energy it is important to denote renewable primary energy demand with subscript following the chosen perimeters: $E_{Pren,onst}$ – renewable primary energy demand produced on-site $E_{Pren,nrby}$ – renewable primary energy demand produced nearby $E_{Pren,dist}$ – renewable primary energy demand produced distant
Objectives /Justification	The objective of energy-efficient buildings is to cover the building's energy demand with renewable energy sources. The energy demand is commonly expressed with the primary energy demand in kWh/(m²y). Tracking renewable primary energy demand is important to incentive the consumption and production of renewable energy.
Unit of measurement	**Renewable annual primary energy demand per useful floor area** for energy performance of buildings services (EPB services) E_{Pren} in **kWh/(m²y)** **Useful floor area** A_{use} in [m²] for EPB assessments is the total internal floor area of a building where energy for space heating/cooling is consumed to condition the space measured up to the internal wall surfaces (see Table B.20 – Specifications of the useful floor area within the EN ISO 52000-1:2017). Useful floor area is used in EPCs for expressing annual energy (e.g., primary, delivered energy) and carbon emissions per unit of conditioned area.
System boundary	Delivered and exported energy are calculated or metered (measured) at the system (or assessment) boundary. Multiplying renewable primary energy factors with the delivered/exported energy to calculate renewable primary energy demand follows outside the system boundary. Also, it is noteworthy that for example, PV panels installed on the roof of the building for the on-site renewable energy production, are considered as outside the system boundary. Consequently, electricity produced is considered as delivered energy, because it has to cross the system boundary before it reaches the technical building system. NOTE: The system 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 distant sources, the assessment boundary does not change.
Certification case	1. **New buildings after construction – new buildings 'as built'** (without long-term use data) In the case of new buildings after construction, only the calculated (asset) method can be applied to calculate this indicator. 2. **Existing buildings in the use phase** (with long-term use data of at least three years) In the case of existing buildings in the use phase, both methods, calculated (asset) and measured (operational) methods can be applied for the calculation of this indicator.

<table>
<tr><td></td><td>3. Existing buildings after major renovation (<u>without long-term use data</u>)
In the case of existing buildings after major renovation, only the calculated (asset) method can be applied to calculate this indicator.</td></tr>
<tr><td>Scope</td><td>The scope of the indicator includes both residential and non-residential buildings with the following building services considered (default choices taken from Table B.18 of EN ISO 52000-1):
<table>
<tr><th rowspan="2">Building service
(or EPB service)</th><th colspan="2">Building service considered in the calculation of indicator (Yes/No)</th></tr>
<tr><th>Residential buildings</th><th>Non-residential buildings</th></tr>
<tr><td>Heating</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Cooling</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Ventilation</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Humidification</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Dehumidification</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Domestic hot water</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Lighting</td><td>No</td><td>Yes</td></tr>
<tr><td>External lighting</td><td>No</td><td>No</td></tr>
<tr><td>People transport (e.g., elevators)</td><td>No</td><td>No</td></tr>
<tr><td>Appliances</td><td>No</td><td>No</td></tr>
<tr><td>Others</td><td>No</td><td>No</td></tr>
</table>
<u>NOTE</u>: When calculating this indicator, the building services considered must always be clearly declared if they differ from default choices.</td></tr>
<tr><td>Reference standards</td><td>The energy calculation method for energy performance available across the EU include:

use of national or regional calculation methods and associated software tools (which must comply with Annex I of the EPBD) or
use of calculation methods compliant with the EN ISO 52000 series and standards developed under mandate 480.

The majority of national or regional calculation methods are currently based on EN 15603[14] and its associated standards (EN 15316 series). It is anticipated that, over time, these methods will be updated to reflect the new EN ISO 52000-115 series.
According to EN ISO 52000, there are two types/methods of the energy performance of building assessment:

calculated (asset) assessment method,
measured (operational) assessment method.

The assessment type used (as defined by the EN ISO 52000 series) should be reported in all cases for the purposes of comparability.</td></tr>
</table>

EN 15603:2008 Energy performance of buildings – Overall energy use and definition of energy ratings

EN ISO 52000-1 Energy performance of buildings – Overarching EPB assessment – Part 1: General framework and procedures

Type	Sub-type	Input data		
		Use	Climate	Building
Calculated (asset)	Design	Standard	Standard	Design
	As built	Standard	Standard	Actual
	Tailored	Depending on purpose		
Measured (operational)	Climate corrected	Actual	Corrected to standard	Actual
	Use corrected	Corrected to standard	Actual	Actual
	Standard	Corrected to standard	Corrected to standard	Actual

Energy performance of building assessment types

Assessment protocol

The renewable primary energy demand is calculated by multiplying the delivered quantities of renewable energy carriers with the renewable primary energy factors for each renewable energy carrier.

Calculation method / Assessment approach

The formula for calculating renewable annual primary energy demand per useful floor area is the same for both calculated (asset) and measured (operational) assessment methods.
The calculated renewable primary energy demand is based on the calculated amounts of delivered energy carriers, whereas the measured renewable primary energy demand is calculated using the measured amounts of delivered energy carriers.

Calculated (asset) assessment method
Renewable annual primary energy demand per useful floor area for EPB services E_{Pren} in **kWh/(m²y)** is calculated by multiplying the calculated annual delivered energy for each energy carrier (*cr*) with the renewable primary energy factors corresponding to each energy carrier and then dividing by useful floor area:

$$E_{\text{Pren}} = \frac{\sum \left(E_{\text{del},cr,\text{calc}} \cdot f_{\text{Pren,del},cr} \right)}{A_{\text{use}}}$$

where:

$E_{del,cr,calc}$ is the calculated annual delivered energy for energy carrier (*cr*) [kWh/a]
$f_{Pren,del,cr}$ – renewable primary energy factor for the delivered energy carrier (*cr*) [–]
A_{use} – useful floor area [m²]

Format for reporting the results of an assessment using calculation method:

	Building service	***Energy need***	***System efficiency*** [1]	***Energy carrier*** [2]	***Delivered energy per energy carrier***	***Renewable primary energy factor*** [3]	
		kWh/yr	Decimal	Free text	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						
	Measured (operational) assessment method **Renewable annual primary energy demand per useful floor area** for EPB services ***E*****Pren** in **kWh/(m²y)** is calculated by multiplying measured annual delivered energy for each energy carrier (*cr*) with the renewable primary energy factors corresponding to each energy carrier and then dividing by useful floor area: $E_{\mathrm{Pren}} = \frac{\sum\left(E_{\mathrm{del},cr,\mathrm{meas}} \cdot f_{\mathrm{Pren,del},cr}\right)}{A_{\mathrm{use}}}$ where: $E_{\mathrm{del},cr,\mathrm{meas}}$ is the measured annual delivered energy for energy carrier (*cr*) [kWh/a] $f_{\mathrm{Pren,del},cr}$ – renewable primary energy factor for the delivered energy carrier (*cr*) [–] A_{use} – useful floor area [m²] Format for reporting the results of an assessment using the measured (operational) assessment method:						

<table>
<tr>
<td></td>
<td>
<table>
<tr><th>Building service</th><th>Energy carrier [1]</th><th>Delivered energy per energy carrier</th><th colspan="2">Renewable primary energy factor [2]</th></tr>
<tr><td></td><td>Free text</td><td>kWh/yr</td><td>Decimal factor</td><td>kWh/yr</td></tr>
<tr><td>Heating</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Cooling</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Ventilation</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Hot water</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Lighting</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Other (please specify) [3]</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Exported renewable energy [4]</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Total</td><td></td><td></td><td></td><td></td></tr>
</table>
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.
</td>
</tr>
<tr>
<td>Data requirements</td>
<td>
Calculated (asset) assessment method
For the calculation of the renewable annual primary energy demand per useful floor area for EPB services $\boldsymbol{E_{Pren}}$ in kWh/(m²y) the following values are required:

$E_{del,cr,calc}$ – the calculated annual delivered energy for energy carrier (cr) [kWh/y]
$f_{Pren:del;cr}$ – renewable primary energy factor for the delivered energy carrier (cr) [–]
A_{use} – useful floor area [m²]

Measured (operational) assessment method
For the calculation of the renewable annual primary energy demand per useful floor area for EPB services $\boldsymbol{E_{Pren}}$ in kWh/(m²y) the following values are required:

$E_{del,cr,meas}$ – the measured annual delivered energy for energy carrier (cr) [kWh/y]
$f_{Pren,del,cr}$ – renewable primary energy factor for the delivered energy carrier (cr) [–]
A_{use} – useful floor area [m²]

</td>
</tr>
<tr>
<td>Assessors' required qualifications</td>
<td>The level of competence of the assessor must be in compliance with the competence levels defined in the CEN Workshop Agreement (CWA) of TRAIN4SUSTAIN, n° 17939 (october 2022).</td>
</tr>
<tr>
<td>Comparability</td>
<td>
The results of this indicator are comparable between the buildings:

If the buildings are of the same building type, located in the same climatic zone,
If the renewable primary energy factors are the same for given energy carriers,

</td>
</tr>
</table>

	• If the same assessment methods (either calculated or measured) and subtypes are used, • if the same perimeters (on-site, nearby, distant) are used when calculating this indicator, • if the same building services are considered when calculating this indicator.

3.2.6 Indicator 6 “Renewable energy ratio (on-site, nearby)”

<table>
<tr><td>Name</td><td>Renewable energy ratio (on-site, nearby)</td></tr>
<tr><td>Reference framework</td><td>CESBA MED</td></tr>
<tr><td>Definition and description</td><td>Renewable energy ratio (on-site, nearby) is the ratio of the renewable primary energy demand produced on-site and nearby to the total primary energy demand. According to the EN ISO 52000-1, this KPI excludes distant produced primary energy demand.

<table>
<tr><th>Perimeter choice</th><th>Choice – RER calculation (renewable energy)</th><th>Choice – RER calculation (total energy)</th></tr>
<tr><td>On-site</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Nearby</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Distant</td><td>No</td><td>Yes</td></tr>
</table>
NOTE: When calculating this indicator, the perimeter choices must always be clearly declared if they differ from default choices.</td></tr>
<tr><td>Objectives /Justification</td><td>One main sustainability target within the European Union is to increase the share of renewable primary energy demand in total primary energy demand to lower the dependency of the EU on fossil energy sources and to reduce the greenhouse gas emissions caused by fossil energy sources.

This KPI aims to measure the share of renewable primary energy demand in total primary energy demand. Its tracking is important to maximise the use of renewable energy sources.

The renewable energy ratio RER states how much of total primary energy demand is marked as renewable primary energy.</td></tr>
<tr><td>Unit of measurement</td><td>Renewable energy ratio (on-site, nearby) $RER_{onst,nrby}$ in %</td></tr>
<tr><td>System boundary</td><td>Dividing the renewable primary energy demand with the total primary energy demand follows outside the assessment boundary.

NOTE: The system/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 distant sources, the assessment boundary does not change.</td></tr>
<tr><td>Certification case</td><td>1. New buildings after construction – new buildings ‘as built’ (without long-term use data)
In the case of new buildings after construction, only the calculated (asset) method can be applied to calculate this indicator.
2. Existing buildings in the use phase (with long-term use data of at least three years)
In the case of existing buildings in the use phase, both methods, calculated (asset) and measured (operational) methods can be applied for the calculation of this indicator.
3. Existing buildings after major renovation (without long-term use data)</td></tr>
</table>

<table>
<tr><td></td><td>In the case of existing buildings after major renovation, only the calculated (asset) method can be applied for the calculation of this indicator.</td></tr>
<tr><td>Scope</td><td>The scope of the indicator includes both residential and non-residential buildings with the following building services considered (informative default choices taken from Table B.18 of EN ISO 52000-1):
<table>
<tr><th rowspan="2">Building service (or EPB service)</th><th colspan="2">Building service considered in the calculation of indicator (Yes/No)</th></tr>
<tr><th>Residential buildings</th><th>Non-residential buildings</th></tr>
<tr><td>Heating</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Cooling</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Ventilation</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Humidification</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Dehumidification</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Domestic hot water</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Lighting</td><td>No</td><td>Yes</td></tr>
<tr><td>External lighting</td><td>No</td><td>No</td></tr>
<tr><td>People transport (e.g., elevators)</td><td>No</td><td>No</td></tr>
<tr><td>Appliances</td><td>No</td><td>No</td></tr>
<tr><td>Others</td><td>No</td><td>No</td></tr>
</table>
<u>NOTE</u>: When calculating this indicator, the building services considered must always be clearly declared if they differ from default choices.</td></tr>
<tr><td>Reference standards</td><td>The energy calculation method for energy performance available across the EU include:

use of national or regional calculation methods and associated software tools (which must comply with Annex I of the EPBD) or
use of calculation methods compliant with the EN ISO 52000 series and standards developed under mandate 480.

The majority of national or regional calculation methods are currently based on EN 15603[16] and its associated standards (EN 15316 series). It is anticipated that, over time, these methods will be updated to reflect the new EN ISO 52000-1[17] series.
According to EN ISO 52000, there are two types/methods of the energy performance of building assessment:

calculated (asset) rating method),
measured (operational) rating method.

The assessment type used (as defined by the EN ISO 52000 series) should be reported in all cases for the purposes of comparability.</td></tr>
</table>

EN 15603:2008 Energy performance of buildings – Overall energy use and definition of energy ratings

EN ISO 52000-1 Energy performance of buildings – Overarching EPB assessment – Part 1: General framework and procedures

<table>
<tr>
<td></td>
<td>
<table>
<tr><th rowspan="2">Type</th><th rowspan="2">Sub-type</th><th colspan="3">Input data</th></tr>
<tr><th>Use</th><th>Climate</th><th>Building</th></tr>
<tr><td rowspan="3">Calculated (asset)</td><td>Design</td><td>Standard</td><td>Standard</td><td>Design</td></tr>
<tr><td>As built</td><td>Standard</td><td>Standard</td><td>Actual</td></tr>
<tr><td>Tailored</td><td colspan="3">Depending on purpose</td></tr>
<tr><td rowspan="3">Measured (operational)</td><td>Climate corrected</td><td>Actual</td><td>Corrected to standard</td><td>Actual</td></tr>
<tr><td>Use corrected</td><td>Corrected to standard</td><td>Actual</td><td>Actual</td></tr>
<tr><td>Standard</td><td>Corrected to standard</td><td>Corrected to standard</td><td>Actual</td></tr>
</table>
Energy performance of building assessment types
</td>
</tr>
<tr>
<td>Assessment protocol</td>
<td>
Renewable energy ratio (on-site, nearby) $RER_{onst,nrby}$ in % is calculated by dividing the renewable annual primary energy demand per useful floor area for the purpose of RER calculation $E_{Pren,RER}$ in [kWh/(m²y)] with the total annual primary energy demand per useful floor area in [kWh/(m²y)] and then multiplying with 100.

In the case using calculated (asset) assessment method the renewable annual primary energy demand (on-site, nearby) per useful floor area for EPB services $E_{Pren,RER}$ in kWh/(m²y) is calculated using the calculated values of annual on-site and nearby delivered energy ($E_{del,cr,calc,onsite}$, $E_{del,cr,calc,nrby}$).

In the case using measured (operational) assessment method the renewable annual primary energy demand (on-site, nearby) per useful floor area for EPB services $E_{Pren,RER}$ in kWh/(m²y) is calculated using the measured values of annual on-site and nearby delivered energy ($E_{del,cr,meas,onsite}$, $E_{del,cr,meas,nrby}$).
</td>
</tr>
<tr>
<td>Calculation method / Assessment approach</td>
<td>
Calculated (asset) assessment method
The renewable energy ratio (onsite, nearby) $RER_{onst,nrby}$ in % is calculated by formula:
$$RER_{onst,nrby} = \frac{E_{Pren,onst,nrby}}{E_{Ptot}} \cdot 100$$
where:
E_{Ptot} – is the total annual primary energy demand per useful floor area <u>based on the calculated delivered energy</u> [kWh/(m²y)]
$E_{Pren,onst,nrby}$ – is the renewable annual primary energy demand per useful floor area in [kWh/(m²y)] for the purpose of RER calculation, including the on-site and the nearby produced renewable primary energy demand <u>based on the calculated renewable energy</u>.

Measured (operational) assessment method
The renewable energy ratio (onsite, nearby) $RER_{onst,nrby}$ in % is calculated by formula:
$$RER_{onst,nrby} = \frac{E_{Pren,onst,nrby}}{E_{Ptot}} \cdot 100$$
where:
E_{Ptot} – is the total primary annual energy demand per useful internal floor area <u>based on the measured delivered energy</u> [kWh/(m²y)]
$E_{Pren,onst,nrby}$ – is the renewable annual primary energy demand per useful floor area in [kWh/(m²y)]for the purpose of RER calculation, including the on-site and the nearby produced renewable primary energy demand <u>based on the measured renewable energy</u>.
</td>
</tr>
</table>

	NOTE: The renewable energy ratio $RER_{onst,nrby}$ cannot be calculated using measurement approach if the contribution of renewable sources (e.g., thermal solar contribution, heat captured by a heat pump from the environment) cannot be measured. The renewable energy ration $RER_{onst,nrby}$ can be calculated using the same above given formula based on measured value only in case all contributions of renewable sources are measured! NOTE: When calculating this indicator using either calculated or measured method, the calculated *RER* value must always be clearly denoted with subscript/s declaring which perimeter/s is/are considered: RER_{onst} – renewable energy ratio (on-site) [%] RER_{nrby} – renewable energy ratio (nearby) [%] $\boldsymbol{RER_{onst, nrby}}$ – renewable energy ratio (on-site, nearby) [%] → default choices according to EN ISO 52000-1 $RER_{onst, nrby, dist}$ – renewable energy ratio (on-site, nearby, and distant) [%]
Data requirements	**Calculated (asset) assessment method** For the calculation of the **renewable energy ratio (onsite, nearby)** $\boldsymbol{RER_{onst,nrby}}$ in % the following values are required: • E_{Ptot} – the total annual primary energy demand per useful floor area based on the calculated delivered energy [kWh/(m^{2}y)] • $E_{Pren,onst,nrby}$ – the renewable annual primary energy demand per useful floor area for the purpose of *RER* calculation, including the on-site and the nearby produced renewable primary energy demand based on the calculated renewable energy [kWh/(m^{2}y)] For the calculation of the renewable annual primary energy demand per useful floor area $\boldsymbol{E_{Pren,onst,nrby}}$ in [kWh/(m^{2}y)] the following values are required: • $E_{del,cr,calc,onsite}$ – the calculated annual on-site delivered energy for energy carrier (*cr*) [kWh/(m^{2}y)] • $E_{del,cr,calc,nrby}$ – the calculated annual nearby delivered energy for energy carrier (*cr*) [kWh/(m^{2}y)] • $f_{Pren,del,cr}$ – renewable primary energy factor for the delivered energy carrier (*cr*) [–] **Measured (operational) assessment method** For the calculation of the **renewable energy ratio (onsite, nearby)** $\boldsymbol{RER_{onst,nrby}}$ in % the following values are required: • E_{Ptot} – is the total annual primary energy demand per useful internal floor area based on the measured delivered energy [kWh/(m^{2}y)] • $E_{Pren,onst,nrby}$ – the renewable annual primary energy demand per useful floor area for the purpose of *RER* calculation, including the on-site and the nearby produced renewable primary energy demand based on the measured renewable energy [kWh/(m^{2}y)] For the calculation of the renewable annual primary energy demand per useful floor area $\boldsymbol{E_{Pren,onst,nrby}}$ in [kWh/(m^{2}y)] the following values are required: • $E_{del,cr,meas,onsite}$ is the measured annual on-site delivered energy for energy carrier (*cr*) [kWh/(m^{2}y)] • $E_{del,cr,meas,nrby}$ is the measured annual nearby delivered energy for energy carrier (*cr*) [kWh/(m^{2}y)] • $f_{Pren,del,cr}$ – renewable primary energy factor for the delivered energy carrier *cr* [–]
Assessors' required qualifications	The level of competence of the assessor must be in compliance with the competence levels defined in the CEN Workshop Agreement (CWA) of TRAIN4SUSTAIN, n° 17939 (october 2022).

Comparability	The results of this indicator are comparable between the buildings: • If the buildings are of the same building type, located in the same climatic zone, • If the same assessment methods (either calculated or measured) and subtypes are used, • if the same perimeters (on-site, nearby, distant) are used when calculating this indicator, • if the same building services are considered when calculating this indicator.

3.2.7 Indicator 7: "Annual use stage energy-related Global Warming Potential (GWP) "

Name	**Annual use stage energy-related Global Warming Potential (GWP)**
Reference framework	CESBA MED KPIs and passport – indicator C1.3 „Global Warming Potential" (D 3.4.2, oct. 2019)
Definition and description	This indicator gives a measurement of the quantity of greenhouse gases (GHG) of the building, emitted directly and indirectly during its use stage, due to energy consumption for a list of uses or services, knowing the energy sources / carriers involved. The variety of GHG are represented by the Global Warming Potential (GWP), which is an aggregated indicator using characterization factors for the radiative forcing impact of one mass-based unit of each greenhouse gas relative to that of CO_2, over a given period of time (100 years in general). GWP is supposed to represent the potential contribution of a system to the earth's global warming and the associated effects on climate change. The indicator is an **extension of indicator 1 "Delivered annual final energy demand per useful floor area"** in terms of GHG emissions. The knowledge of the energy sources/carriers linked to the flows of delivered final energy is necessary. Note : the GWP indicator is based on final energy, not on primary energy. Regarding the description form of indicator 1, attention in drawn on the following points: - only "delivered final energy" is considered here, without reduction due to exported energy, - delivered final energy can be calculated or measured, - in case of district heating or cooling, each network has its own official GHG emission factor.
Objectives / Justification	This indicator aims to quantify the contribution of use stage energy systems to Global Warming Potential. EPBD is clearly focused on the reduction of GHG emissions, and this indicator is essential in an Energy Performance Certificate. This indicator can measure progress towards EU climate objectives, which can be reached mainly by applying energy-efficient measures, using decarbonized energy sources, and adapting users' behaviour.
Unit of measurement	2 possibilities: - kg CO_2 eq. / m^2 useful internal floor area, for a reference study period (RSP) of 50 years - kg CO_2 eq. / (m^2.y) (per useful internal floor area and per year)

<table>
<tr><td>System boundary</td><td>The system boundary is the same as for indicator 1 "Delivered annual final energy demand per useful floor area", for consistency reasons.

Other systems than energy-related ones can contribute to use stage GWP as the provision of potable water, wastewater treatment or refrigerants leakage, but here they are <u>excluded</u> from the scope.</td></tr>
<tr><td>Certification case</td><td>1) New buildings: modelling and calculation at detailed design and construction stages, based on design study, and at as-built and in-use stages, based on what is actually installed.

2) Existing buildings (in use): GWP may be based on calculated or measured energy consumption.

3) Under major renovation buildings: modelling and calculation at detailed design and renovation work stages, based on design study, and at as-built and in-use stages, based on what is actually installed.</td></tr>
<tr><td>Scope</td><td>The scope includes both residential and non-residential buildings.

The building services (also called EPB services) considered are mentioned in the KPI 1 description form (table taken from Table B.18 of EN ISO 52000-1).

<table>
<tr><th rowspan="2">Building service
(or EPB service)</th><th colspan="2">Building service considered in the calculation of indicator (Yes/No)</th></tr>
<tr><th>Residential buildings</th><th>Non-residential buildings</th></tr>
<tr><td>Heating</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Cooling</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Ventilation</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Humidification</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Dehumidification</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Domestic hot water</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Lighting</td><td>No</td><td>Yes</td></tr>
<tr><td>External lighting</td><td>No</td><td>No</td></tr>
<tr><td>People transport (e.g., elevators)</td><td>No</td><td>No</td></tr>
<tr><td>Appliances</td><td>No</td><td>No</td></tr>
<tr><td>Others</td><td>No</td><td>No</td></tr>
</table>
<u>NOTE</u>: When calculating this indicator, the building services considered must always be clearly declared if they differ from default choices.</td></tr>
<tr><td>Reference standards</td><td>o ISO 14067 (Product Carbon Footprint)
o ISO 16745-1 (Carbon metric of an existing building during use stage)
o EN 15978-1 (Assessment of environmental performance of buildings - under revision in 2022 and 2023)
o EN 15804 :2012+A2:2019 (EPDs for construction products)</td></tr>
<tr><td>Assessment protocol</td><td>This indicator is the result of final energy consumption data, expressed per energy carrier, and per use for electricity, each of them multiplied by the corresponding GHG emission factor expressed in kg CO2eq/kWh, then summed up for all energy uses included in the scope and energy carriers.</td></tr>
<tr><td>Calculation method / Assessment approach</td><td><u>Calculation method:</u>

GWP linked to annual energy consumption: each type of energy flow is multiplied by an emission factor drawn from an official national database, and multiplied by the RSP (50 years), or kept per year, and divided by the useful floor area of the building.

It is assumed that emission factors are constant during the RSP, representing current situation.</td></tr>
</table>

	The indicator value (here called E) is calculated with the following formula (drawn from CESBA MED): $$E = \left[\sum (Q_{fuel,i} \times LHV_i \times k_{em,i}) + (Q_{el} \times k_{em,el}) + (Q_{dh} \times k_{em,dh})\right] \div S_u$$ With: $Q_{fuel,I}$ = annual quantity of i-th fuel (m^3 or Kg) Q_{el} = annual quantity of electrical energy from the grid (kWh) Q_{dh} = annual quantity of energy from district heating/cooling (kWh) LHV_i = lower heating value of the i-th fuel (kWh/m3 or kWh/Kg) $K_{em,i}$ = CO_2 eq. emission factor of the i-th fuel (Kg CO_2eq/kWh) $K_{em,i}$ = CO_2 eq. emission factor of the electrical energy from the grid (Kg CO_2eq/kWh) $K_{em,i}$ = CO_2 eq. emission factor of energy from district heating/cooling (Kg CO_2/kWh) S_u = useful internal floor area Assessment approach: During the design stage (new building or building under renovation) the indicator can't be calculated if the energy sources/carriers are not chosen yet. Results reporting: Transparency is required, and sub-indicators should be visible.
Data requirements	The necessary data are: • Final energy consumption per use and per energy carrier (from indicator KPI 1) • Emission factors for energy carriers For the electricity consumptions, it is important to distinguish use by use, because the emission factors generally differ according to the use, for instance heating, domestic hot water, cooling, etc., because the temporality or seasonality implies different combinations of energy sources, more or less carbon intensive. Note: The existence of a Building Logbook can facilitate data collection
Assessors' required qualifications	The level of competence of the assessor must be in compliance with the competence levels defined in the CEN Workshop Agreement (CWA) of TRAIN4SUSTAIN, n° 17939 (october 2022).
Comparability	The results of this indicator are comparable if: • The final energy figures coming from indicator KPI 1 respect its comparability conditions • the building type, its main functionalities and the conditions of use are the same (included in the "functional equivalent" of the building under assessment) • the climate is the same (in practice it often means buildings are located in the same urban or rural area) • the assessment boundaries are the same (spatial and temporal) • the area unit is the same (useful internal floor area) • the emissions factors per energy carrier is of the same (good) quality level • the main assumptions and scenarios are the same • the greenhouse gases taken into account are the same (at least for the significant ones) • the same standards and assessment methods are used • the assessments are made by trained/qualified assessors

3.2.8 Indicator 8 "Life Cycle Global Warming Potential (GWP)"

Name	Life Cycle Global Warming Potential (GWP).
Reference framework	Level(s) indicator 1.2 - Life cycle Global Warming Potential (GWP) (EC/JRC report version 1.1 - January 2021)
Definition and description	This indicator measures the building's contribution to the earth's global warming and the associated effects on climate change throughout its life cycle. The greenhouse gases (GHG) emitted through the different stages of the building life cycle, from the production of building materials to the end of the building's useful life and the subsequent demolition and recovery of the building material, are summed up. Global Warming Potential uses characterization factors describing the radiative forcing impact of one mass-based unit of each greenhouse gas relative to that of CO_2 over a given period of time (100 years in general).
Objectives / Justification	This indicator aims to quantify the <u>embodied</u> and <u>operational</u> Global Warming Potential contributions of a building along its life cycle. In recent and new buildings, considering the high energy performance achieved by regulated uses, the embodied GWP is higher than the operational. So, building design must consider low-carbon elements (construction products and technical services) on their life cycle (from cradle to grave). Combined with decarbonised energy sources for building operation, low-carbon elements contribute to the European Union climate objectives.
Unit of measurement	kg CO_2 eq. / m² useful internal floor area, for a reference study period (RSP) of 50 years.
System boundary	The assessment boundary is set at the building and its site (plot of land) including at least: - Shell (substructure and superstructure): foundations, load bearing structural frame, non-load bearing elements, façades, roof, parking facilities - Core: fittings and furnishings, in-built lighting system, energy system, ventilation system, sanitary system, other systems - External works: utilities, landscaping **Full life cycle**: from cradle to grave as defined in EN 15978, reported separately for: - product stage (A1-5), - use stage (B1-7), - end of life stage (C1-4) - additional benefits and loads (D). Note: The use stage includes: - B1: Use - B2: Maintenance - B3: Repair - B4: Replacement - B5: Refurbishment - B6: Operational energy use - B7: Operational water use <u>Note</u>: The part of the produced on-site energy that is <u>exported</u> outside the building is considered in module D. Results about module D shall be presented separately, because of different nature. For **major renovations** of existing buildings, the system boundary shall encompass all life cycle stages that relate to the extension of the building's

	service life (the stages relating to the original production (A1-3) and construction (A4-5) are ignored).
Certification case	1) **New buildings**: modelling and calculation at detailed design and construction stages, based on design study, and at as-built and in-use stages, based on what is actually installed. 2) **Existing buildings (in use)**: generally, embodied GWP is not applicable. But an assessment similar to new buildings is feasible if life cycle data on embodied GWP in the initial construction products are available (case of recently built buildings). For the use phase, GWP may be based on calculated or measured energy consumption. 3) **Under major renovation buildings**: without the original production and construction stages.
Scope	Residential and non-residential buildings
Reference standards	• EN 15804:2012+A2:2019, Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products • EN 15978-1, Sustainability of construction works – Methodology for the assessment of performance of buildings – Part 1: Environmental Performance (under revision in august 2022) • ISO 14040 and ISO 14044 • European Commission's Product Environmental Footprint (PEF) method • prEN 15941:2021, Sustainability of construction works - Data quality for environmental assessment of products and construction works - Selection and use of data (formal vote scheduled in autumn 2023) • ISO 15686-8:2008, Buildings and constructed assets – Service-life planning – Part 8: Reference service life and service-life estimation • Note: Environmental data sets for construction products which are compliant with EN 15804 (the latest version or the previous one) are much more numerous than those compliant with PEF method.
Assessment protocol	This protocol is defined step by step: 1. Defining the goal and intended use of the assessment, and the specification of the object of assessment (this preliminary information may be shared by all environmental indicators) 2. Selecting software tools and databases (compliant with EN 15978 and EN 15804) 3. Setting up the model of building adapted to the calculation process for life cycle GWP 4. Defining scenarios for the building life cycle 5. Data selection and quality check 6. Processing the data and assumptions using the LCA tool 7. Using the LCA tool to calculate the chosen environmental impacts (here GWP) 8. Interpretation of results, carrying out a hot spot analysis 9. *(optional)* Comparison of results with other buildings (paying attention to the comparability criteria listed hereafter) 10. *(optional)* Opportunity to improve the design so as to get a better result 11. Completing the reporting format with the results and main assumptions, together with a concise background report
Calculation method / Assessment approach	**Calculation method:** GWP is calculated as follows:

- Life cycle of products: linear combinations based on the bill of quantities for initial construction, the number of replacements, and the corresponding EPDs. Data gaps may be filled by conservative assumptions with average or generic data.
- GWP linked to energy and water consumption: each type of flow is multiplied by an emission factor drawn from an official national database, and multiplied by the RSP (50 years).

Assessment approach:
Ideally, all the life cycle stages of all elements present in the building and on its site, including necessary replacement of products during the RSP, must be included.
The cut-off rules described in EN 15804 for construction products shall be followed.

An alternative simplified method may consider incomplete life cycle, limited to:

- Product stage (A1-A3) (it corresponds to a "cradle-to-gate" assessment)
- Part of use stage (B4-B6)

Results: The results are to be reported separately for each life cycle stage (from A to D), as presented in the following table (extract from Level(s) user manual for indicator 1.2).

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

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

This way of reporting may accept, if LCA practice is not mature enough, only a part of results.

Data requirements

- Bill of quantities (complete and detailed)
- Lifespan of each product or element
- EPDs corresponding to products
- Generic or default data if specific EPDs are missing (so as to avoid empty boxes)
- Final energy consumption per energy carrier
- Water consumption
- Emission factors for energy carriers and for water (including pre- and post-use treatment)

Note: The existence of a Building Logbook can facilitate data collection

Assessors' required qualifications

The level of competence of the assessor must be in compliance with the competence levels defined in the CEN Workshop Agreement (CWA) of TRAIN4SUSTAIN, n°17939 (october 2022).

Comparability	The results of this indicator are comparable if: • the building type, its main functionalities and the conditions of use are the same (included in the "functional equivalent" of the building under assessment) • the reference study period is the same (included in the "functional equivalent") • the climate is the same (in practice it often means buildings are located in the same urban or rural area) • the assessment boundaries are the same (spatial and temporal) • the area unit is the same (useful internal floor area) • the quality and completeness of input data (e.g. bill of quantities, EPDs quality) is of the same (good) level • the main assumptions and scenarios are the same • the greenhouse gases taken into account are the same (at least for the significant ones) • the same standards and assessment methods are used • In case of renovation projects, the renovation level is similar (light, medium, deep), and the initial building state is close • the assessments are made by trained/qualified assessors

3.2.9 Indicator 9 "Percentage of time outside of thermal comfort range"

Name	**Percentage of time outside of thermal comfort range**
Reference framework	"Level(s) indicator 4.2: Time outside of thermal comfort range" (Publication version 1.1 – January 2021)
Definition and description	This indicator measures the percentage of the year when building occupiers are not comfortable with the thermal conditions inside a building. Thermal comfort is guaranteed when the indoor temperature in those spaces or zones that account for >10% of the total useful floor area of a building is within a range of 18°C to 27°C. Linked to this, the indicator also seeks to measure the ability of a building (with and without building services) to maintain pre-defined thermal comfort conditions during the heating and cooling seasons.
Objectives / Justification	Because of a combination of factors including poor insulation, low-quality windows, cold bridging through the building fabric, high levels of air infiltration, and insufficient or poorly maintained heating systems, a significant portion of the housing stock in the EU is unable to provide adequate levels of thermal comfort. The control of thermal comfort is an important factor to consider in all buildings because uncomfortable circumstances can put more vulnerable residents at risk from illnesses, reduce the productivity level of the occupants, and/or may necessitate the usage of additional cooling/heating energy. As the control of overheating is specifically addressed by the Energy Performance of Buildings Directive 2010/31/EU (EPBD), this indicator primarily focuses on summertime thermal comfort, but it also considers residents' capacity to maintain a comfortable indoor temperature in winter. EUB SuperHub indicator 19 (Summer thermal comfort in 2030 and 2050) can be used to determine future climate scenarios and report on them in order to address the possibility that adverse climate circumstances would exacerbate both of these issues in the future.
Unit of measurement	The percentage of time (%) in which the indoor temperature is out of a range of 18°C to 27°C during the heating and cooling seasons with and without building services.

System boundary	The system/assessment boundary is the building. Heat losses and gains, both internal and external, that may 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 factored into calculations.
Certification case	1) New buildings: In the form of a calculation process 2) Existing buildings (in use): in the form of a calculation process 3) Under major renovation buildings: in the form of a calculation process
Scope	Both residential and non-residential buildings.
Reference standards	- The calculation of the reported performance shall be based on a dynamic energy simulation complying with the ISO EN 52000-1 series. - An overheating assessment that forms part of a National Calculation Method shall be accepted if it is based on a dynamic simulation method. If a more advanced calculation method is used, it shall also be compliant with the ISO EN 52000-1 series. - The calculation of this indicator can be carried out only if the indoor air temperature and relative humidity of the analyzed building are within the range of values ditched by the standard EN ISO 7730.
Assessment protocol	This indicator's objective is to calculate the percentage of the year when the indoor temperature in those spaces or zones that account for >10% of the total useful floor area of a building is out of a range of 18°C to 27°C. The assessor shall be able to: • Document the evaluated zones in the building • Document the used building thermal and physical values • Document the building's actual or simulated heating and cooling systems • Document the building's use and occupancy profile used • Document the dynamic simulation method used.
Calculation method / Assessment approach	**Calculation method:** • Identify whether the national/regional calculation method is dynamic and whether an overheating assessment is also required in order to obtain a building permit. • If the national/regional calculation method is dynamic, this may be used to calculate the time out of range. If not, a dynamic simulation method and the software tool will need to be selected for use. • Determine if default values for the building occupancy and conditions of use patterns are stipulated in a national calculation method, or whether real-life assumptions can be made. Determine also whether the weather files are stipulated. • Run the simulation in order to obtain the internal temperatures per hour for a year for each thermal space or zone that accounts for >10% of the total useful floor area of a building. • Calculate the average value of the global building indoor temperature, weighted on the surface areas and the occupancy intensity of the different thermal spaces or zones. If the simulation does not automatically calculate the time out of range, the result shall be analyzed in order to derive the percentages for the upper and lower temperature bands.
Data requirements	The input data collected by the assessors shall be compliant with the input data required in the ISO EN 52000-1 series. Examples of requested input data are listed below: • about building envelope and windows U values and construction method (can be substituted by data from construction year class for existing buildings) • Building openings and orientation

	• Building Details usage and occupancy profiles • Building heating systems • Building cooling systems
Assessors' required qualifications	The level of competence of the assessor must be in compliance with the competence levels defined in the CEN Workshop Agreement (CWA) of TRAIN4SUSTAIN, n° 17939 (october 2022).
Comparability	The results of the indicator are comparable between the buildings that share the same usage, cooling and heating season, and climatic location as long as the same dynamic simulation method is used.

3.2.10 Indicator 10 "Ventilation rate"

Name	**Ventilation rate**
Reference framework	**Level(s)**[18] (the European framework for sustainable buildings) indicator 4.1: Indoor air quality. Document developed by European Commission - Joint Research Centre, January 2021.
Definition and description	According to **EN 16798-1**, the ventilation rate is the magnitude of outdoor air flow to a room or building through the ventilation system or device. A ventilation system is a combination of appliances or building components designed to supply indoor spaces with outdoor air and/or to extract polluted indoor air. The system may be mechanical (e.g. using a combination of air handling units, ducts and terminals), natural (e.g. achieving air flow via temperature differences and wind via façade grills) or a hybrid combination of both mechanical and natural aspects[19]. To ensure suitable Indoor Air Quality (IAQ) level, a number of different performance aspects must be addressed, such us the ventilation rate; indeed, the indicator measures the ventilation rate in each main room of the building, in relation to the expected use patterns.
Objectives / Justification	Since most of the Europeans spend more than the 90% of their time inside buildings, indoor air quality (IAQ) is a highly important influence on human health. Ventilation rate is one of the most effective strategies to control air changes, CO_2 and humidity. Indeed, the ventilation rate involves filtering out harmful pollutants that could enter via intakes of outdoor air. It also includes the provision of a minimum air exchange rate to prevent unhealthy levels of CO_2, humidity and pollutants arising from indoor materials in the indoor.
Unit of measurement	Ventilation rate (air flow) is measured as: [l /s]
System boundary	The assessment boundary of the ventilation rate is the building. It is important to point out that the indicator is only applicable to buildings equipped with a mechanical ventilation.
Certification case	**1) New buildings:** Based on the calculation of the total ventilation rate as described in the EN 16798-1. **2) Existing buildings (in use):** Based on the calculation of the total ventilation rate as described in the EN 16798-1. Or

https://environment.ec.europa.eu/topics/circular-economy/levels_en

Level(s) indicator 4.1: Indoor air quality, European Commission - Joint Research Centre, January 2021.

	Based on measurement method described in EN 12599: 2012 - Ventilation for buildings - Test procedures and measurement methods to hand over air conditioning and ventilation systems, where are described checks, test methods and measuring instruments in order to verify the fitness for purpose of the installed systems (air speed, ventilation filters and their suitability for the building location, indirect measure useful to understand the proper system design, etc.). **3) Under major renovation buildings:** Based on the calculation of the total ventilation rate as described in the EN 16798-1.
Scope	Both residential and non-residential buildings, that are equipped with mechanical ventilation.
Reference standards	Ventilation rate indicator is developed in accordance with **Level(s)**[20] (the European framework for sustainable buildings) indicator 4.1: Indoor air quality. The main reference standard for the calculation of the ventilation rate at the design phase is the **EN 16798-1: 2019** *Energy performance of buildings - Ventilation for buildings - Part 1: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics*". When considering ventilation needs, the expected use patterns should be considered, especially if occupant densities might vary significantly from one zone to another or in the same zone, but during different times of day or week. **CEN/TR 16798-2**, is the reference for the identification of the four categories of indoor environmental quality, which correspond to different expectation levels. The reference standard for the measurement of the ventilation rate is the **EN 12599: 2012** - *Ventilation for buildings - Test procedures and measurement methods to hand over air conditioning and ventilation systems*. This European Standard enables the choice between simple test methods, when sufficient, and extensive measurements, when necessary. It applies to mechanically operated ventilation and air conditioning systems. The measuring methods in this European Standard can be used in the frame of the energy inspection of air conditioning systems according to EU Directive 2010/31/EU "Energy performance of buildings Directive" (see EN 15239, EN 15240).
Assessment protocol	For the **calculation of the ventilation rate**, it is necessary to evaluate the ideal ventilation rate for the building in relation to its intended use and its construction type (with reference to the pollution level of the finishes and materials used in it). For the **measurement of the ventilation rate** in as-built performance and in-use phase, it is necessary to measure the parameters dependent on proper air exchange through mechanical ventilation.
Calculation method / Assessment approach	**Calculation method:** The underlying calculation method for the ventilation rate at the detailed design phase is provided by the "**EN 16798-1** - *Energy performance of buildings - Ventilation for buildings - Part 1: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics*".

https://environment.ec.europa.eu/topics/circular-economy/levels_en

	The standard defines three different methods for the assessment of the air quality. Method 1: based on perceived air quality. Method 2: based on the use of limit values for the concentration of pollutants. Method 3: based on pre-defined ventilation flow rates. In term of accuracy of the final result, **method 1** is the one to be preferred and the calculation methodology is described in short below. The ventilation rate is calculated by combining the share of ventilation to dilute and/or remove pollutants produced by occupants with the share of ventilation to dilute and/or remove pollutants produced by buildings (materials, components, etc.) and by the installations. **Assessment approach (as built and in-use):** The metering strategies for the measurement of the ventilation rate in as-built performance and in-use phase are different but all useful to evaluate the real performance of the building. The reference standard to be used is the **EN 12599: 2012** which provides test methods and measuring instruments to assess the air flow injected by the terminals of a mechanical ventilation system measuring the velocity of the outgoing air using different methodologies (different kind of anemometers could be used) The standard applies to ventilation and air conditioning systems designed for the maintenance of comfort conditions in buildings. Testing during occupation captures any additional impacts on IAQ caused by the activities of occupants and the installation of furniture and equipment. **Assessment approach (perceptual):** It is also important to add that, while many aspects of indoor air quality can be physically measured, whether or not these measurements correlate with occupant satisfaction will depend on the subjective perception of occupants. Since the purpose of building design and of building system operation is to provide a satisfactory living or working space for occupants, some basic principles for carrying out a survey relating to perceptions of the indoor environment have been developed by **ISO 28802**[21].
Data requirements	For the **calculation of the ventilation rate**, data needed are the following: • the dimension of the building zones in which the ventilation rates are calculated/ measured, its intended use and its internal distribution of the spaces; • the expected use patterns of the building (as per CEN/TR 16798-2, four categories of indoor environmental quality have been identified, and they correspond to different expectation levels); • the occupation schedule for each building zone; • A description of the ventilation system including the nominal and/ or actual air change rate capacity of the installed ventilation systems; • material specifications for insulation and fit-out materials (pay attention to manufacturer declarations and product labels that provide information on the tested emissions of VOCs and other hazardous substances). The objective is to identify the typology and the concentration of indoor pollutants in order to classify the building as low, medium or high pollutant.

ISO 28802: Ergonomics of the physical environment. Assessment of environments by means of an environmental survey involving physical measurements of the environment and subjective responses of people.

	For the **measurement of the ventilation rate** in as-built performance and in-use phase, data required are the following: • In addition to the requirements mentioned in the calculation part, the assessor will need to inquire about the elements needed to perform in-situ measurements are the equipment necessary to evaluate the selected parameters (anemometer, flow hood, fan anemometer, etc.)
Assessors' required qualifications	The ventilation rate shall be calculated by an assessor with working knowledge of the design process set out by EN 16798. Professional profiles recommended are architects, service engineers, any specialist ventilation consultant, heating and cooling system engineers, etc. The level of competence of the assessor must be in compliance with the competence levels defined in the CEN Workshop Agreement (CWA) of TRAIN4SUSTAIN, n° 17939 (october 2022).
Comparability	Comparability relies on the definition of the expected use patterns of the building, on the occupation schedule for each building zone, on the intended use and on the pollutant classification of the building (in relation to its fit-out materials, internal finishes, etc.). Concerning the calculation of the ventilation rate, it's also important to be consistent on the definition of the floor area taken into account in the calculation steps, (m²), because definition of net floor area varies according to the country. The reference to standard has to be the same when comparing results.

3.2.11 Indicator 11 "CO_2 concentration"

Name	**CO_2 concentration**
Reference framework	**Level(s)**[22] (the European framework for sustainable buildings) indicator 4.1: Indoor air quality. Document developed by European Commission - Joint Research Centre, January 2021
Definition and description	The carbon dioxide (chemical formula CO_2) is a chemical compound occurring as a colorless gas with a density about 53% higher than that of dry air. Carbon dioxide molecules consist of a carbon atom covalently double bonded to two oxygen atoms. The term "concentration" is used to describe the amount of gas by volume in the air, measured as parts-per-million (ppm). At design stage, the predictive estimation of CO_2 concentration is very difficult to perform. At contrary, in the use stage of the building, the CO2 concentration is a simple parameter to measure. The measurement must be in compliance with the requirements of the **EN 15251: 2007** *Indoor Environmental Criteria* and with **EN 16798: 2019** *Energy performance of buildings - Ventilation for buildings.*
Objectives / Justification	indoor air quality can have multiple effects on the human health. The quality of the indoor air depends on multiple variables that are closely related to pollutant levels and air conditions (e.g. CO_2 and humidity). To ensure suitable Indoor Air Quality (IAQ) level, a number of different performance aspects must be addressed to ensure that the, the CO_2 concentration are within the safe limits it's fundamental to limit the CO_2 concentration level in indoor air for occupants' well-being. Furthermore, the measurement of the CO_2

[22] https://environment.ec.europa.eu/topics/circular-economy/levels_en

	concentration is an indirect measure that allows to understand if the mechanical ventilation works properly and if there are anomalies
Unit of measurement	CO_2 concentration is measured as: particle per million [ppm]
System boundary	The system/assessment boundary of the CO_2 concentration is the building.
Certification case	1. **New buildings:** Not applicable 2. **Existing buildings (in use):** CO_2 concentration in-situ measurement is measured according to EN 15251 and EN 16798. 3. **Under major renovation buildings:** Not applicable
Scope	Both residential and non-residential buildings.
Reference standards	CO_2 concentration indicator is developed in accordance with **Level(s)** (the European framework for sustainable buildings) indicator 4.1: Indoor air quality. The main reference standard for the measurement of the CO_2 concentration is the **EN 15251: 2007** *Indoor Environmental Criteria.* The standard identifies parameters to be used by monitoring and displaying the indoor air quality in existing buildings. It specifies criteria for measurements which can be used, if required, to measure compliance by inspection. The other reference standard for the measurement of the ventilation rate is the **EN 16798-1: 2019** *Energy performance of buildings - Ventilation for buildings.*
Assessment protocol	For the **measurement of the CO_2 concentration** in as-built performance and in-use phase, it is necessary to measure the CO_2 concentration of the internal air and of the external air next to the building, at the same time, through the use of a carbon dioxide detector. The measurement should be done over the representative time periods and in representative rooms as defined in **EN 15251: 2007 . The ISO 16000-26:2012 CO_2 measurement strategy can be used to guide the assessor on defining the sampling period and location.**
Calculation method / Assessment approach	**Calculation method:** The indicator is only metered. **Assessment approach (as built and in-use):** The measurement of the CO_2 concentration must be performed in all the main rooms with full occupancy of the building, measuring at the same time the CO_2 concentration in indoor air and the CO_2 concentration in outdoor air. Thanks to these two measures, it will be easy evaluate the increase in CO_2 of indoor air compared to outdoor air for each main room. The measurement should be made in building rooms in which its known that users spend most of their time in and cover various representative periods of time. The measurement is performed using carbon dioxide detectors.
Data requirements	• Documentation of the rooms in which the measurement took place • Documentation of the CO_2 measurement device that was use and its sensitivity and accuracy

	• Documentation about the occupancy of the measured rooms • Documentation about the outdoor CO_2 concentration • Documentation about the duration of the measurement • Justification of the used measurement systems, rooms, occupancy and measurement duration • Documentation about ventilation system (if available).
Assessors' required qualifications	The CO_2 concentration shall be measured by an assessor with knowledge about the EN 16798-1 and EN 15251, the standards which identify parameters to be used by monitoring and displaying the indoor air quality in buildings. The level of competence of the assessor must be in compliance with the competence levels defined in the CEN Workshop Agreement (CWA) of TRAIN4SUSTAIN, n° 17939 (october 2022).
Comparability	Concerning the CO_2 concentration measurement, comparability relies on the reference standard to be used for data assessment and the typology of instrument used (calibration, resolution, etc.). Nevertheless, the CO_2 concentration levels in indoor rooms are in general comparable between the buildings without restriction on type, use and location

3.2.12 Indicator 12 "Relative humidity"

Name	Relative humidity
Reference framework	**Level(s)**[23] (the European framework for sustainable buildings) indicator 4.1: Indoor air quality. Document developed by European Commission - Joint Research Centre, January 2021.
Definition and description	The relative humidity is the amount of water vapour present in air expressed as a percentage of the amount needed for saturation at the same temperature. The relative humidity can be measured both after the completion of the construction of the building and in in-use phase. The measurement must be in compliance with the requirements of the **EN 15251: 2007** *Indoor Environmental Criteria* and with **EN 16798: 2019** *Energy performance of buildings - Ventilation for buildings - Part 1: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics*.
Objectives / Justification	The level of relative humidity is an important influencing factor on occupant comfort. Excessively high humidity (> 90%) increases the intensity of hot or cold temperatures, while excessively low humidity (< 20%) can cause irritation of the eyes, nose and throat. Poor control of humidity from outdoor air or from kitchen and bathroom areas can create ideal conditions for mould growth, which in turn can provoke respiratory or allergenic health issues[24]. Studies relating to homes suggested that around 17% of the EU population (approximately 80 million people) live in homes in which damp and associated mould growth may provoke health effects[25]

---

https://environment.ec.europa.eu/topics/circular-economy/levels_en

Level(s) indicator 4.1: Indoor air quality, European Commission - Joint Research Centre, January 2021.

Grun G., Urlaub S., Foldbjerg P., Towards an identification of European indoor environments' impact on health and performance – Mould and dampness. Frauhofer-Institut fur Bauphysik IBP

Unit of measurement	Relative humidity is measured as: [%]
System boundary	The assessment boundary of the relative humidity levels is the building.
Certification case	1. **New buildings:** The indicator is only metered at the as built stage. 2. **Existing buildings (in use):** Relative humidity in-situ measurement measured according to what stated in EN 15251 and EN 16798. 3. **Under major renovation buildings:** The indicator is only metered at the as built stage.
Scope	Both residential and non-residential buildings.
Reference standards	Relative humidity indicator is developed in accordance with **Level(s)** (the European framework for sustainable buildings) indicator 4.1: Indoor air quality. The main reference standard for the measurement of the ventilation rate is the **EN 15251: 2007** *Indoor Environmental Criteria*. The standard identifies parameters to be used by monitoring and displaying the indoor air quality in existing buildings. It specifies criteria for measurements which can be used, if required, to measure compliance by inspection. The other reference standard for the measurement of the ventilation rate is the **EN 16798-1: 2019** *Energy performance of buildings - Ventilation for buildings.*
Assessment protocol	For the **measurement of the relative humidity** in as-built performance and in-use phase, it is necessary to measure the relative humidity of the internal air and of the external air, next to the building through the use of datalogger, psychrometer or hygrometer.
Calculation method / Assessment approach	**Calculation method:** The indicator is only metered. **Assessment approach (as built):** After the completion of a building, it is important to evaluate the internal air relative humidity in order to check the level of drying of construction materials. The measurement of the internal air relative humidity could be performed using a datalogger, by evaluating also the thermohygrometric conditions in the area considered within the measurement. **Assessment approach (in-use):** During the occupation of the building (in-use phase), the verification of the relative humidity must be performed in all the main rooms of the building in order to be able to characterise the way in which the user manages the installations establishing, therefore, the user profile of the building. The relative humidity measurement must be carried out also for the external air. It is recommended to perform the measurement for a period sufficient to establish a complete time profile of internal thermo-hygrometric conditions, using a datalogger for data collection (better with stand-alone power supply and with adequate storage capacity). For the measurement it is necessary the use of hygrometric sensors (psychrometric, dew point, capacitive type) with the following minimal requirements: • range: 10 ÷ 90 %

	• uncertainty: ±3% • resolution: 0.1% Furthermore, the measurement of the relative humidity is an indirect measure that allows to understand if the mechanical ventilation works properly and if there are anomalies not identified at the design stage.
Data requirements	• Documentation of the rooms in which the measurement took place • Documentation of the psychrometer or hygrometer measurement device that was use and its sensitivity and accuracy • Documentation about the occupancy of the measured rooms • Documentation about the outdoor humidity levels • Documentation about the duration of the measurement • Justification of the used measurement systems, rooms, occupancy and measurement duration • Documentation about ventilation system (if available) • Documentation about the used dataloggers.
Assessors' required qualifications	The relative humidity shall be measured by an assessor with knowledge about the EN 15251, the standard which identifies parameters to be used by monitoring and displaying the indoor air quality in buildings. The level of competence of the assessor must be in compliance with the competence levels defined in the CEN Workshop Agreement (CWA) of TRAIN4SUSTAIN, n° 17939 (october 2022).
Comparability	Concerning the relative humidity measurement, comparability relies on the reference standard to be used for data assessment and the typology of instrument used (calibration, resolution, etc.). Nevertheless, the relative humidity levels in the indoor rooms are in general comparable between the buildings without restriction on type, use and location

3.2.13 Indicator 13 "Total VOCs"

Name	Total VOCs
Reference framework	**Level(s)**[26] (the European framework for sustainable buildings) indicator 4.1: Indoor air quality. Document developed by European Commission - Joint Research Centre, January 2021.
Definition and description	The Total Volatile Organic Compounds (TVOCs) are compounds that have a high vapor pressure and low water solubility. TVOCs are emitted as gases from certain solids products or liquids; they include a variety of chemicals, some of which may have short- and long-term adverse health effects. Concentrations of many VOCs are consistently higher indoors (up to ten times higher) than outdoors. **WHO guidelines** for indoor air quality: selected pollutants[27,] are a key document to be referred to, which specifies that indoor air has a special role as a health determinant and that the management of indoor air quality requires approaches different from those used for outdoor air. The measurement of TVOCs must be in compliance with what stated in **EN 16516**: *construction products: Assessment of release of dangerous substances*

https://environment.ec.europa.eu/topics/circular-economy/levels_en
https://www.euro.who.int/__data/assets/pdf_file/0009/128169/e94535.pdf

	- *Determination of emissions into indoor air*28. This European Standard specifies a horizontal reference method for the determination of emissions of regulated dangerous substances from construction products into indoor air. Another key reference standard explaining the methods to be followed for determining the VOCs in indoor air is the **ISO 16000-6:2021** - *Indoor air — Part 6: Determination of organic compounds (VVOC, VOC, SVOC) in indoor*[29].
Objectives / Justification	. People are spending an increasing amount of time indoors. There they are exposed to pollutants generated outdoors that penetrate to the indoor environment and also to pollutants produced indoors, for example as a result of space heating, cooking and other indoor activities, or emitted from products used indoors. Multiple variables of indoor air quality (IAQ) impact on the human health and several are closely related to Volatile Organic Compounds (VOCs) the TVOC emissions can be limited through the careful selection of VOC free construction products and materials
Unit of measurement	TVOCs is measured as: [μg/m³]
System boundary	The assessment boundary of the TVOCs is the building.
Certification case	1. **New buildings:** The indicator is only metered at the as built stage. 2. **Existing buildings (as built and in use):** TVOCs are metered according to what stated in EN 16516 and the ISO 16000-6:2021. Reference limit values for TVOCs concentration in indoor air are indicated within the WHO Guidelines. 3. **Under major renovation buildings:** The indicator is only metered at the as built stage.
Scope	Both residential and non-residential buildings.
Reference standards	TVOCs indicator is developed in accordance with **Level(s)** (the European framework for sustainable buildings) indicator 4.1: Indoor air quality. The main reference standard for the measurement of the TVOCs is the **EN 16516**, according to it, the Total Volatile Organic Compound (TVOC) is the sum of the concentrations of the identified and unidentified volatile organic compounds (as defined in 3.1.3.11 of EN 16516), calculated by summing the reference room concentrations in relation to the external values of these pollutants. Another key standard to be referred to, is the **ISO 16000-6:2021** - *Indoor air — Part 6*, this document specifies a method for determination of volatile organic compounds (VOC) in indoor air and in air sampled for the determination of the emission from products or materials used in indoor environments (according to ISO 16000-1) using test chambers and test cells. The method uses sorbent sampling tubes with subsequent thermal desorption (TD) and gas chromatographic (GC) analysis employing a capillary column and a mass spectrometric (MS) detector with or without an additional flame ionisation detector (FID). Of course, the reference limit values for TVOCs concentration in indoor air are indicated within the **WHO Guidelines**.

https://standards.iteh.ai/catalog/standards/cen/858d31b1-10ac-427b-8ac8-f3d8dcf66f58/en-16516-2017
https://www.iso.org/obp/ui#iso:std:iso:16000:-6:ed-3:v1:en

Assessment protocol	For the **measurement of the TVOCs** in as-built performance and in-use phase, it is necessary to measure the TVOCs concentration of the internal air and of the external air, next to the building, through the use of VOCs detectors located on tripod at a height of 1.5 metres.
Calculation method / Assessment approach	**Calculation method:** The indicator is only metered. **Assessment approach (as built):** After the completion of a building, it is important to evaluate the internal air TVOCs concentration level for the health of future occupants. The measurement of the TVOCs in as built phase could be performed both in presence of mechanical ventilation and in case of natural ventilation. During the as built phase, the verification of the TVOCs concentration level must be performed in all the main rooms of the building and, simultaneously, in the external area closed to the building. For each pollutant measured, is to be checked the quantitative increase of the indoor air value in relation to the external air value. The reference values for the TVOCs in indoor air are highlighted in the WHO guidelines. The instruments to be utilised for the measurement may vary in relation to what pollutant is necessary to assess, in most cases VOCs detectors are used, located on tripod at a height of 1.5 metres. It is recommended to perform the measurement for a period sufficient to establish the TVOCs concentration level trend (not less than a week). **Assessment approach (in-use):** The measurement of the TVOCs concentration in use phase is the same of the as-built stage (see above). The additional thing that must be considered is the fact that, since the building is in use, all the variants that may affect the measure must be noticed, as for example: number of occupants, smoking habit, typology of the furniture, etc.
Data requirements	Devices used to measure the TVOCs may vary in relation to what pollutant is necessary to assess, in most cases VOCs detectors are used, located on tripod at a height of 1.5 metres. In all cases the assessor must collect information about the rooms in which the measurement took place, their location, the type of furniture and finishing materials used in the rooms, the date and type of devices used and the ventilation system of the rooms.
Assessors' required qualifications	The TVOCs shall be measured by an assessor with knowledge about the EN 16516 and the ISO 16000- Part 6, standards describing the procedures to be followed for the measurement of the TVOCs concentration in indoor air. The level of competence of the assessor must be in compliance with the competence levels defined in the CEN Workshop Agreement (CWA) of TRAIN4SUSTAIN, n° 17939 (october 2022).
Comparability	Concerning the TVOCs concentration measurement, comparability relies on the reference standard to be used for data assessment, duration of the measurement and the typology of instrument used (calibration, resolution, etc.). Nevertheless, the TVOCs concentration levels in indoor rooms are in general only comparable between the buildings of the same state i.e. newly built or in-use without restriction on type, use and location. Comparison of the results between a newly built building and an in-use building is not recommended.

3.2.14 Indicator 14 "CMR VOCs concentration":

Name	CMR VOCs concentration
Reference framework	**Level(s)**[30] (the European framework for sustainable buildings) indicator 4.1: Indoor air quality. Document developed by European Commission - Joint Research Centre, January 2021.
Definition and description	The abbreviation of CMR stands for: Carcinogen, Mutagen, Reprotoxic and refers to substances which are chronically toxic and have very serious impacts on health. CMR VOCs are classified as Carcinogenic, Mutagenic or toxic for Reproduction according to Regulation (EC) No 1272/2008[31]. Concentrations of CMR VOCs are consistently higher indoors than outdoors. **WHO guidelines**[32] for indoor air quality, is a key document to be referred to, which specifies that indoor air has a special role as a health determinant and that the management of indoor air quality requires approaches different from those used for outdoor air. The measurement of CMR VOCs must be in compliance with what stated in **EN 16516**: *construction products: Assessment of release of dangerous substances - Determination of emissions into indoor air*[33]. This European Standard specifies a horizontal reference method for the determination of emissions of regulated dangerous substances from construction products into indoor air. Another key reference standard explaining the methods to be followed for determining the CMR VOCs in indoor air is the **ISO 16000-6:2021** - *Indoor air — Part 6: Determination of organic compounds (VVOC, VOC, SVOC) in indoor*[34].
Objectives / Justification	People are spending an increasing amount of time indoors. There they are exposed to pollutants generated outdoors that penetrate to the indoor environment and also to pollutants produced indoors, for example as a result of space heating, cooking and other indoor activities, or emitted from products used indoors. Multiple variables of IAQ impact on the human health and several are closely related to CMR VOCs. CMRs entering routes into organisms include inhalation (of dust, fumes, gas, vapours), ingestion (by eating, drinking, smoking with dirty hands or by accidental ingestion) and penetration through (intact or damaged) skin and mucous membranes. In addition to Total VOCs estimation, a value for total CMR VOCs is necessary to separately identify the more hazardous substances that may be emitted.
Unit of measurement	CMR VOCs is measured as: [μg/m³]
System boundary	The system boundary of the CMR VOCs is the building.
Certification case	**1) New buildings:** The indicator is only metered.

[30] https://environment.ec.europa.eu/topics/circular-economy/levels_en
[31] Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006.
[32] https://www.euro.who.int/__data/assets/pdf_file/0009/128169/e94535.pdf
[33] https://standards.iteh.ai/catalog/standards/cen/858d31b1-10ac-427b-8ac8-f3d8dcf66f58/en-16516-2017
[34] https://www.iso.org/obp/ui#iso:std:iso:16000:-6:ed-3:v1:en

	2) Existing buildings (as built and in use): CMR VOCs are metered according to what stated in EN 16516 and the ISO 16000-6:2021. Reference limit values for CMR VOCs concentration in indoor air are indicated within the WHO Guidelines. **3) Under major renovation buildings:** The indicator is only metered.
Scope	Both residential and non-residential buildings.
Reference standards	CMR VOCs indicator is developed in accordance with **Level(s)** (the European framework for sustainable buildings) indicator 4.1: Indoor air quality. The main reference standard for the measurement of the CMR VOCs is the **EN 16516** *construction products: Assessment of release of dangerous substances - Determination of emissions into indoor air*. Another key standard to be referred to, is the **ISO 16000-6:2021** - *Indoor air — Part 6*, this document specifies a method for determination of volatile organic compounds (VOC) in indoor air and in air sampled for the determination of the emission from products or materials used in indoor environments (according to ISO 16000-1) using test chambers and test cells. The method uses sorbent sampling tubes with subsequent thermal desorption (TD) and gas chromatographic (GC) analysis employing a capillary column and a mass spectrometric (MS) detector with or without an additional flame ionisation detector (FID). Of course, the reference limit values for CMR VOCs concentration in indoor air are indicated within the **WHO Guidelines**.
Assessment protocol	For the **measurement of the CMR VOCs** in as-built performance and in-use phase, it is necessary to measure the CMR VOCs concentration of the internal air and of the external air, next to the building, through the use of CMR VOCs detectors located on tripod at a height of 1.5 metres.
Calculation method / Assessment approach	**Calculation method:** The indicator is only metered. **Assessment approach (as built):** After the completion of a building, it is important to evaluate the internal air CMR VOCs concentration level for the health of future occupants. The measurement of the CMR VOCs in as built phase could be performed both in presence of mechanical ventilation and in case of natural ventilation. During the as built phase, the verification of the CMR VOCs concentration level must be performed in all the main rooms of the building and, simultaneously, in the external area closed to the building. For each pollutant measured, is to be checked the quantitative increase of the indoor air value in relation to the external air value. The reference values for the CMR VOCs in indoor air are highlighted in the WHO guidelines. The instruments to be utilised for the measurement may vary in relation to what pollutant is necessary to assess, in most cases CMR VOCs detectors are used, located on tripod at a height of 1.5 metres. It is recommended to perform the measurement for a period sufficient to establish the CMR VOCs concentration level trend (not less than a week). **Assessment approach (in-use):** The measurement of the CMR VOCs in use phase is the same of the as-built stage (see above). The additional thing that must be considered is the fact that, since the building is in use, all the variants that may affect the measure

	must be noticed, as for example: number of occupants, smoking habit, typology of the furniture, etc.
Data requirements	Devices used to measure the CMR VOCs may vary in relation to what pollutant is necessary to assess, in most cases CMR VOCs detectors are used, located on tripod at a height of 1.5 metres.
Assessors' required qualifications	The CMR VOCs shall be measured by an assessor with knowledge about the EN 16516 and the ISO 16000- Part 6, standards describing the procedures to be followed for the measurement of the CMR VOCs concentration in indoor air. The level of competence of the assessor must be in compliance with the competence levels defined in the CEN Workshop Agreement (CWA) of TRAIN4SUSTAIN, n° 17939 (october 2022).
Comparability	Concerning the CMR VOCs concentration measurement, comparability relies on the reference standard to be used for data assessment, duration of the measurement and the typology of instrument used (calibration, resolution, etc.). Nevertheless, the CMR VOCs concentration levels in indoor rooms are in general only comparable between the buildings of the same state i.e. newly built or in-use without restriction on type, use and location . Comparison of the results between a newly built building and an in-use building is not recommended

3.2.15 Indicator 15 "R Value"

Name	R value
Reference framework	**Level(s)**[35] (the European framework for sustainable buildings) indicator 4.1: Indoor air quality. Document developed by European Commission - Joint Research Centre, January 2021.
Definition and description	The R value is the main metric that links to the **EU LCI (Lowest Concentration of Interest) values. The R value for an individual VOC is the ratio of the measured concentration to the EU-LCI value.** For example, a measured concentration of 24 µg/m3 and an EU LCI value of 200 µg/m3 would correspond to an R value of 0.12[36]. When more than one substance with an EU-LCI value is measured, the R values of each substance are added together. The harmonisation process for the LCI values (Lowest Concentration of Interest) is not finalised yet. The LCI approach was developed to assess the health effects of compounds from building materials. It was originally part of a basic scheme for the evaluation of VOC emissions. The R value is a metered indicator, it can be measured after the completion of the building and during the in-use phase. The measurement must be in compliance with what stated in **EN 16516**: *construction products: Assessment of release of dangerous substances - Determination of emissions into indoor* air37. This European Standard specifies a horizontal reference method for the determination of emissions of regulated dangerous substances from construction products into indoor air.

https://environment.ec.europa.eu/topics/circular-economy/levels_en

https://susproc.jrc.ec.europa.eu/product-bureau/sites/default/files/2021-02/UM3_Indicator_4.1_v1.1_37pp.pdf

https://standards.iteh.ai/catalog/standards/cen/858d31b1-10ac-427b-8ac8-f3d8dcf66f58/en-16516-2017

	Another key reference standard explaining the methods to be followed for determining the pollutant mass concentration in indoor air is the **ISO 16000-6:2021** - *Indoor air — Part 6: Determination of organic compounds (VVOC, VOC, SVOC) in indoor38*. Concerning the LCI values, the main document to which refer to is the **Agreed EU-LCI values39**, developed by the European Commission, released in December 2021.
Objectives / Justification	Since each individual VOC has its own potential toxicity upon exposure to humans, the R value has been developed, trying to translate data from total VOC measurements into potential human health risks. The LCI concept was first developed by the European Collaborative Action on Indoor Air Quality and its Impact on Man when considering the best way to evaluate emissions from solid flooring materials. Nowadays, the European Commission subgroup on EU-LCI values task is to derive and recommend EU-wide harmonised health-based reference values for the assessment of product emissions, based on the so-called 'lowest concentration of interest' (LCI) concept[40]. Indeed, the R value normalises each individual VOC concentration against a specific LCI value for that individual VOC. This creates a coefficient for each VOC and, when coefficients for individually identified VOCs in the same sample are totalled together, the overall R value can be generated. An R value >1 would then suggest that the VOC content in indoor air is a concern for human health impacts41.
Unit of measurement	R value is measured as: [decimal ratio]
System boundary	The assessment boundary of the R value is the building.
Certification case	1. **New buildings:** The indicator is only metered at the as built stage. 2. **Existing buildings (in use):** R value in-situ measurement is measured according to what stated in EN 16516 and in ISO 16000-6. 3. **Under major renovation buildings:** The indicator is only metered at the as built stage.
Scope	Both residential and non-residential buildings.
Reference standards	R value indicator is developed in accordance with **Level(s)** (the European framework for sustainable buildings) indicator 4.1: Indoor air quality. The main reference standard for the measurement of the R value is the **EN 16516** *construction products: Assessment of release of dangerous substances - Determination of emissions into indoor air*. Another key standard to be referred to, is the **ISO 16000-6:2021** - *Indoor air — Part 6*, this document specifies a method for determination of volatile organic compounds (VOC) in indoor air and in air sampled for the determination of

https://www.iso.org/obp/ui#iso:std:iso:16000:-6:ed-3:v1:en

https://ec.europa.eu/growth/sectors/construction/eu-lci-subgroup/eu-lci-values_en

https://ec.europa.eu/growth/sectors/construction/eu-lci-subgroup_en

Level(s) indicator 4.1: Indoor air quality, European Commission - Joint Research Centre, January 2021.

	the emission from products or materials used in indoor environments (according to ISO 16000-1) using test chambers and test cells. Concerning the LCI values, the main document to which refer to is the **Agreed EU-LCI values.**
Assessment protocol	According to EN 16516, the R value is the sum of all Ri values obtained during a given test. The Ri value is the ratio of Ci / LCIi, where: - Ci is the mass concentration in the air of the reference room; - LCIi is the LCI value of compound i. Accordingly, for the **measurement of the R value** in as-built performance and in-use phase, it is necessary to measure the mass concentration of a specific pollutant dividing the value obtained by the LCI pollutant related value. Devices used are VOCs detectors and tester pollutant absorbing material.
Calculation method / Assessment approach	**Calculation method:** The indicator is only metered. **Assessment approach (as built and in-use):** After the completion of a building, it is important to evaluate the mass concentration of pollutants in the indoor air in order to ensure health safety of future occupants. Those concentration levels must be related to the LCI pollutant related value. For the measurement procedures, make reference to what stated in the description template of total VOCs, CMR VOCs and formaldehyde concentration.
Data requirements	Device used to measure the R value are VOCs detectors and tester pollutant absorbing material. Moreover, the assessor must collect information about the rooms in which the measurement took place, their location, the type of furniture and finishing materials used in the rooms, the date and type of devices used and the ventilation system of the rooms
Assessors' required qualifications	The R value shall be measured by an assessor with knowledge about the EN 16516 and the ISO 16000 part 6, which are standards defining methods and approaches for determination of pollutants mass concentration in indoor air. The level of competence of the assessor must be in compliance with the competence levels defined in the CEN Workshop Agreement (CWA) of TRAIN4SUSTAIN, n° 17939 (october 2022).
Comparability	Concerning the R value measurement, comparability relies on the reference standard to be used for data assessment and the typology of instrument used (calibration, resolution, etc.). Nevertheless, the R value measurement results are in general only comparable between the buildings of the same state i.e. newly built or in-use without restriction on type, use and location . Comparison of the results between a newly built building and an in-use building is not recommended

3.2.16 Indicator 16 "Formaldehyde concentration"

Name	Formaldehyde concentration
Reference framework	**Level(s)**[42] (the European framework for sustainable buildings) indicator 4.1: Indoor air quality. Document developed by European Commission - Joint Research Centre, January 2021.
Definition and description	Formaldehyde was reclassified as a category 1B carcinogen and category 2 mutagen in 2015[43]. It is a commonly used resin in the surface treatment of textile fabrics, as a binder in wood-based panels and in numerous other applications. Upon contact with moisture, formaldehyde resins can break down, releasing continual small quantities of formaldehyde to the indoor air. Formaldehyde is also a VOC but is generally reported separately from other CMR VOCs because of its serious health risk (it is classified as carcinogenic)44. The measurement of formaldehyde concentration must be in compliance with **EN 16516**: *construction products: Assessment of release of dangerous substances - Determination of emissions into indoor air45*. This European Standard specifies a horizontal reference method for the determination of emissions of regulated dangerous substances from construction products into indoor air. Another key reference standard explaining the methods to be followed for determining the formaldehyde concentration in indoor air is the **ISO 16000-6:2021** - *Indoor air — Part 6: Determination of organic compounds (VVOC, VOC, SVOC) in indoor46*. **WHO guidelines**[47] for indoor air quality, is a key document to be referred to, which specifies that indoor air has a special role as a health determinant and that the management of indoor air quality requires approaches different from those used for outdoor air. Another very relevant document to which refer to for establishing limit values for formaldehyde concentration in indoor air, is the **AFSSET**[48], the French agency for health safety of the environment, which has developed a in depth analysis concerning the limit values in indoor air of formaldehyde concentration.
Objectives / Justification	Indoor exposure to formaldehyde pollutant through inhalation is a dominant contributor to cause adverse health effects. The lowest concentration reported to cause sensory irritation of the eyes in humans is 0.36 mg/m3 for four hours. Increases in eye blink frequency and conjunctival redness appear at 0.6 mg/m3. There is no indication of accumulation of effects over time with prolonged exposure[49]. The perception of odour may result in some individuals reporting subjective sensory irritation.

---

https://environment.ec.europa.eu/topics/circular-economy/levels_en

Commission Regulation (EU) No 605/2014 of 5 June 2014 amending, for the purposes of introducing hazard and precautionary statements in the Croatian language and its adaptation to technical and scientific progress, Regulation (EC) No 1272/2008 of the European Parliament and of the Council on classification, labelling and packaging of substances and mixtures. OJ L 167, 6.6.2014, p.36-49.

https://susproc.jrc.ec.europa.eu/product-bureau/sites/default/files/2021-02/UM3_Indicator_4.1_v1.1_37pp.pdf

https://standards.iteh.ai/catalog/standards/cen/858d31b1-10ac-427b-8ac8-f3d8dcf66f58/en-16516-2017

https://www.iso.org/obp/ui#iso:std:iso:16000:-6:ed-3:v1:en

https://www.euro.who.int/__data/assets/pdf_file/0009/128169/e94535.pdf

https://www.anses.fr/fr/system/files/AIR2004etVG002Ra.pdf

https://www.euro.who.int/__data/assets/pdf_file/0009/128169/e94535.pdf

	Due to its serious health risk, as it is classified as carcinogenic, it is necessary to prevent human health from exposure to the contaminant; in that sense, it is preferable the use of low-emitting building materials and products. Preventing exposure to environmental tobacco smoke and other combustion emissions, will minimize exposure-related risk. In addition, ventilation can reduce indoor exposure to formaldehyde.
Unit of measurement	Formaldehyde concentration is measured as: [µg/m³]
System boundary	The system/assessment boundary of the formaldehyde concentration is the building.
Certification case	1. **New buildings:** The indicator is only metered at the as built stage 2. **Existing buildings (in use):** Formaldehyde concentration is measured according to what stated in EN 16516 and the ISO 16000-6:2021. Reference limit values for formaldehyde concentration in indoor air are indicated within the WHO Guidelines and in the AFSSET document. 3. **Under major renovation buildings:** The indicator is only metered at the as built stage.
Scope	Both residential and non-residential buildings.
Reference standards	Formaldehyde concentration indicator is developed in accordance with **Level(s)** (the European framework for sustainable buildings) indicator 4.1: Indoor air quality. The main reference standard for the measurement of the formaldehyde concentration is the **EN 16516** *construction products: Assessment of release of dangerous substances - Determination of emissions into indoor air*. Another key standard to be referred to, is the **ISO 16000-6:2021** - *Indoor air — Part 6*, this document specifies a method for determination of volatile organic compounds (VOC) in indoor air and in air sampled for the determination of the emission from products or materials used in indoor environments (according to ISO 16000-1) using test chambers and test cells. Of course, the reference limit values for formaldehyde concentration in indoor air are indicated within the **WHO Guidelines** and in the **AFSSET document**.
Assessment protocol	For the **measurement of the formaldehyde concentration** in as-built performance and in-use phase, the normal measurement method used is to collect a known volume of air over a period of time, passing it through an absorbing material, where the pollutants are retained. The material is then transported to a lab and the formaldehyde pollutants are released under controlled conditions. The average concentration, based on the sum of the individual measurements carried out, is then evaluated.
Calculation method / Assessment approach	**Calculation method:** The indicator is only metered. **Assessment approach (as built):** After the completion of a building, it is important to evaluate the internal air formaldehyde concentration, in order to ensure the health of future occupants. The measurement could be performed both in case of only natural ventilation and in case of mechanical ventilation. The measures must be performed

	within the longer permanence rooms and in the main areas of the building. At least 3 measures must be performed in the selected rooms, for a minimum duration of 30 minutes. To properly conduct the measurement, the absorbing material tester for formaldehyde is located on a tripod, at a height of 1.5 metres. To assess the level of formaldehyde concentration, it must be evaluated the average concentration based on the sum of the individual measurements carried out. The reference values for the formaldehyde concentration in indoor air are highlighted in the WHO guidelines and in the AFSSET document. **Assessment approach (in-use):** The measurement of the formaldehyde concentration in use phase is the same of the as-built stage (see above). The additional thing that must be considered is the fact that, since the building is in use, all the variants that may affect the measure must be noticed, as for example: number of occupants, smoking habit, typology of the furniture, etc.
Data requirements	There are different typologies of devices to be used to measure the formaldehyde concentration in indoor air. Generally, it is measured through the use of tester absorbing material. In all cases the assessor must collect information about the rooms in which the measurement took place, their location, the type of furniture and finishing materials used in the rooms, the date and type of devices used and the ventilation system of the rooms
Assessors' required qualifications	The formaldehyde concentration shall be measured by an assessor with knowledge about the EN 16516 and the ISO 16000 part 6, which are standards defining methods and approaches for determination of formaldehyde concentration in indoor air. The level of competence of the assessor must be in compliance with the competence levels defined in the CEN Workshop Agreement (CWA) of TRAIN4SUSTAIN, n° 17939 (october 2022).
Comparability	Concerning the formaldehyde concentration measurement in indoor air, comparability relies on the reference standard to be used for data assessment and the typology of instrument used (calibration, resolution, etc.). Nevertheless, the formaldehyde concentration levels in indoor rooms are in general only comparable between the buildings of the same state i.e. newly built or in-use without restriction on type, use and location . Comparison of the results between a newly built building and an in-use building is not recommended

3.2.17 Indicator 17 "Operational Energy Costs"

Name	**Operational Energy Costs**
Reference framework	B10.1 NewTREND (Operational Energy Costs publication) date July 28, 2016 and partially Level(s) indicator 6.1: Life cycle costs, published January 2021
Definition and description	The indicator measures the economic performance of a building. The operational energy cost equates to the total cost of energy during the operational stage of the building. Operational energy is the energy that is used during the in-use stage of building life cycle for space and water heating, space cooling, lighting, running the equipment and appliances, etc. The aspects of primary energy conversion to final energy are excluded. The starting point to calculate this is based on the actual or simulated amount of the building final energy demand for each usage and fuel type as per the methodology used in the KPI 02 (delivered final energy demand).

Objectives / Justification	The energy cost is the one of the largest if not the largest operating expense in non-residential buildings. In residential building the energy cost can be so high that over 10% of the household income is spent on heating cost alone. Indeed, it is estimated that about 8% of the EU population are unable to keep their home adequately warm due to high energy cost and thus suffering from energy poverty. Energy poverty therefore remains a major challenge and lifting vulnerable citizens out of it is an urgent task for the EU and its members. Moreover, there is a strong correlation between the building energy efficiency performance, its environmental footprint and its operational energy cost. Hence, the indicator encourages the uptake of energy efficient buildings and renovation actions
Unit of measurement	Operational energy cost per unit of reference floor area per year, in €/(m²·y).
System boundary	The assessment boundary of this is constrained to the total cost of energy occurring during the operational stage of the building as per the definition of Building life cycle stage B6 in the and CEN—EN 15804 This includes thermal and electrical energy for space cooling, heating, lighting, ventilation and auxiliary systems. For new building and under renovation buildings the cost of electrical plug load or any other load that is not included in the calculation of the final energy demand as per the KPI 02 delivered final energy demand are excluded from this calculation.
Certification case	1) New buildings: Calculation approach 2) Existing buildings (in use): Measurement approach 3) Under major renovation buildings: Calculation approach
Scope	Residential and non-residential building
Reference standards	The calculation method is based on the same principles used in national or regional calculation method for energy performance laid down in the Member State where the building is located. In all cases, the calculation method and assessment type used shall be reported.
Assessment protocol	1. New buildings: • During the detailed design phase, the assessor is ensuring that the operational energy cost calculation and simulation cover a period of 12 months and include all the delivered fuel types used in the operation of the building (as per KPI 02). Moreover, the assessor is to ensure that representative energy prices for each fuel types are used and that the building's reference floor area is identical to the building reference floor area used in the KPI 02. 2. As-built and in-use: • During the in-use phase, the assessor is ensuring that the operational energy cost are based on recent (not older than 2 years) annual (12 month) metered data of all the delivered fuel types used in the operation of the building. Moreover, the assessor is to ensure that actual energy prices for each fuel types are used and that the building's reference floor area is identical to the building reference floor area used in the KPI 02. 3. Under renovation buildings: • During the detailed design phase, the assessor is ensure that the operational energy cost calculation and simulation include all the delivered fuel types used in the operation of the building (as per KPI 02). Moreover, the assessor is to unsure that representative energy prices for each fuel types are used and that the building's reference floor area is identical to the building reference floor area used in the KPI 02.

Calculation method / Assessment approach	**Calculation method (for new building and under renovation buildings):** 1. Determine the delivered energy demand as described in the KPI 02. The simulated/ calculated total final energy demand of the building will include the final energy end use with a breakdown for each fuel type. 2. Calculate the yearly operational energy costs by multiplying the final energy demand for each fuel type by a representative energy price. 3. Calculate the operational energy costs (normalised) for the building based on the reference floor area by dividing the Annual operational energy costs on the reference floor area 4. The resulting operational energy cost will be presented in €/(m²·y). **Measurement approach (for existing building):** 1. Determine the delivered final energy for the buildings based on actual and recent (not older than 2 years) metered energy bills. 2. Calculate the yearly operational energy costs by multiplying the final energy demand for each fuel type by the actual energy price. 3. Calculate the operational energy costs (normalised) for the building based on the reference floor area by dividing the Annual operational energy costs (inferred from recent energy bills) on the reference floor area 4. The resulting operational energy cost will be presented in €/(m²·y).
Data requirements	• Annual delivered energy by fuel type in kWh.y • Reference floor area in m2 • Energy prices by fuel type in €
Assessors' required qualifications	The level of competence of the assessor must be in compliance with the competence levels defined in the CEN Workshop Agreement (CWA) of TRAIN4SUSTAIN, n° 17939 (october 2022).
Comparability	The comparability of the indicator results is not possible due to the dynamics of fuel prices in each MS, and within each region. The specifics of final energy usage of buildings as per their type and fuel carriers and user behavior. Nevertheless, the results of the indicator can be used to optimize the design decisions and to reduce the building performance gap and indirectly to reduce the building environmental footprint and resources consumption.

3.2.18 Indicator 18 "Smart Readiness Indicator"

Name	**Smart Readiness Indicator**
Reference framework	The optional common European Union scheme for rating the smart readiness of buildings C/2020/6930 defined in Commission Delegated Regulation (EU) 2020/2155
Definition and description	The Smart Readiness Indicator for buildings is a composite indicator that intended to measure the technological readiness of the buildings in three main functionalities: 1. The ability to **maintain energy efficiency performance and operation** of the building through the adaptation of energy consumption - for example through use of energy from renewable sources. 2. The ability to adapt its operation mode in **response to the needs of the occupant**, paying due attention to the availability of user-friendliness, maintaining healthy indoor climate conditions and ability to report on energy use. 3. The **flexibility of a building's overall electricity demand**, including its ability to enable participation in active and passive as well as implicit

	and explicit demand-response, in relation to the grid, for example through flexibility and load shifting capacities.
Objectives / Justification	One of the main objectives of the Energy Performance of Buildings Directive (EPBD) is to leverage on the potential of smart technologies in the building sector to support creating healthy and comfortable buildings with lower energy consumption and carbon impact. Moreover, the smart technologies can also facilitate the integration of renewable energy sources in energy systems. Therefore, the EPBD sets out provisions to establish a "Smart Readiness Indicator" (SRI) as an instrument for rating the smart readiness of buildings.
Unit of measurement	A percentage value and a corresponding class with an Alphabetical Rating Scale from A to G
System boundary	The assessment boundary is the building or the part of a building. The assessed **smart-ready services*** that the building has or could use are grouped in 9 technical domains: • Heating • Cooling • Domestic Hot water • Ventilation • Lighting • Dynamic building envelope • Electricity • Electric vehicle charging • Monitoring and control
Certification case	1) New buildings: Calculation approach 2) Existing buildings (in use): Calculation approach 3) Under major renovation buildings: Calculation approach
Scope	Residential building and Non-Residential building
Reference standards	Version 4.4 of the Calculation sheet for SRI assessment method A/B. The user can refer to the PRACTICAL GUIDE SRI CALCULATION FRAMEWORK v 4.4 published on January 18th of 2022 and to the FINAL REPORT ON THE TECHNICAL SUPPORT TO THE DEVELOPMENT OF A SMART READINESS INDICATOR FOR BUILDINGS published in June of 2020
Assessment protocol	The Auditor uses Method B with default weighing as defined in the Calculation sheet for SRI assessment method A/B (V4.4). The Auditor assigns the correct functionality level in each smart ready service of the 9 domains based on the installed and working systems in the building : • Heating (H-1a to H4) • Domestic Hot water (DHW-1a to DHW3) • Ventilation (V-1 to V6) • Lighting (L1 and L2) • Electricity (E2 to E12) The Auditor indicates which systems are actually present in the building based on on-site or virtual inspection of the buildings. The allocation of other user defined domains and systems beyond the ones included by default Method B in is not permitted.
Calculation method / Assessment approach	**Calculation method:** Using V4.4 of the Calculation sheet for SRI assessment method A/B the Auditor is to:

	1. In the building information tab the Auditor is to choose the service catalogue B and leave the preferred weighting to Default and chose only the following domains (Even if other domains are present): • Heating • Domestic Hot water • Ventilation • Lighting • Electricity 2. The Auditor is to choose from the drop down menus the building type, usage and location as and input the building year of construction and useful floor area as per the building information used in the EPC 3. In the Calculation tap the auditor is to indicate the available services as per the installed system or the ones indicated in the final drawing and specification of the building (column I). This process is applicable to the following domain: • Heating (H-1a to H4) • Domestic Hot water (DHW-1a to DHW3) • Ventilation (V-1 to V6) • Lighting (L1 and L2) • Electricity (E2 to E12) 4. For each applicable service the auditor is to choose and indicate the functionality level of the service (column J) and its share (column K) 5. The resulting Total SRI score and rating are to be taken from the Results sheet in the Calculation sheet for SRI assessment method A/B (V4.4)
Data requirements	• Building type, building location (climate zone), construction year and useful floor area • Technical building systems that are present in the building • Smart ready services available in the building • Functionality level and surface share for each smart ready service
Assessors' required qualifications	The level of competence of the assessor must be in compliance with the competence levels defined in the CEN Workshop Agreement (CWA) of TRAIN4SUSTAIN, n° 17939 (october 2022).
Comparability	The comparability of SRI between buildings has several limitations: • The default weighting factors are different depending on the type of building (residential or non-residential) and on the location (climate zone) • The smart readiness score of a building is a percentage that expresses how close (or far) the building is from maximal smart readiness. But the maximum nominal impact score is not simply the sum of all the impacts of the services listed in the SRI catalogue. It is very likely that due to local and site-specific context some domains and services are not relevant, not applicable or not desirable. The SRI methodology accommodates this by performing a triage process to identify the relevant services for a specific building.

3.2.19 Indicator 19 "Summer thermal discomfort in 2030 and 2050 - Percentage of time outside of thermal comfort range"

Name	**Summer thermal discomfort in 2030 and 2050 - Percentage of time outside of thermal comfort range**
Reference framework	Level(s) indicator 5.1: Protection of occupier health and thermal comfort
Definition and description	This indicator measures the percentage of the year in which building occupants are not satisfied with the summer thermal conditions within a building based on the climate condition projections for the years 2030 and 2050. Thermal comfort in summer months is guaranteed when the indoor temperature in those spaces or zones that account for >10% of the total useful floor area of a building does not exceed 27°C. In conjunction with this, it is also intended to measure the ability of a building (with and without building services) to meet predefined thermal comfort conditions during the cooling season
Objectives / Justification	The climate is set to change in the future and the heat waves, as well as tropical nights, are expected to become more frequent and sever in the years 2030 and 2050, which can pose a significant health risk to vulnerable groups. Given the longevity of buildings, this indicator is intended to help identify and implement climate adaptation measures that can minimize the risk of overheating and maintain an acceptable degree of thermal comfort in the summer. The indicator follows basically the same methodology as Indicator 9 (Time outside of thermal comfort range), except that it uses projections for future climate in 2030 and 2050 to measure the thermal performance of the building instead of past weather data
Unit of measurement	The percentage of time [%] in which the indoor temperature exceeds 27 °C during the cooling season (summer months).
System boundary	The performance of the building to keep the indoor temperature below the 27 °C thresholds should be evaluated with or without mechanical cooling. For buildings with full or mixed mechanical cooling, the performance of the building envelope without the operation of these mechanical systems shall be evaluated. This is to evaluate the inherent thermal resistance of the building envelope. The indicator must include the internal operating temperature and the comfort conditions of the users within the building. The specified performance must apply to the rooms or zones that account for more than 10% of the total floor area of the building.
Certification case	1. New buildings: In the form of a calculation process 2. Existing buildings (in use): In the form of a calculation process 3. Under major renovation buildings: In the form of a calculation process
Scope	Both residential and non-residential buildings
Reference standards	• The calculation of the reported performance shall be based on a dynamic energy simulation complying with the ISO EN 52000-1 series . • Overheating assessment that is part of a national calculation method shall be accepted if it is based on a dynamic simulation method similar to one above mentioned standard. • Dynamic simulations shall be performed using weather files for the site or region based on reliable climate projections for 2030 and 2050. • The climate projection modeling must be based on the UN IPCC Mitigation emissions scenario (SRES E1 or RCP 6.0). In all cases, the

	source of the climate projections and associated weather files for 2030 and 2050 must be clearly stated. • ISO 52016-1:2017 Energy performance of buildings — Energy needs for heating and cooling, internal temperatures and sensible and latent heat loads
Assessment protocol	The indicator's objective is to measure the percentage of time in the years 2030 and 2050 in which the indoor temperature exceeds 27 °C during the cooling season (summer months) for every zone in the building that occupies 10% or of the total floor area. The assessor shall be able to: • Document the weather file used • Document the climate projection year, weather file • Document the evaluated zones in the building • Document the Mitigation emissions scenario used (SRES E1 or RCP 6.0). • Document the used building thermal and physical values • Document the performance characteristics and operating regimes of the actual or simulated cooling systems • Document the building the use and occupancy profile used • Document the length of the cooling period for the years 2030 and 2050 • Document the dynamic simulation method used
Calculation method / Assessment approach	**Calculation method:** • Select reliable climate projections for 2030 and 2050 based on the UN IPCC mitigation emissions scenario SRES E1 or RCP 6.0, that are intended for the site or region. • Identify whether the national/regional calculation method is dynamic and whether an overheating assessment is also required in order to obtain a building permit. • If the national/regional calculation method is dynamic, this may be used to calculate the time out of range. If not, a dynamic simulation method and the software tool will need to be selected for use. • Determine if default values for the building occupancy and conditions of use patterns are stipulated in a national calculation method, or whether real-life assumptions can be made. • Run the simulation in order to obtain the internal temperatures per hour for a year for each thermal space or zone that accounts for >10% of the total useful floor area of a building. • Calculate the average value of the global building indoor temperature, weighted on the surface areas and the occupancy intensity of the different thermal spaces or zones. • If the simulation does not automatically calculate the time out of range, the result shall be analyzed in order to derive the percentages for the upper and lower temperature bands.
Data requirements	The input data collected by the assessors shall be compliant with the input data required in the ISO EN 52000-1 series. Examples of requested input data are listed below: • Details about building envelope and windows U values and construction method (can be substituted by data from construction year class for existing buildings) • Building openings and orientation • Weather files for the years 2030 and 2050 • Building usage and occupancy profiles as per national definitions for the building type and use • Characteristics of the building cooling and technical systems

	• External and internal thermal loads • Cooling period as per national definitions Dynamic simulations shall be performed using weather files for the site or region based on reliable climate projections for 2030 and 2050. The climate projection modeling must be based on the UN IPCC Mitigation emissions scenario (SRES E1 or RCP 6.0).
Assessors' required qualifications	The level of competence of the assessor must be in compliance with the competence levels defined in the CEN Workshop Agreement (CWA) of TRAIN4SUSTAIN, n° 17939 (october 2022).
Comparability	The results of the indicator are comparable between the buildings that share the same usage, cooling period, and climatic location as long as the same dynamic simulation method and climatic projection weather file are used.

3.2.20 Indicator 20 "Installation of pre-cabling / number of recharging points in relation to the number of parking spaces "

Name	**Installation of pre-cabling / number of recharging points in relation to the number of parking spaces**
Reference framework	EPBD recast - art.12 (Infrastructure for sustainable mobility)
Definition and description	This indicator measures the building's readiness for sustainable transport, smart energy management and grid flexibility.
Objectives / Justification	Electric vehicles combined with an increased share of renewable electricity production play a crucial role for reducing greenhouse gas emissions and decarbonisation of the electricity system by providing flexibility, balancing and storage services. The number of available purpose built recharging points is crucial for the establishment of electric vehicles. Electric vehicles park regularly and for long periods, giving the opportunity to recharge. Buildings, especially those where people park for reasons of residence or employment, therefore play a crucial role in providing the necessary infrastructure for re-charging. Moreover, the installation of recharging points at building's parking lots is not only a useful service to the users but can also provide energy storage to the related building. The (pre-) equipping of parking spaces provides a rapid and cost-efficient installation of recharging points for individual owners and ensures the required access to recharging points.
Unit of measurement	Percentage of recharging points and installed pre-cabling in relation to the number of parking spaces in %.
System boundary	The assessment boundary is set at the building's parking lot respectively the area where the building's users park their vehicles as defined by the building construction permit.
Certification case	1) New buildings: In the form of a calculation process based on the building permit 2) Existing buildings (in use): in the form of a calculation process based on the existing on-site parking situation 3) Under major renovation buildings: in the form of a calculation process based on the construction permit

Scope	Both residential and non-residential buildings.
Reference standards	Proposal for the EPBD recast: • Article 12 defines the amount of recharging points that have to be installed and pre-cabled in new buildings, existing non-residential buildings or buildings undergoing major renovation, depending on the amount of parking spaces and the usage of the building (residential, non-residential, offices,…).
Assessment protocol	The assessor is to determine the percentage of the parking space that are fitted with purpose built electric recharging spaces to the total amount of parking spaces. Installed charging facilities count 100%, pre-cabled recharging facilities count 50%.
Calculation method / Assessment approach	1. Determine the number of car parking spaces allocated from the building 2. Count the number of parking spaces in which a purpose built recharging station is provided 3. Count the number of parking spaces with pre-cabled recharging stations 4. Divide the sum of the e-parking spaces and 50% of the pre-cabled recharging stations by the total number of available parking space to get the ratio.
Data requirements	• Number of parking spaces • Number of purpose built electrical recharging spaces • Number of pre-cabled recharging spaces
Assessors' required qualifications	The level of competence of the assessor must be in compliance with the competence levels defined in the CEN Workshop Agreement (CWA) of TRAIN4SUSTAIN, n° 17939 (october 2022).
Comparability	The ratio of e-car parking spaces to can be compared between the buildings that share the same use and construction status (newly built- in use – major renovation)

3.2.21 Indicator 21 "Daylight provision"

Name	**Daylight provision**
Reference framework	**CEN European Daylight Standard EN 17037 – Daylighting in buildings**[50], paragraph 5.1.2 *Criteria for daylight provision* and paragraph 5.1.3 *Daylight Provision Calculation Methods*.
Definition and description	Daylight can contribute significantly to the lighting needs of any type of building and accordingly, to improving the energy performance of buildings. Daylight can provide significant quantities of light indoors, views and connection to the outside and exposure to sunlight indoors and effects the human health and performance Sufficient daylight should be provided in main rooms throughout the year.
Objectives / Justification	Daylight can contribute significantly to the lighting needs of any type of building and accordingly, in improving the energy performance of buildings. This means that daylight openings should have appropriate areas to provide sufficient daylight throughout the year. Moreover, it is not to overlook the fact that light impacts human health and performance by enabling performance of visual tasks, controlling the

[50] https://standards.iteh.ai/catalog/standards/cen/836e5b91-1eb0-4643-a2ba-7ca5a5988e64/en-17037-2018

	body's circadian system, affecting mood and perception, and by enabling critical chemical reactions in the body.
Unit of measurement	Daylight provision is measured as percentage [%]
System boundary	The system boundary of the daylight provision is the building. The daylight provision in a space is affected by the buildings' exterior geometry and the external environment
Certification case	**1. New buildings:** The daylight provision is calculated in new buildings accordingly to EN 17037. Paragraph 5.1.3 and Annex B, fully describe the two possible calculation methods. **2. Existing buildings (in use):** Daylight provision can be verified with on-site measurements. It needs to be conducted at grid points of a reference plane, as described by the standard EN 17037 in Annex B. **3. Under major renovation buildings:** The daylight provision is calculated in under major renovation buildings accordingly to EN 17037. Paragraph 5.1.3 and Annex B, fully describe the two possible calculation methods.
Scope	Both residential and non-residential buildings.
Reference standards	Daylight provision indicator is developed in accordance with EN 17037.
Assessment protocol	The **calculation** of the daylight provision in building relies on what stated by EN 17037–Daylighting in buildings in paragraph 5.1.3-Daylight Provision Calculation Methods and in Annex B of the standard. For the **measurement of the daylight** in as-built performance and in-use phase, it is necessary to measure the indoor and outdoor illuminance level simultaneously, through the use of the luxmeter.
Calculation method/Assessment approach	**Calculation method:** The daylight provision is calculated in new buildings and under major renovation buildings accordingly to EN 17037. Paragraph 5.1.3 fully describes the two possible calculation methods: Method 1) Calculation method using daylight factors on the reference plane. • Identify the grid of points on the plane • Predict the daylight factors across the plane • Calculate the target daylight factor D_T and D_{TM} • Ensure that the daylight factors equal or exceed the target values (D_{TM} and D_T). Method 2) Calculation method of illuminance levels on the reference plane using climatic data for the given site and an adequate time step. • Simulate illuminance values on the reference plane based on hourly internal daylight illuminance values • Ensure that the targeted illuminance levels are achieved or exceeded. Annex A gives values for target illuminances and minimum target illuminances to be achieved. Annex B describes recommendations for the daylight calculations using the two methods.

<table>
<tr><td></td><td>Assessment approach (as built and in-use):
After the completion of a building, it is important to verify the compliance of the as built performance with what stated in the design phase for the daylight provision. Steps to be followed are described below:
Identify several measuring points in each main room of the building
Conduct the measurements with a luxmeter
At the same time measure the external values (best in overcast conditions with no direct solar radiation). In addition to the luxmeter and if necessary, a shadow ring could be used.
Calculate the average daylight factor making a ratio between the average indoor values measured and the average outdoor values.
In case of the in-use building, some adjusting must be adopted to obtain an accurate measurement (curtains drawn, obstruction resulting from the furniture, absence of occupants, etc.).</td></tr>
<tr><td>Data requirements</td><td>Data requirements for calculating daylight provision are the followings:

Method 1:
Specific climatic data (sky luminance, daylight time, global solar radiation, building's orientation)
External surroundings (balconies, obstructions, etc.);
Internal characteristics of the room (geometry, partition and surface reflectance);
Dimension of the vertical façade windows;
Daylight openings (glazing, material and components).
Method 2:
Climate data (hourly sky and sun conditions)
Internal characteristics of the room (geometry, partition and surface reflectance).
Device used to measure daylight provision is the luxmeter. There are different kind of luxmeters which differ from each other by resolution, measure range and class Some adjusting must be adopted to obtain an accurate measurement (curtains drawn, obstruction resulting from the furniture, absence of occupants, etc.)</td></tr>
<tr><td>Assessors' required qualifications</td><td>The daylight provision shall be calculated and metered by an assessor with knowledge about the EN 17037, the standard specifying elements for achieving an impression of lightness indoors and for providing an adequate view out.
The daylight provision shall be metered by an assessor with knowledge about EN 17037.

The level of competence of the assessor must be in compliance with the competence levels defined in the CEN Workshop Agreement (CWA) of TRAIN4SUSTAIN, n° 17939 (october 2022).</td></tr>
<tr><td>Comparability</td><td>Concerning the daylight provision calculation, comparability relies on the reference standard to be used for data assessment.

For the measurement, comparability relies on the typology of instrument used (class, resolution, etc.) and on the correct time alignment of the indoor and outdoor measurements.</td></tr>
</table>

3.3 Elements of analysis – First conclusions on KPIs

These 21 KPIs are not only a list of indicators, but a **system of indicators**.

This means that:

- some of them are linked together, especially in the energy and GHG thematic areas,
- an overall coherence / consistency and homogeneity are necessary, in terms of terminology, units, system boundaries, methodology, results reporting, etc.
- the space-based indicators, as in the comfort and health issues, shall have consistent perimeters and a common methodology when addressing the types of spaces to be studied and the aggregation of results at the building scale.

At this point of work, coherence / consistency and homogeneity have progressed during T 2.2 work, but needs to continue to progress in T 2.5 and during the CEN workshop process. The deliverable D2.5 will constitute an improvement on D2.2. Then, the CWA, final document on the KPIs, will constitute the more advanced, coherent and consensual document, continuation of EUB SuperHub project. In the future, EUB SuperHub KPIs will have the opportunity to evolve from a CWA to another type of normative document.

As standards are evolutive texts (every 5 years a revision is proposed) the description and assessment (by calculation or measurement) of KPIs is supposed to evolve. This is a more accurate issue when standards are currently under revision, as EN 15978, with on-going methodological discussions, and when the coherence / consistency with recently revised standards is not yet ensured. This is particularly the case between EN 15804 on construction products LCA, revised in 2019, and EN 15978 on building LCA, which is still under revision mid-2023, while depending of / relying on EN 15804. So, the description of KPIs must be flexible enough to allow adaptation due to standardization evolution.

Flexibility in result reporting is also necessary, so as to welcome diverse maturity levels of KPIs assessment, when testing the 21 KPIs through EU. So, clear reporting formats (with sub-indicators) will be necessary, together with transparency in methodology and system boundary compliance explanations.

Last but not least, as EPBD recast process is still ongoing, the documents on which we can rely on are proposal or intermediate texts, not final, so the list of

KPIs and the contents on the EUB e-Passport will need to be reviewed and up-dated at the end of the EUB SuperHub project.

D2.2 constitutes an important step towards European harmonized KPIs for EPCs and building passport, and next EUB SuperHub results and CWA will constitutes the next steps.

3.4 Useful links

Level(s) website of European Commission DG ENV:

https://environment.ec.europa.eu/topics/circular-economy/levels_en

Level(s) framework technical documents on JRC website:

https://susproc.jrc.ec.europa.eu/product-bureau//product-groups/412/documents

CESBA MED Interreg project (completed in 2019):

https://cesba-med.interreg-med.eu/

https://cesba-med.interreg-med.eu/results/deliverables/

TRAIN4SUSTAIN website:

https://train4sustain.eu/

4 Transnational comparison of nationally used indicators and metrics

4.1 Readiness and Maturity Survey

Th second objective of Task 2.2 is to conduct a transnational comparison of nationally used indicators and metrics in order to check the level of "readiness and maturity" of PPs. In a first step, a list of the indicators constituting national sustainability certification protocols was compiled based on T1.1 output "Mapping of EPCs and sustainability certifications". This list can be found in the annex of this document. Once the national sustainability indicators corresponding to SuperHub's KPIs were identified from those listed, an analysis was carried out by letting the PPs answer the 5 questions listed below about the existence of defined calculation methods and assessment approaches in their national regulation or environmental certification/labelling, the existence of numerical calculation tools, and the availability of qualified and experienced assessors to calculate these indicators.

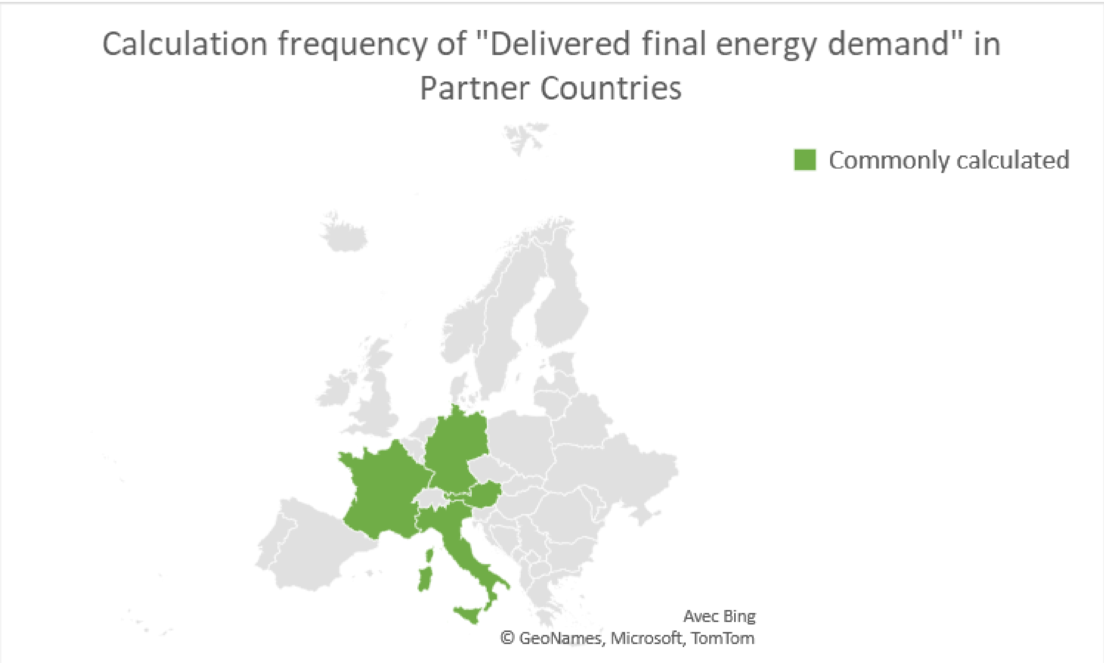
1. Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labelling for this indicator?
2. Numerical tools responding to national requirements/directives for the calculation of the indicator are easily available?
3. Is input data accessibility/availability simple for this indicator?
4. Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?
5. Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare?

The results obtained led to the construction of a "readiness and maturity map" showing the discrepancy in the familiarity with these indicators of different Countries. This analysis may be used in a future step of the EUB SuperHub project in order to divide the retained passport's KPIs in "Certainly calculated" and "Optionally calculated".

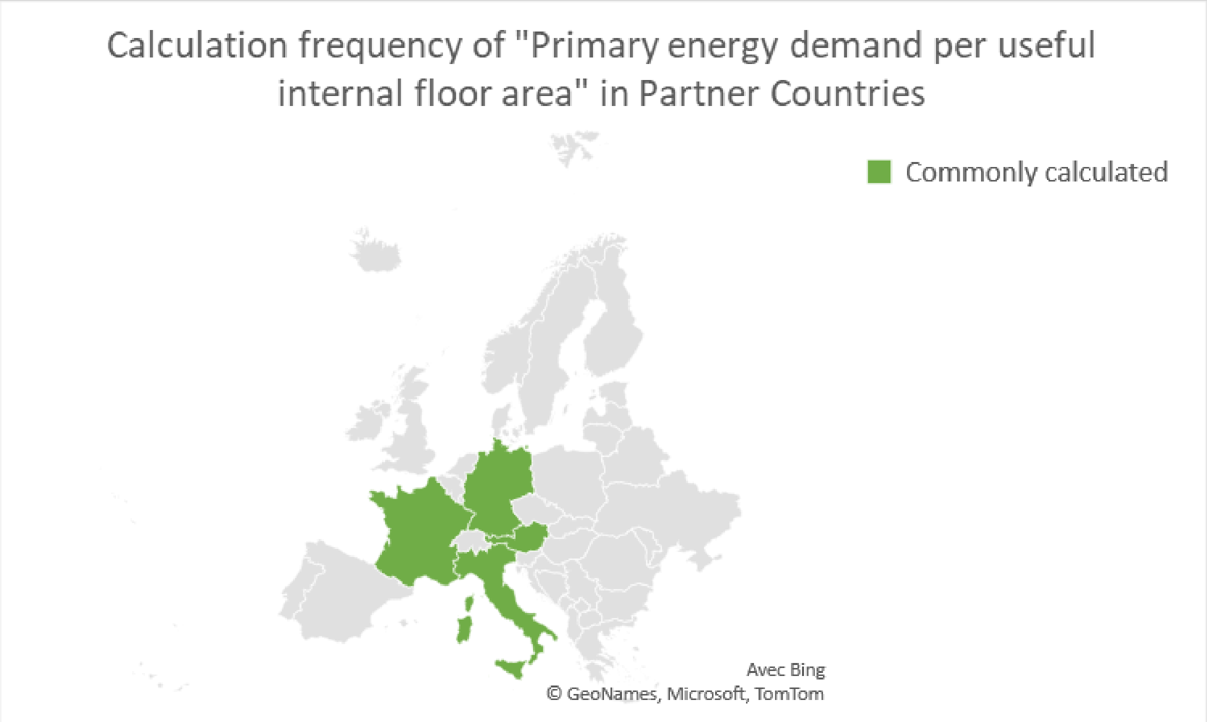
4.2 Mapping of the "readiness and maturity" level of project partners

In this section, the results obtained for each indicator can be found.

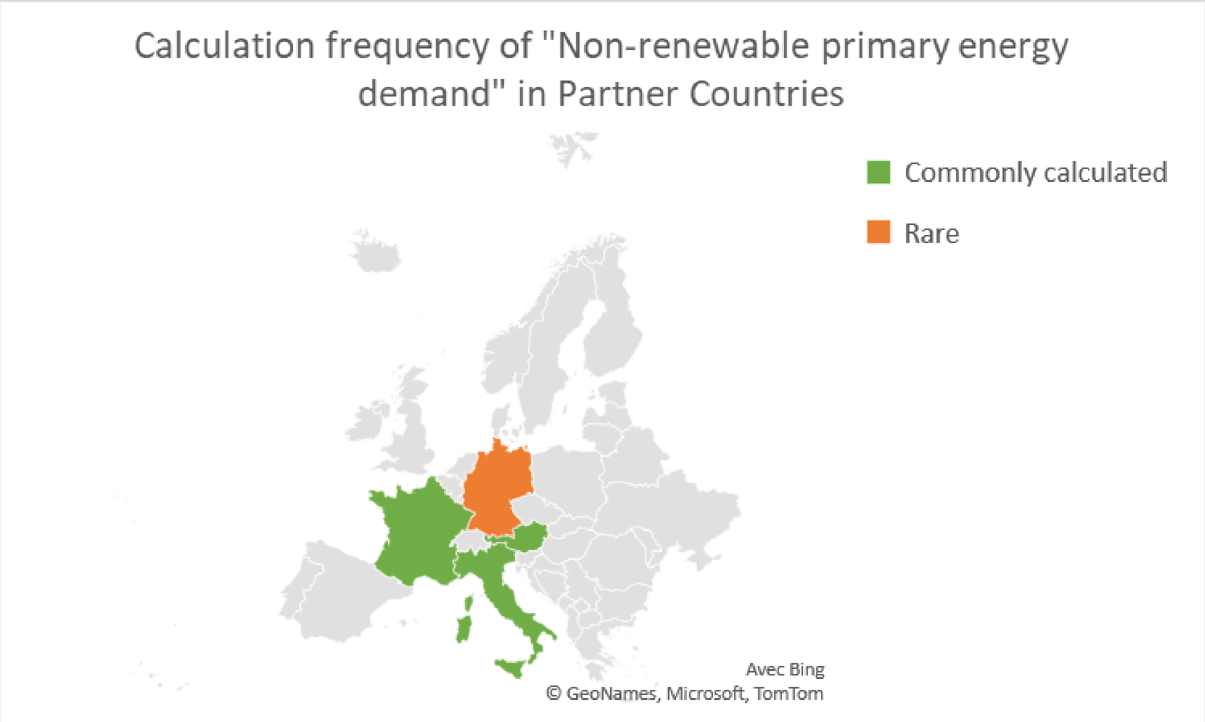
KPI 1	Delivered final energy demand per useful floor area				
	Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labeling for this indicator?	Are numerical tools responding to national requirements/directives for the indicators calculation easily available?	Is input data accessibility/availability simple for this indicator?	Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?	Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare?
Country	Answer	Answer	Answer	Answer	Answer
Austria	Yes	Yes	Yes	Yes	Commonly calculated
France	Yes	Yes	Yes	Yes	Commonly calculated
Germany	Yes	Yes	Yes	Yes	Commonly calculated
Italy	Yes	Yes	Yes	Yes	Commonly calculated



KPI 2	Total primary energy demand per useful floor area				
	Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labeling for this indicator?	Are numerical tools responding to national requirements/ directives for the indicators calculation easily available?	Is input data accessibility/ availability simple for this indicator?	Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?	Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare ?
Country	Answer	Answer	Answer	Answer	Answer
Austria	Yes	Yes	Yes	Yes	Commonly calculated
France	Yes	Yes	Yes	Yes	Commonly calculated
Germany	Yes	Yes	Yes	Yes	Commonly calculated
Italy	Yes	Yes	Yes	Yes	Commonly calculated

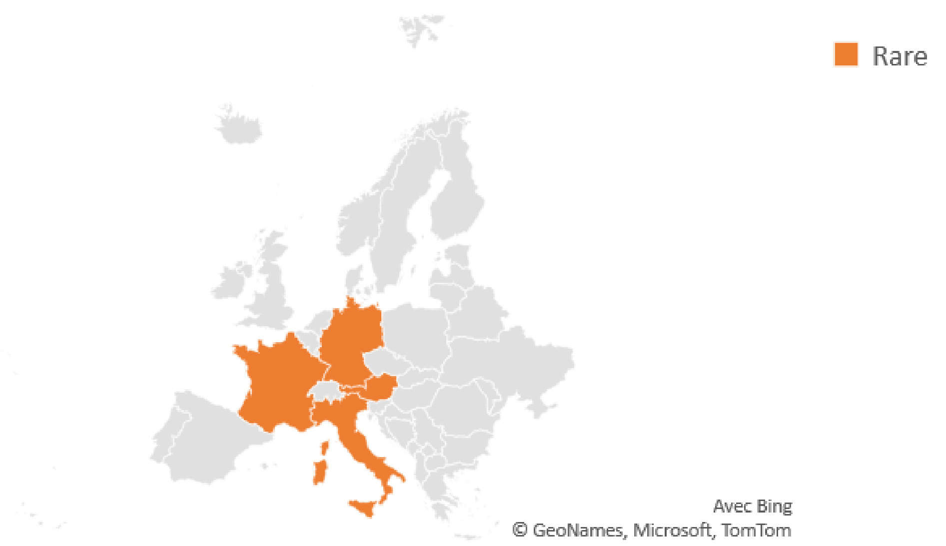


KPI 3	Non-renewable annual primary energy demand per useful floor area				
	Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labeling for this indicator?	Are numerical tools responding to national requirements/directives for the indicators calculation easily available?	Is input data accessibility/availability simple for this indicator?	Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?	Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare?
Country	Answer	Answer	Answer	Answer	Answer
Austria	Yes	Yes	Yes	Yes	Commonly calculated
France	Yes	Yes	Yes	Yes	Commonly calculated
Germany	No	/	/	Yes	Rare
Italy	Yes	Yes	Yes	Yes	Commonly calculated

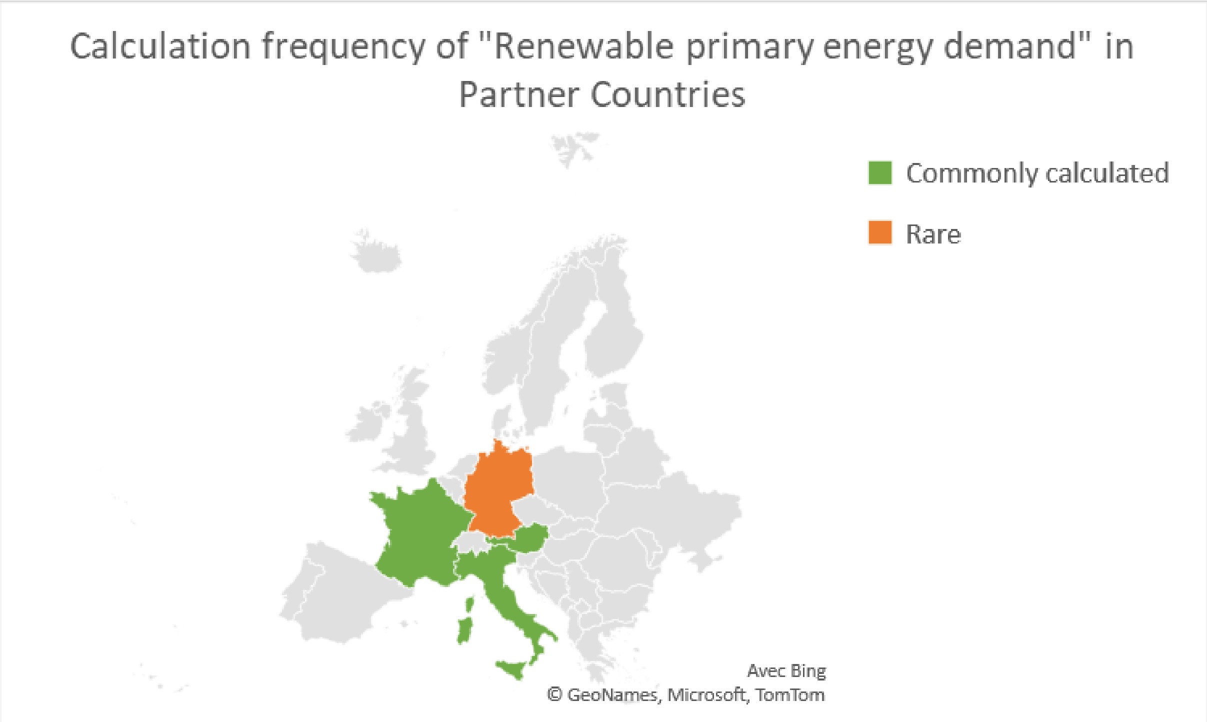


KPI 4	Embodied energy (non-renewable primary energy)				
	Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labeling for this indicator?	Are numerical tools responding to national requirements/ directives for the indicators calculation easily available?	Is input data accessibility/ availability simple for this indicator?	Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?	Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare ?
Country	Answer	Answer	Answer	Answer	Answer
Austria	No	No	No	No	Rare
France	No	No	No	No	Rare
Germany	No	/	/	/	Rare
Italy	No	No	No	No	Rare

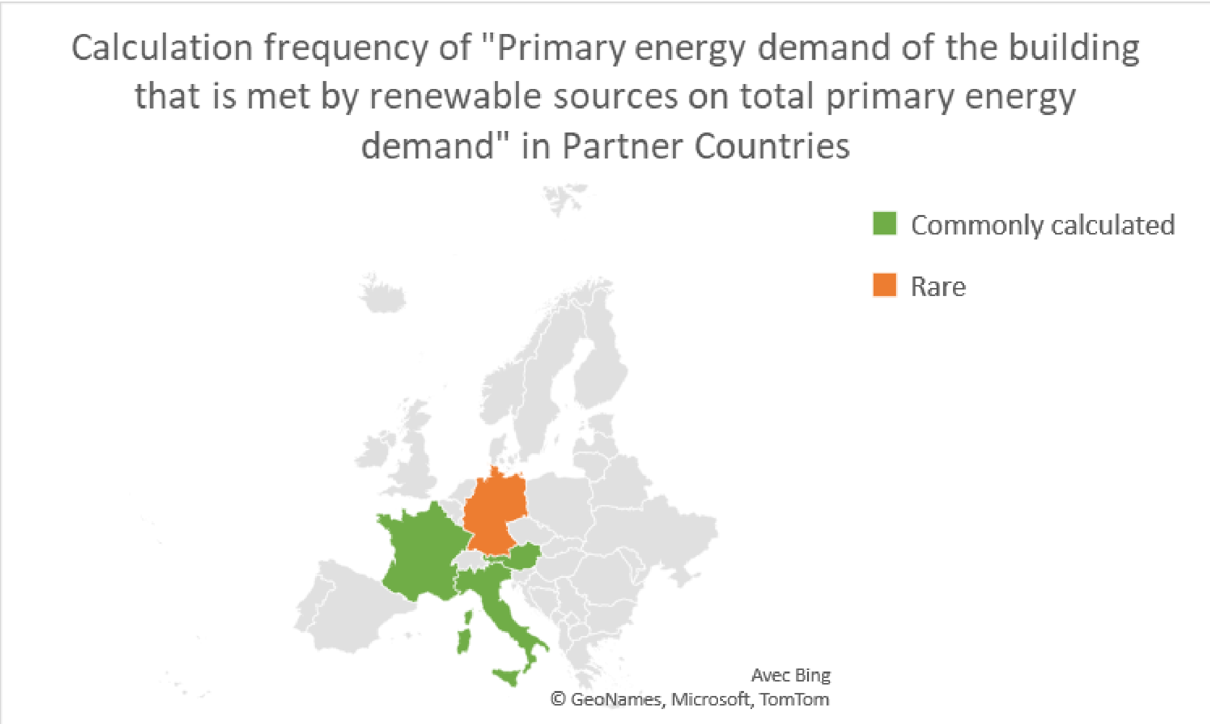
Calculation frequency of „Embodied Energy (non-renewable primary energy)” in Partner Countries



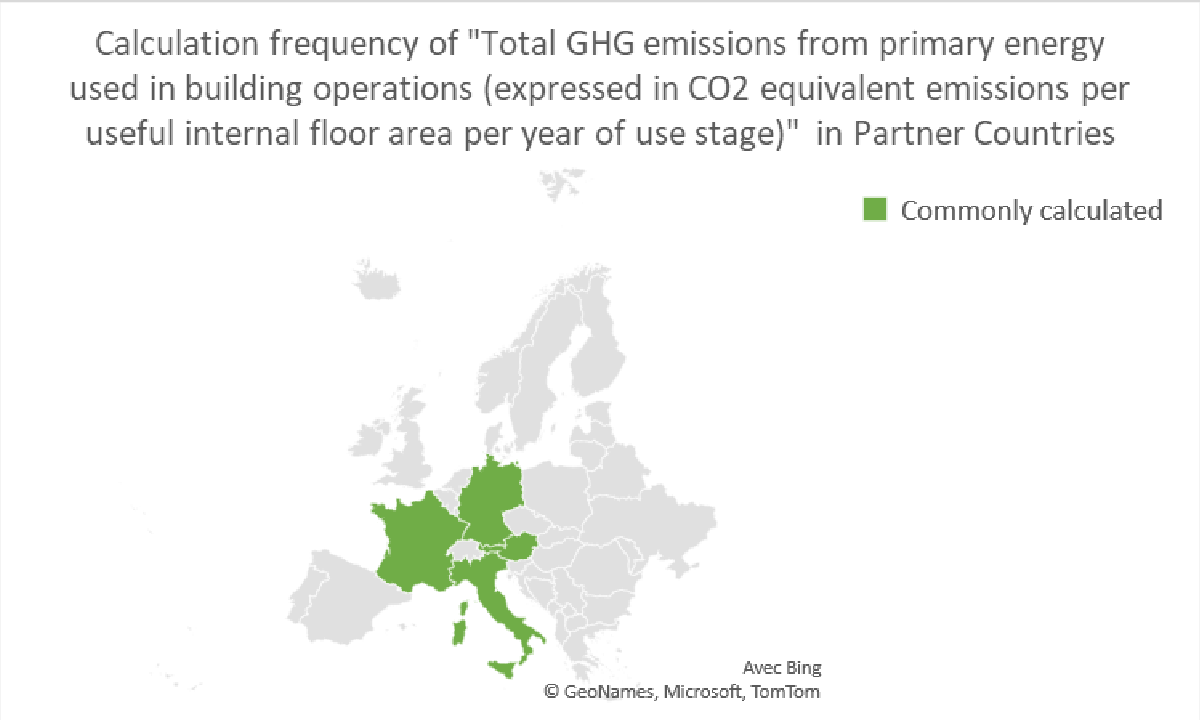
KPI 5	Renewable annual primary energy demand				
	Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labeling for this indicator?	Are numerical tools responding to national requirements/ directives for the indicators calculation easily available?	Is input data accessibility/ availability simple for this indicator?	Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?	Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare ?
Country	Answer	Answer	Answer	Answer	Answer
Austria	Yes	Yes	Yes	Yes	Commonly calculated
France	Yes	Yes	Yes	Yes	Commonly calculated
Germany	No	/	/	Yes	Rare
Italy	Yes	Yes	Yes	Yes	Commonly calculated



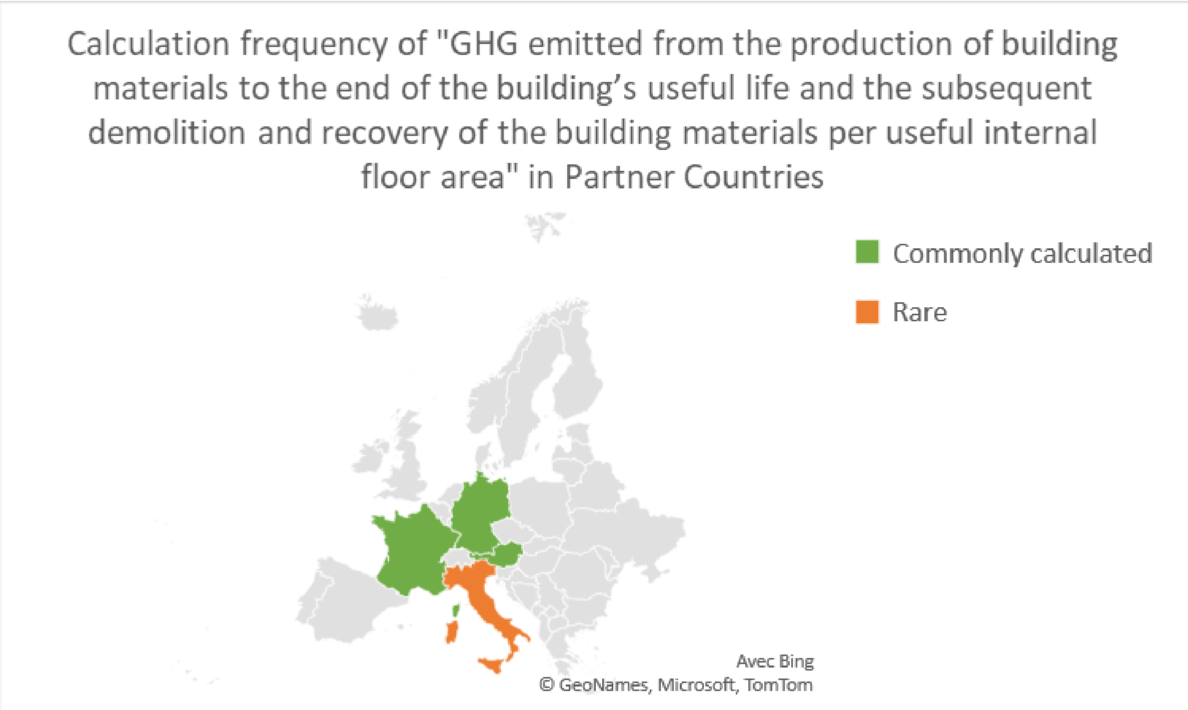
KPI 6	Renewable energy ratio				
	Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labeling for this indicator?	Are numerical tools responding to national requirements/ directives for the indicators calculation easily available?	Is input data accessibility/ availability simple for this indicator?	Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?	Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare ?
Country	Answer	Answer	Answer	Answer	Answer
Austria	Yes	Yes	Yes	Yes	Commonly calculated
France	Yes	Yes	Yes	Yes	Commonly calculated
Germany	No	/	/	Yes	Rare
Italy	Yes	Yes	Yes	Yes	Commonly calculated



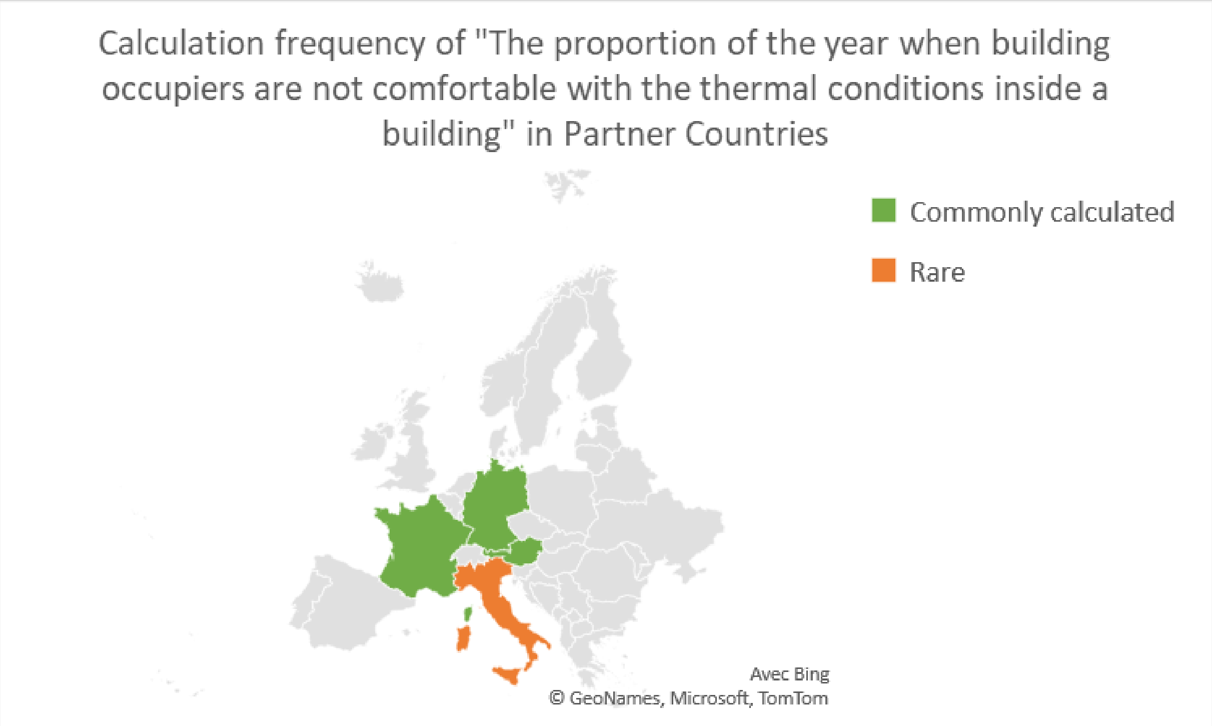
KPI 7	Annual use stage energy-related Global Warming Potential (GWP)				
	Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labeling for this indicator?	Are numerical tools responding to national requirements/ directives for the indicators calculation easily available?	Is input data accessibility/ availability simple for this indicator?	Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?	Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare ?
Country	Answer	Answer	Answer	Answer	Answer
Austria	Yes	Yes	Yes	Yes	Commonly calculated
France	Yes	Yes	Yes	Yes	Commonly calculated
Germany	Yes	Yes	Yes	Yes	Commonly calculated
Italy	Yes	Yes	Yes	Yes	Commonly calculated



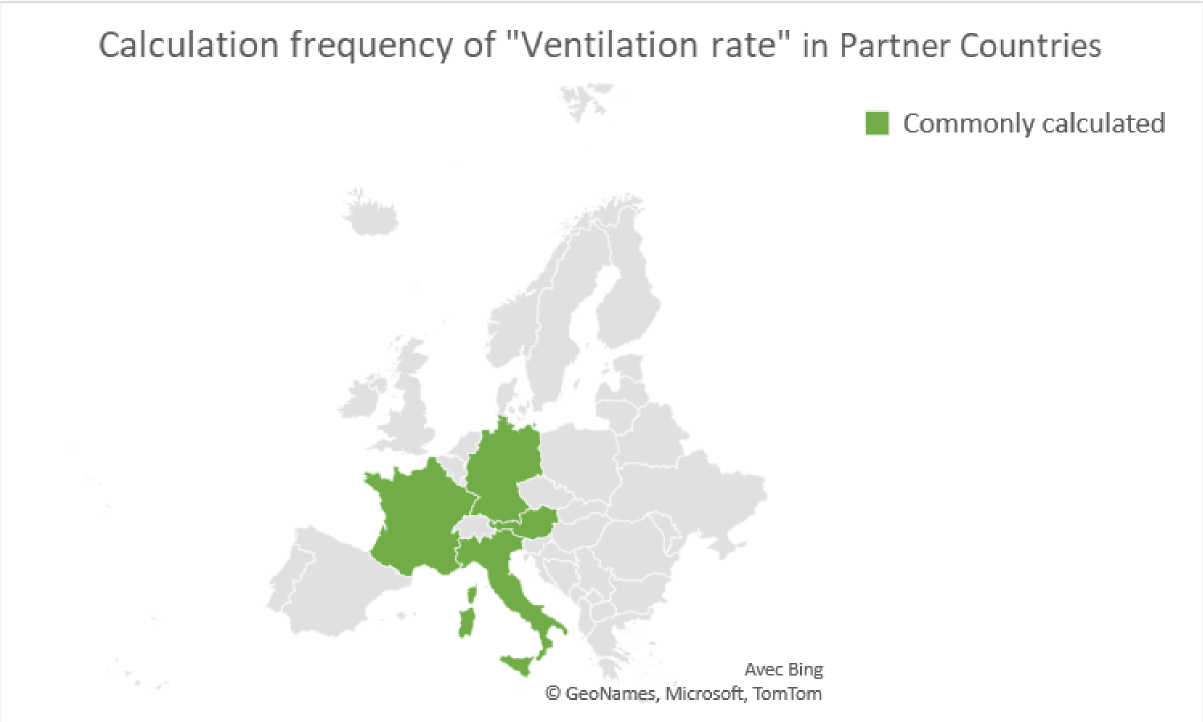
KPI 8	Life Cycle Global Warming Potential (GWP)				
	Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labeling for this indicator?	Are numerical tools responding to national requirements/ directives for the indicators calculation easily available?	Is input data accessibility/ availability simple for this indicator?	Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?	Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare ?
Country	Answer	Answer	Answer	Answer	Answer
Austria	Yes	Yes	Yes	Yes	Commonly calculated
France	Yes	Yes	No	Increasingly easy	Commonly calculated
Germany	Yes	Yes	Yes	Yes	Commonly calculated
Italy	No	No	No	No	Rare



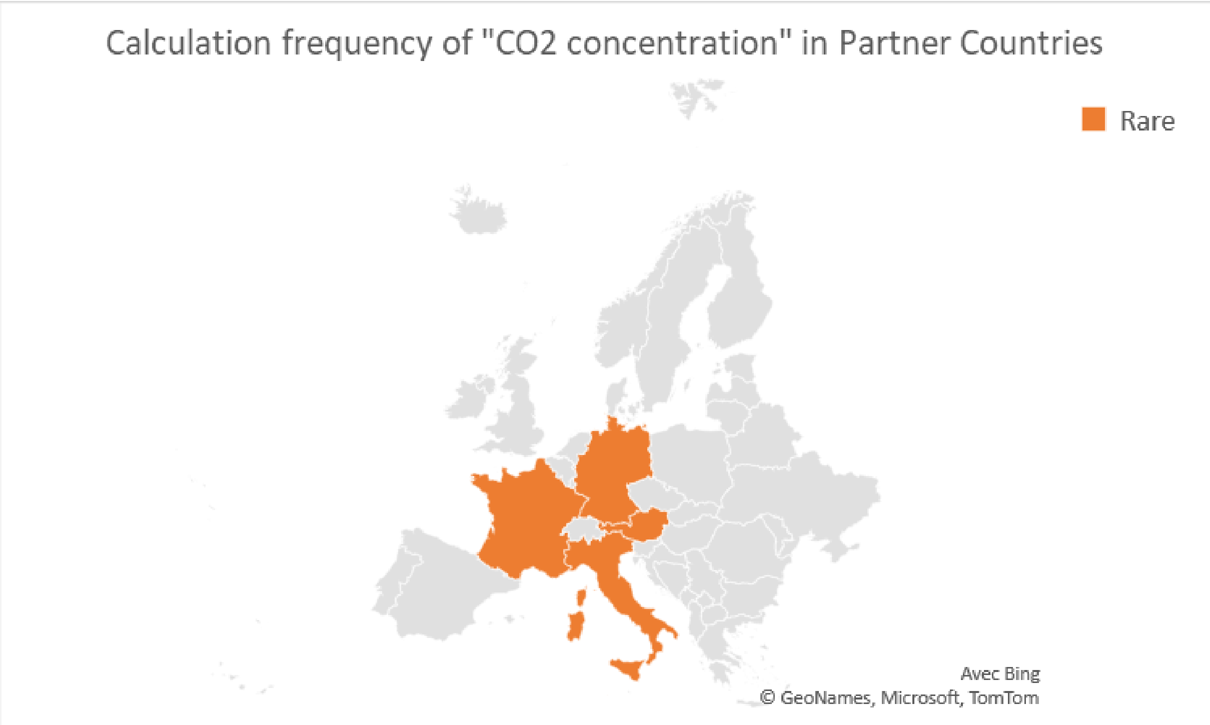
KPI 9	Percentage of time outside of thermal comfort range				
	Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labeling for this indicator?	Are numerical tools responding to national requirements/directives for the indicators calculation easily available?	Is input data accessibility/availability simple for this indicator?	Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?	Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare?
Country	Answer	Answer	Answer	Answer	Answer
Austria	Yes	Yes	Yes	Yes	Commonly calculated
France	Yes	Yes	Yes	Yes	Commonly calculated
Germany	Yes	Yes	Yes	No	Commonly calculated
Italy	No	No	No	No	Rare



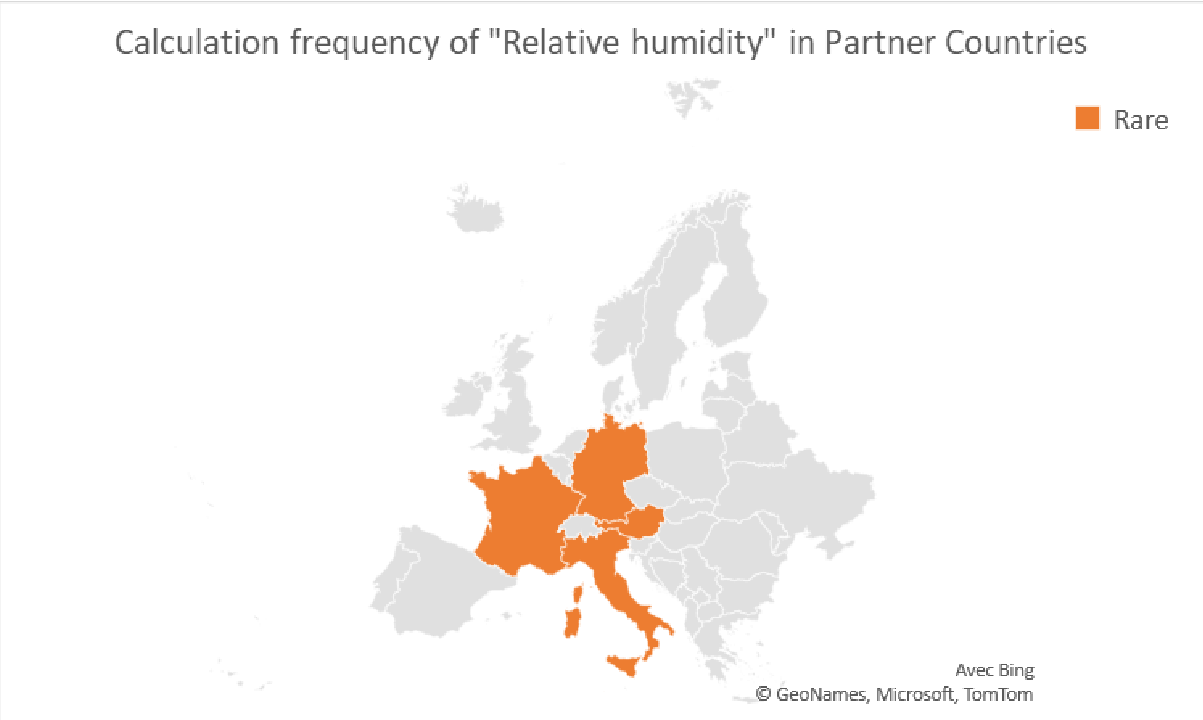
KPI 10	Ventilation rate				
	Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labeling for this indicator?	Are numerical tools responding to national requirements/ directives for the indicators calculation easily available?	Is input data accessibility/ availability simple for this indicator?	Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?	Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare ?
Country	Answer	Answer	Answer	Answer	Answer
Austria	Yes	Yes	Yes	Yes	Commonly calculated
France	Yes	Yes	Yes	Yes	Commonly calculated
Germany	Yes	Yes	Yes	No	Commonly calculated
Italy	Yes	No	Yes	Yes	Commonly calculated



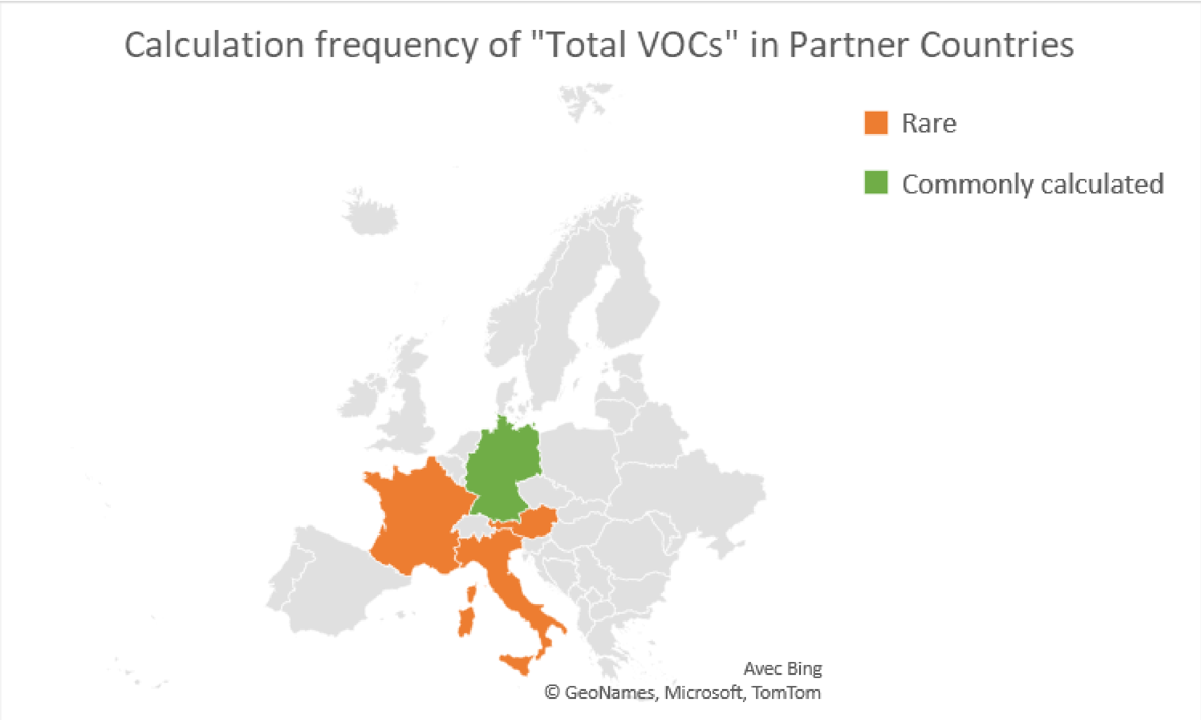
KPI 11	CO_2 concentration				
	Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labeling for this indicator?	Are numerical tools responding to national requirements/ directives for the indicators calculation easily available?	Is input data accessibility/ availability simple for this indicator?	Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?	Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare?
Country	Answer	Answer	Answer	Answer	Answer
Austria	No	No	No	No	Rare
France	No	No	No	No	Rare
Germany	Yes	No	Yes	No	Rare
Italy	No	No	Yes	Yes	Rare



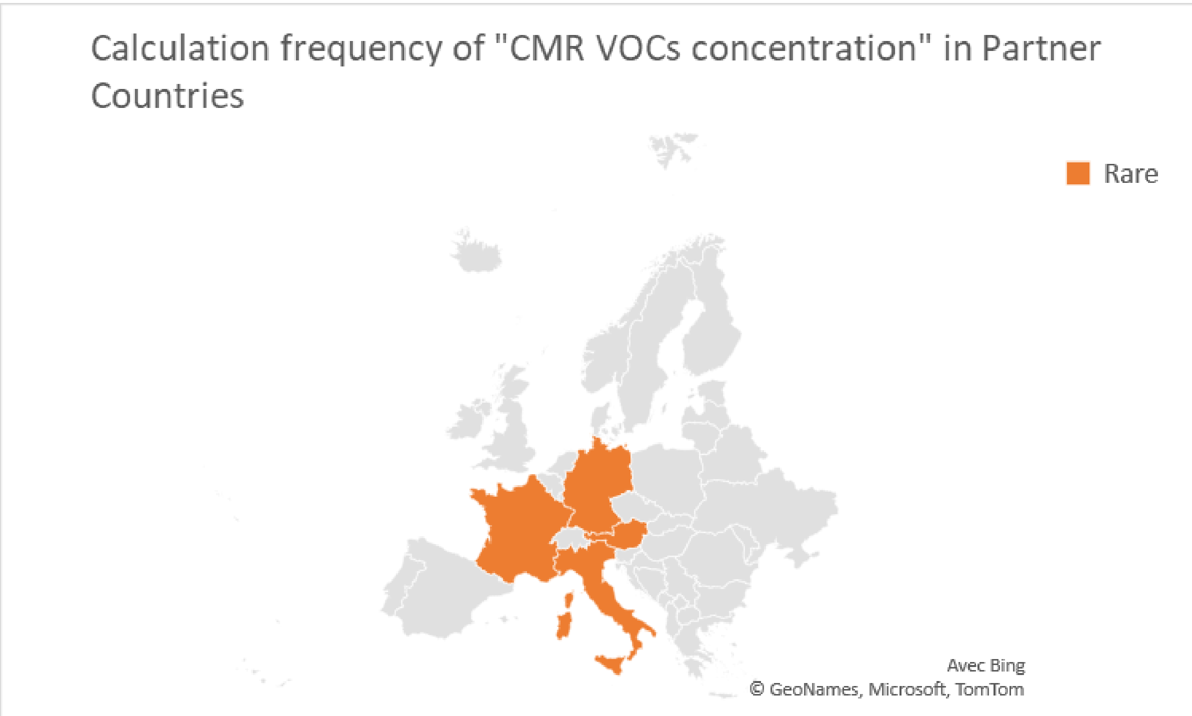
KPI 12	Relative humidity				
	Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labeling for this indicator?	Are numerical tools responding to national requirements/ directives for the indicators calculation easily available?	Is input data accessibility/ availability simple for this indicator?	Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?	Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare ?
Country	Answer	Answer	Answer	Answer	Answer
Austria	Yes	Measured indicator	Yes	Yes	Rare
France	No	No	No	No	Rare
Germany	No	/	/	/	Rare
Italy	No	No	Yes	Yes	Rare



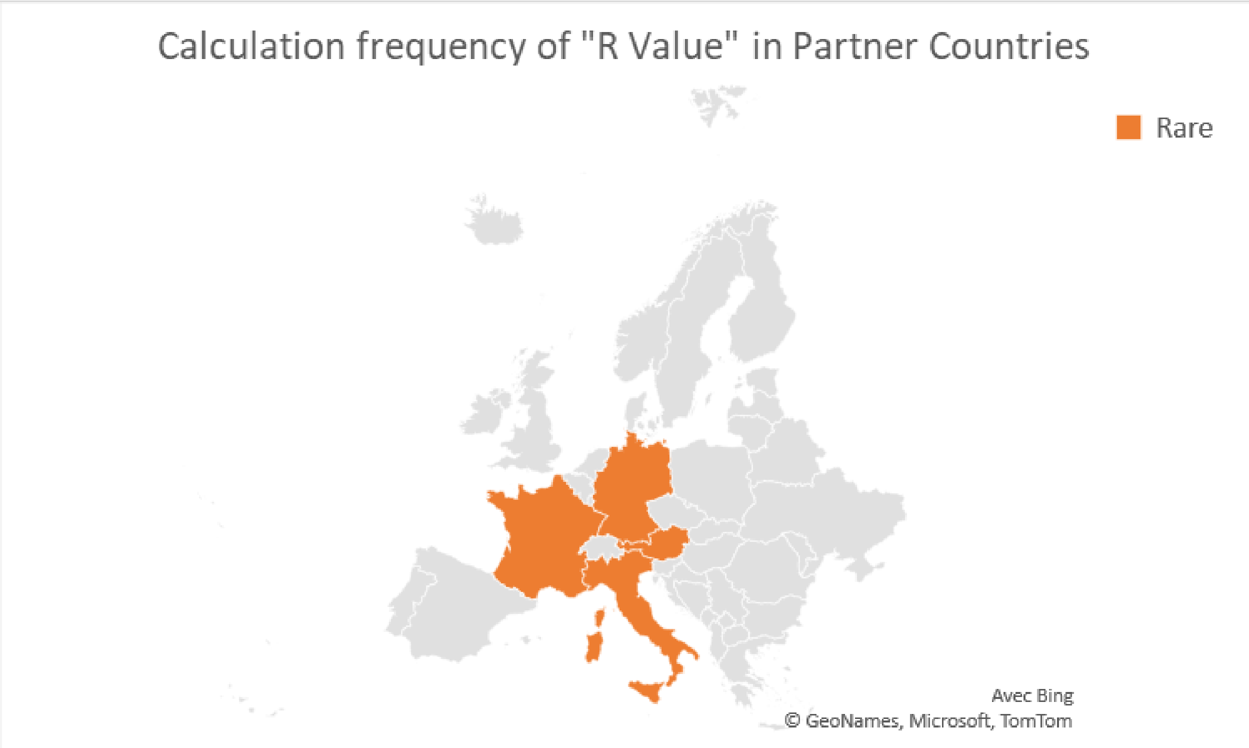
KPI 13	Total VOCs				
	Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labeling for this indicator?	Are numerical tools responding to national requirements/ directives for the indicators calculation easily available?	Is input data accessibility/ availability simple for this indicator?	Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?	Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare ?
Country	Answer	Answer	Answer	Answer	Answer
Austria	Yes	Measured indicator	Yes	Yes	Rare
France	Yes	Measured indicator	Yes	Increasingly easy	Rare
Germany	Yes	Measured indicator	Yes	No	Commonly calculated
Italy	No	No	Yes	Yes	Rare



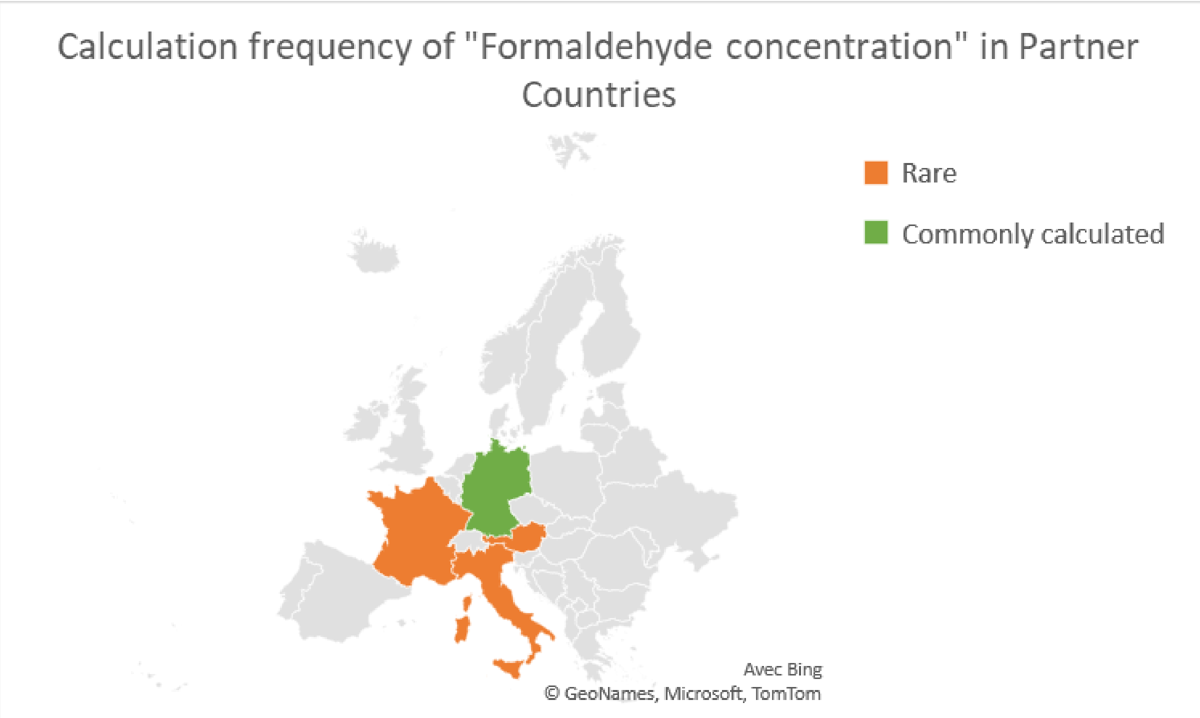
KPI 14	CMR VOCs concentration				
	Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labeling for this indicator?	Are numerical tools responding to national requirements/ directives for the indicators calculation easily available?	Is input data accessibility/ availability simple for this indicator?	Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?	Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare ?
vCountry	Answer	Answer	Answer	Answer	Answer
Austria	No	No	No	No	Rare
France	No	No	No	No	Rare
Germany	No	/	/	/	Rare
Italy	No	No	Yes	Yes	Rare



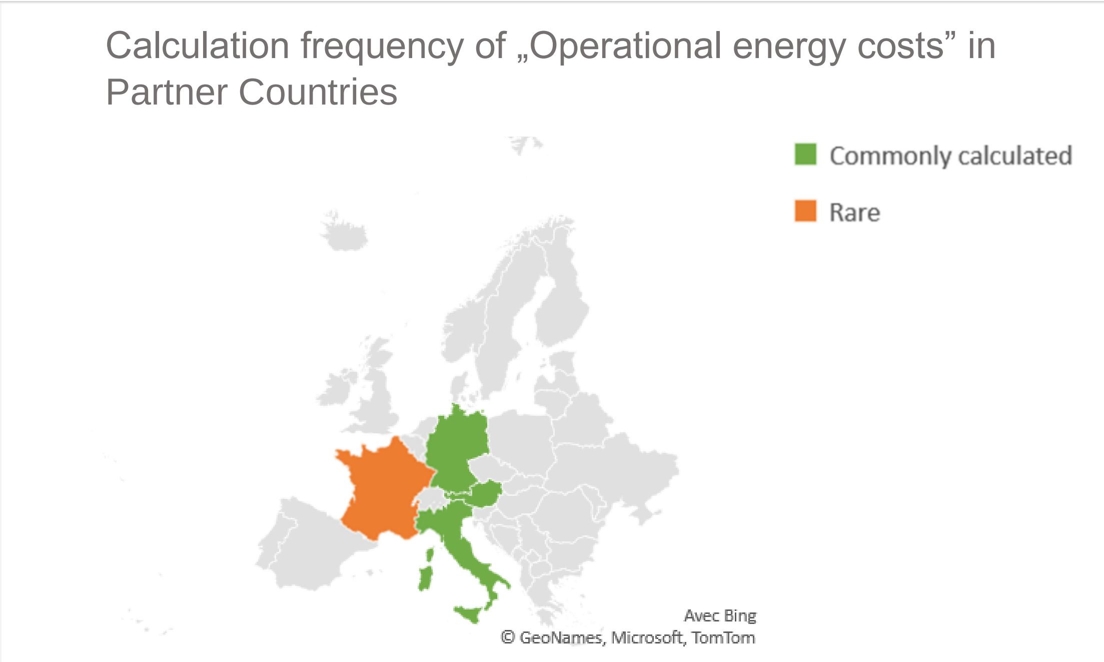
KPI 15	R value				
	Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labeling for this indicator?	Are numerical tools responding to national requirements/ directives for the indicators calculation easily available?	Is input data accessibility/ availability simple for this indicator?	Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?	Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare ?
Country	Answer	Answer	Answer	Answer	Answer
Austria	No	No	No	No	Rare
France	No	No	No	No	Rare
Germany	No	/	/	/	Rare
Italy	No	No	Yes	Yes	Rare



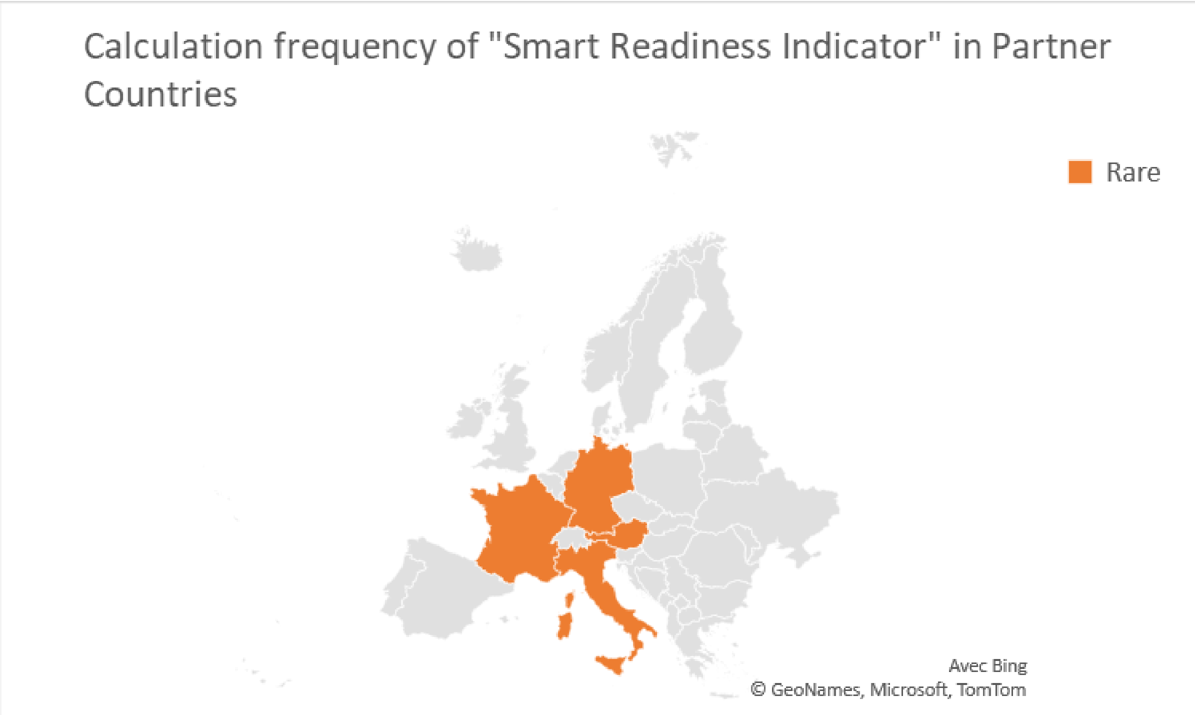
KPI 16	Formaldehyde concentration				
	Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labeling for this indicator?	**Are numerical tools responding to national requirements/ directives for the indicators calculation easily available?**	**Is input data accessibility/ availability simple for this indicator?**	**Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?**	**Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare?**
Country	**Answer**	**Answer**	**Answer**	**Answer**	**Answer**
Austria	Yes	Measured indicator	Yes	Yes	Rare
France	Yes	Measured indicator	Yes	Increasingly easy	Rare
Germany	Yes	Measured indicator	Yes	No	Commonly calculated
Italy	No	No	Yes	Yes	Rare



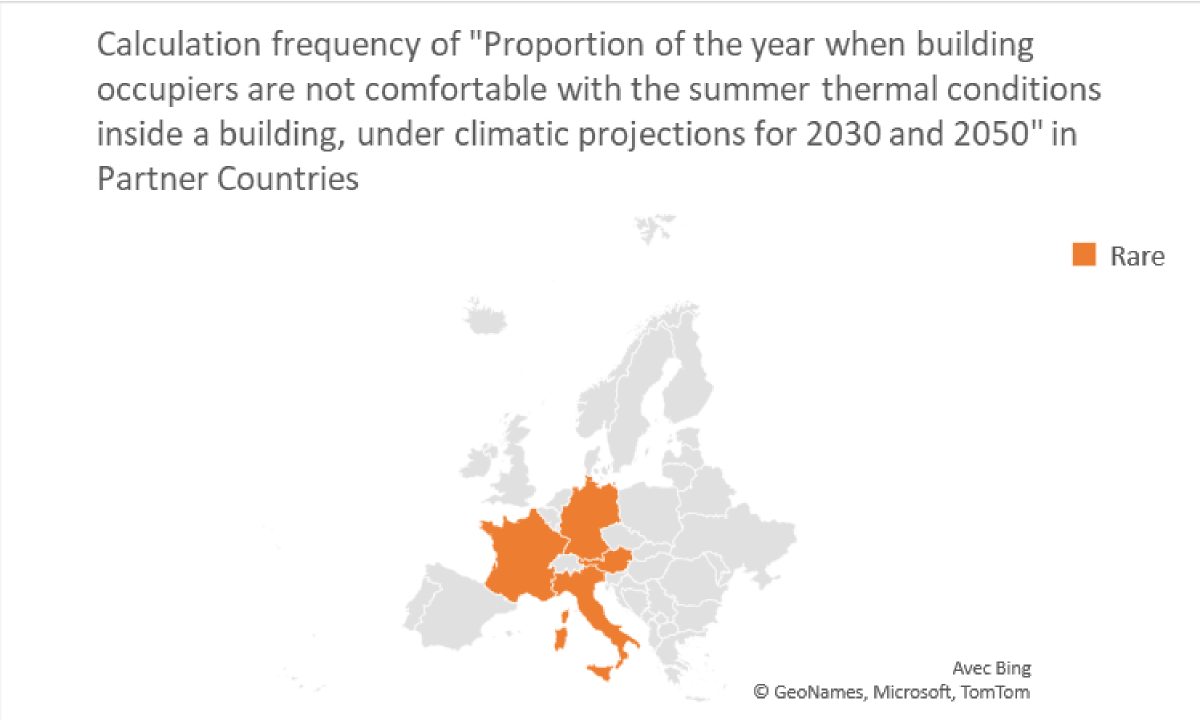
KPI 17	Operational energy costs				
	Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labeling for this indicator?	Are numerical tools responding to national requirements/ directives for the indicators calculation easily available?	Is input data accessibility/ availability simple for this indicator?	Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?	Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare ?
Country	Answer	Answer	Answer	Answer	Answer
Austria	Yes	Yes	Yes	Yes	Commonly calculated
France	No	Yes	No	Increasingly easy	Rare
Germany	Missing line	…	…	…	…
Italy	No	No	Yes	Yes	Commonly calculated



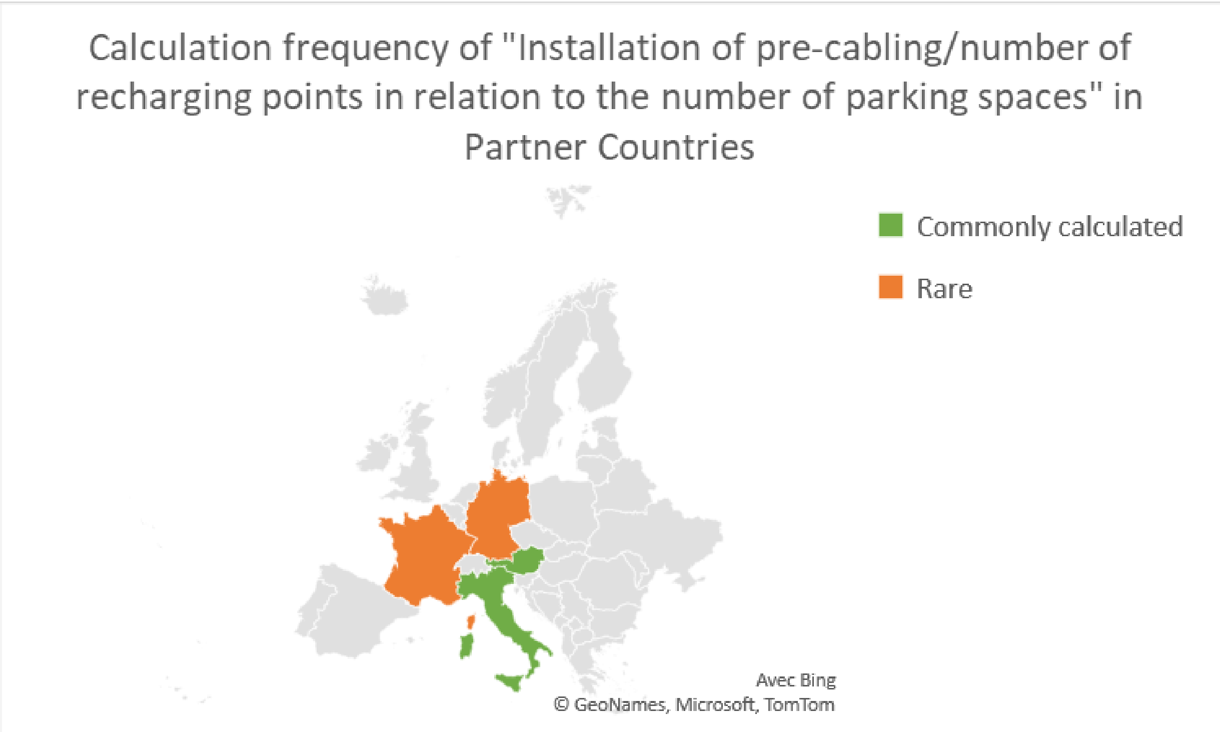
KPI 18	Smart Readiness Indicator				
	Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labeling for this indicator?	Are numerical tools responding to national requirements/ directives for the indicators calculation easily available?	Is input data accessibility/ availability simple for this indicator?	Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?	Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare ?
Country	Answer	Answer	Answer	Answer	Answer
Austria	No	No	No	No	Rare
France	No	No	No	No	Rare
Germany	No	No	No	No	Rare
Italy	No	No	No	No	Rare



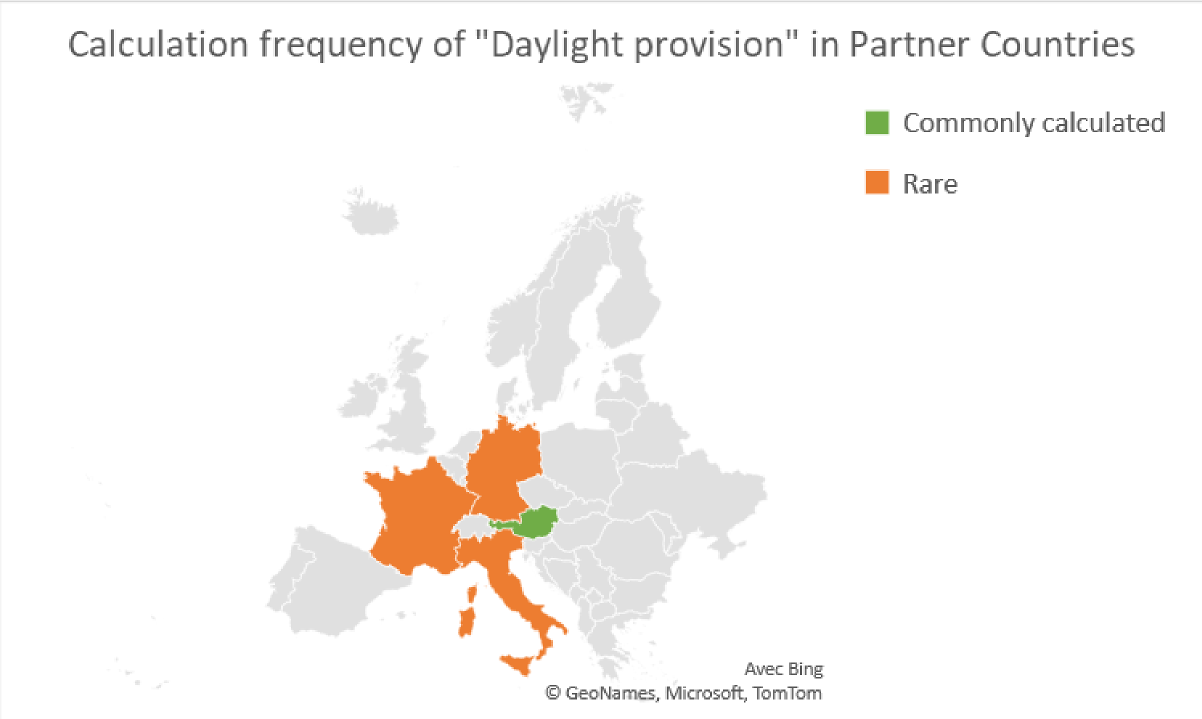
KPI 19	Summer thermal discomfort in 2030 and 2050 - Percentage of time outside of thermal comfort range				
	Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labeling for this indicator?	Are numerical tools responding to national requirements/directives for the indicators calculation easily available?	Is input data accessibility/availability simple for this indicator?	Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?	Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare?
Country	Answer	Answer	Answer	Answer	Answer
Austria	No	No	No	No	Rare
France	No	Yes	No	Yes	Rare
Germany	No	/	/	/	Rare
Italy	No	No	Yes	No	Rare



KPI 20	Installation of pre-cabling / number of recharging points in relation to the number of parking spaces				
	Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labeling for this indicator?	Are numerical tools responding to national requirements/directives for the indicators calculation easily available?	Is input data accessibility/availability simple for this indicator?	Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?	Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare?
Country	Answer	Answer	Answer	Answer	Answer
Austria	Yes	Yes	Yes	Yes	Commonly calculated
France	No	No	No	No	Rare
Germany	Yes	No	Yes	Yes	Rare
Italy	Yes	No	Yes	Yes	Commonly calculated



KPI 21	Daylight Provision				
	Does a calculation method/assessment approach is provided in your national regulation or environmental certification/labeling for this indicator?	Are numerical tools responding to national requirements/ directives for the indicators calculation easily available?	Is input data accessibility/ availability simple for this indicator?	Is it easy to find qualified and experienced assessors to calculate this indicator? Are trainings in this field widely accessible?	Which is the calculation frequency of this kind of indicator? Is it mandatory/commonly calculated/rare ?
Country	Answer	Answer	Answer	Answer	Answer
Austria	Yes	Yes	Yes	Yes	Commonly calculated
France	Yes	Yes	Yes	Yes	Rare
Germany	No	/	/	No	Rare
Italy	No	No	Yes	No	Rare



4.3 Summary table

Table 3 – summary of calculation frequencies per KPI and country

Thematic area	Indicator	Austria	France	Germany	Italy
Energy Consumption	1. Delivered annual final energy demand per useful floor area	Commonly calculated	Commonly calculated	Commonly calculated	Commonly calculated
	2. Total annual primary energy demand per useful floor area	Commonly calculated	Commonly calculated	Commonly calculated	Commonly calculated
	3. Non-renewable primary energy demand per useful floor area	Commonly calculated	Commonly calculated	Rare	Commonly calculated
	4. Embodied energy	Rare	Rare	Rare	Rare
Renewable Energy	5. Renewable annual primary energy demand per useful floor area	Commonly calculated	Commonly calculated	Rare	Commonly calculated
	6. Renewable energy ratio (on-site, nearby)	Commonly calculated	Commonly calculated	Rare	Commonly calculated
Greenhouse Gases Emissions	7. Annual use stage energy-related Global Warming Potential (GWP)	Commonly calculated	Commonly calculated	Commonly calculated	Commonly calculated
	8. Life Cycle Global Warming Potential (GWP)	Commonly calculated	Commonly calculated	Commonly calculated	Rare
Thermal comfort	9. Percentage of time outside of thermal comfort range	Commonly calculated	Commonly calculated	Commonly calculated	Rare
Indoor Air Quality	10. Ventilation rate	Commonly calculated	Commonly calculated	Commonly calculated	Commonly calculated
	11. CO_2 concentration	Rare	Rare	Rare	Rare
	12. Relative humidity	Rare	Rare	Rare	Rare
	13. Total VOCs	Rare	Rare	Commonly calculated	Rare
	14. CMR VOCs concentration	Rare	Rare	Rare	Rare
	15. R value	Rare	Rare	Rare	Rare
	16. Formaldehyde concentration	Rare	Rare	Commonly calculated	Rare
Costs	17. Operational Energy Costs	Commonly calculated	Rare	Commonly calculated	Commonly calculated
Smart Buildings	18. Smart Readiness Indicator	Rare	Rare	Rare	Rare
Resilience	19. Summer thermal discomfort in 2030 and 2050 - Percentage of time outside of thermal comfort range	Rare	Rare	Rare	Rare
E-mobility	20. Installation of pre-cabling / number of recharging points in relation to the number of parking spaces	Commonly calculated	Rare	Rare	Commonly calculated
Daylight sufficiency	21. Daylight Provision	Commonly calculated	Rare	Rare	Rare

Key:
- Commonly calculated
- Rare

Generally speaking, **progress is needed** in the appropriation and practice of about **half of KPIs**, at different levels according to countries:

- Embodied energy
  → among LCA-based indicators, more attention is given to GWP, provided environmental databases exist

- Life Cycle GWP
  → this important (because of the future EPBD or national regulations) but time-consuming indicator requires progress in environmental data availability and professional skills, particularly in Italy where there is currently no national EPD database

- All indoor air quality indicators, excepted ventilation rate
  → awareness and measurement practice are progressing, but not enough, because time and cost consuming indicators

- Smart Readiness Indicator
  → recent concept, under testing

- Summer thermal discomfort in 2030 and 2050
  → same dynamic tool as for KPI 9, with future weather data

- E-mobility
  → relatively new, but easy to implement

- Daylight provision
  → tools exist

5 How to transfer R&I results to a standardization deliverable? The EUB SuperHub pathway

On February 2nd, 2022, the European Commission has released the Communication on "an EU Strategy on Standardisation Setting global standards in support of a resilient, green and digital EU single market"[51]. It considers standards as "the silent foundation of the EU single market and global competitiveness" since "Europe's competitiveness, technological sovereignty, ability to reduce dependencies and protection of EU values, including our social and environmental ambitions, will depend on how successful European actors are in standardisation at international level".

Based on these considerations, it sounds clear how important is that the standardization community and Research and Innovation projects keep up with each other. This "liaison" let indeed innovators avoiding "reinventing the wheel" by taking advantage of the current standards (describing the state of the art); while standardization world keeping up with the market by internalizing the results coming from R&I projects.

EUB SuperHub is doing its part in this: UNI the Italian Standardization Body and all the other partners are working from the beginning to link the project with the relevant technical committees in order to transfer the innovative results to the standardization world.

In particular, this document, the Deliverable D2.2 will be the starting point to develop a pre-standardization document (a CWA – CEN Workshop Agreement) which will transfer to the market the EUB SuperHub innovative results.

This chapter will present a brief overview of the European standardization deliverables, a focus on the CWA, the activities already carried out in EUB SuperHub towards the development of a CWA.

[51] https://ec.europa.eu/docsroom/documents/48598

5.1 Standardization deliverables: an overview

The European Committee for Standardization, also known by its French acronym CEN (Comité Européen de Normalisation) is a public standards body operating within a framework that envisages not only EU member states but also 3 EFTA's members (Switzerland, Norway and Iceland) and 4 other non-EU states such as the United Kingdom, Serbia, Turkey and North Macedonia.

CEN develops and publishes several types of standardization deliverables:

- Technical Standard (EN);
- Technical Specification (TS);
- Technical Report (TR);
- CEN Workshop Agreement (CWA);
- CEN Guide.

All CEN deliverables are created by bringing together interested parties such as manufacturers, consumers and regulators of a particular material, product, process or service. All parties benefit from standardization through increased product safety and quality as well as lower transaction costs and prices.

Each of the aforementioned deliverables has specific characteristics and features related to its application, its use within the sector and the process to publish it:

Technical Standard (EN): is the highest level of technical publication from CEN, is a technical document designed to be used as a rule, guideline or definition and may also serve the European regulatory purposes of the "New Approach". It is consensus-built within a specific CEN Technical Body and based on the sector-specific state of the art represented by the stakeholders involved during its drafting. National CEN members have the obligation to implement the standard at national level and include them within their catalogues, once the standard is published. Conflicting national projects shall be halted, and conflicting published national standards must be withdrawn once the EN is published (*standstill* rule).

Technical Specification (CEN/TS): is a technical publication that serves as normative document in areas where the actual state of the art is not yet sufficiently stable for a European Standard or pertains to highly innovative sectors. The Technical Specification is announced and made available at national level, but conflicting national standards may continue to exist. A Technical Specification may be conflicting with another Technical Specification with the same scope, but a Technical Specification may not conflict with a European Standard. CEN introduced the Technical Specification to provide an 'appropriate' consensus/transparency solution to a market need where there is no immediate need for national implementation.

Technical Report (CEN/TR): is an informative document made available by CEN in at least one of the three official languages. Being informative, it cannot contain requirements. Technical Report are usually used to provide the market with sensible data or quick informative reports. No time limit is specified for the lifetime of Technical Reports, but it is recommended that Technical Reports are regularly reviewed.

CEN Workshop Agreement (CWA): is a normative document that aims at bringing about consensual agreements based on deliberations of open Workshops with unrestricted direct representation of interested parties. Differently from the other deliverables, it is not drafted within a Technical Body, although CEN/TC members may be invited to participate in the Workshop. A CWA is valid for 3 years, after which the Workshop Secretariat shall consult the Workshop participants and relevant technical bodies to determine whether the CWA shall be confirmed for another 3 years, revised, transformed into another deliverable, or withdrawn.

The Guide (CEN Guide): is an informative document that provides for information about standardization principles, policies and guidance to standards writers.

5.2 **CWA: why, how, the Project Plan development**

5.2.1 Why: the rationale behind a CWA

As per previous description, a CWA could be considered a "pre-standard" or "proto-standard" due to the following characteristics:

- it is still a normative document and can contain requirements;
- it has a quicker drafting process than every other deliverable;
- it is not drafted within a Technical Body but rather in an open Workshop;
- it has a maximum life of six years (3+3) after which either it is revised/transformed into another deliverable or it is withdrawn;
- it is preparatory/propaedeutic to the publication of other deliverables.

The rationale that brought CEN to introduce such a deliverable is that a CWA:

(1) answers to the need from specific sectors of a **quick response** from the standardization world (ENs or TSs take years to be published);

(2) provides the possibility, by drafting a pre-standard, to foster spill-over effects from the most **innovative projects** directly to Technical Bodies in order to update the state of the art.

In a constantly evolving world, a time-saving process and a deliverable prone to foster innovation findings, make a CWA the perfect tool for modern era standardization needs.

5.2.2 How: the process

As said, a CWA is not like any other deliverable we mentioned since it is not drafted within a Technical Body but rather in an open ad-hoc Workshop, that is to say a dedicated working group (*infra*: “CEN/WS”) created with the precise scope of drafting that very CWA and performing related actions (dissemination, organization of events, drafting of explanatory statements, etc.).

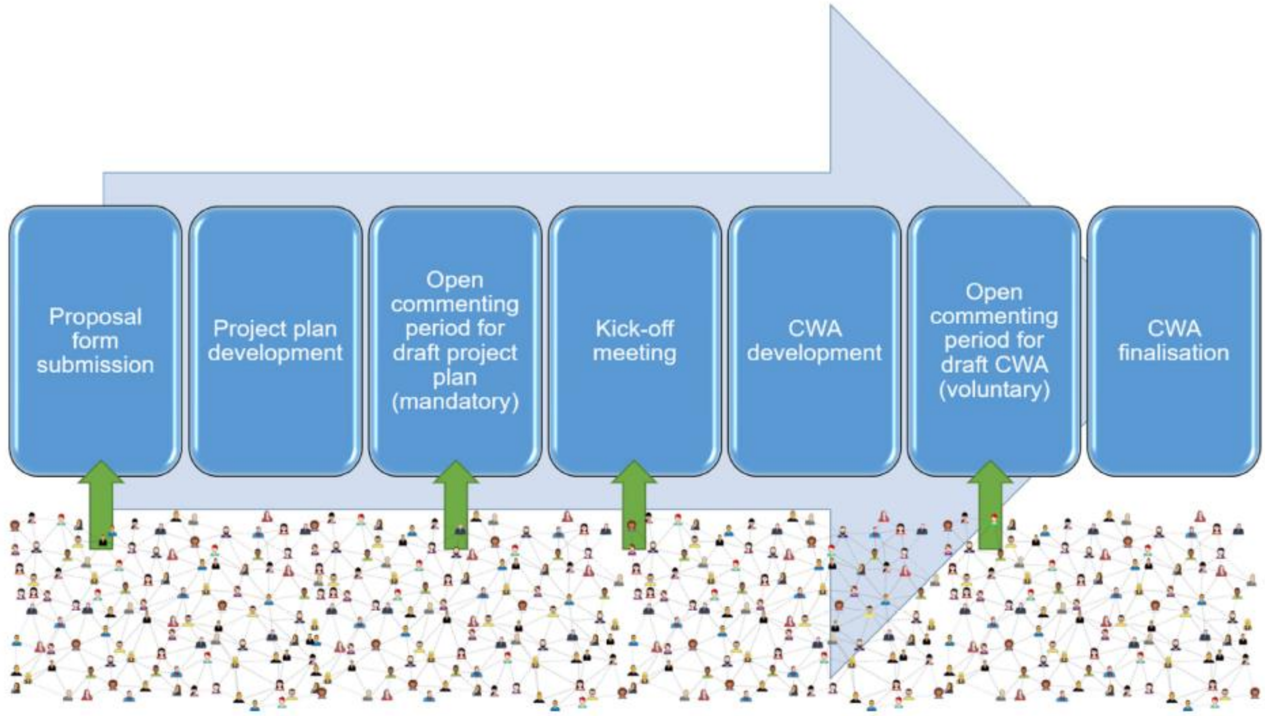


Figure 2 - CWA process[52]

Everything starts when the Workshop Proposer of a CWA, with the assistance of the CEN Member, shall prepare the CEN Workshop Proposal Form. The

[52] Source: CEN

Workshop Secretariat submits the CEN Workshop Proposal Form to relevant CEN and/or CENELEC Technical Committees (TCs), if any are identified, for eventual consultation in order to avoid conflicts with ongoing standardization activities or if other reasons to drop the proposal arise (security issues, standards involving management systems, other specific objections from the Technical Body).

After that, a Draft Project Plan is required in order for CEN to launch a 30-days consultation to inform every NSB and relevant stakeholders of the proposed CWA.

5.2.3 The Project Plan development

The proposal for the constitution of the CEN Workshop is specified in the document called Project Plan (PP). The PP defines the activities to be developed within the Workshop with particular reference to:

- scope and objectives;
- programme of the CEN/WS including its timescale;
- possible final public enquiry phase;
- identification of potential market players that could participate in the work;
- resources.

The preparation of the PP is supported by the Standardisation Body that will be entrusted with the CEN/WS Secretariat and will support the proposer in the initial phases of the submission of the draft PP to CEN.

As said above, the Project Plan must suggest a scheduled timeline of the CEN/WS and provide for tentative dates of the first meeting (Kick-off), the drafting meetings and the final meeting (Approval Meeting). In case the Project Plan envisions it, a consultation period can be added to the time schedule, including a meeting to resolve any comment sent to the Secretariat during consultation.

The finalisation of the PP is subject to a phase of verification and evaluation of the document itself by all potential interested stakeholders, after which the PP is published for at least 30 days on the CEN website to collect comments, if any. Once this step is completed, it is possible to formalise the starting of the activities of the CEN/WS through a kick-off meeting.

The PP is published for at least 30 days on the CEN website for comments from other stakeholders and it is meant to attract potential stakeholder interested to participate to the works of the CEN/WS A CEN/WS is opened to any subject, also from outside Europe.

A CEN Workshop Agreement is adopted through consensus, which is reached by the CEN/WS participants who are responsible for its contents.

During the Kick-off Meeting the Project Plan is approved and further implemented. Participation to the Kick-off Meeting does not automatically ensure registration to the CEN/WS. After the Kick-off Meeting the participants wishing to continue contributing to the development of the draft CWA will be requested to officially register to the CEN/WS by means of signing the registration form, therefore becoming CEN/WS participants. The CEN/WS participants draft the CWA(s) according to the specifications laid down in the Final Workshop Project Plan. During the drafting, draft CWA must be available for comments on the CEN online platform.

After the document has been drafted, commented upon and modified, it can be approved during the Approval Meeting. After that, if foreseen in the Final Workshop Project Plan, and in any case if the draft CWA covers safety aspects, an open commenting phase (30/60 days) is launched, so external comments can be sent to the Secretariat and will have to be addressed during the final meeting after consultation.

Once the whole process is over, the CEN/WS Secretariat shares the final version of the documents with all participants and sends it to CEN CCMC for final editorial revision and publication with a specific reference number and publication date.

Although a CWA is revised every 3 years and has a maximum life of 6 years, it can be transformed into another deliverable at any time after its publication.

5.3 EUB SuperHub: towards the development of a CWA

The EUB SuperHub definition of a harmonized set of Key Performance Indicators (KPIs), including sustainability indicators, for the next generation of assessment and certification framework of buildings energy performance (EPCs) has been considered as most prominent result to be transformed in a CWA The EUB Superhub harmonized set of Key Performance Indicators has been developed within task 2.2 and summarized in the deliverable D2.2. UNI and all the partners have worked together to prepare a Project Plan of the CWA, based on the results of the deliverable D2.2.

The Project Plan of a CWA represents an initial projection to CEN of what the future standardisation work will be. Below, the table of contents of the Project Plan as it has been drafted for EUB SuperHub.

Table 4 - CEN Workshop Project Plan: Table of contents and partners' contributions

Section number	Title	Reference partner
	Summary	UNI
1	Status of the project plan	UNI
2	Workshop proposer and Workshop participants	UNI
2.1	Workshop proposer	UNI
2.2	Other potential participants	UNI
2.3	Participants at the kick-off meeting	UNI
2.4	Registered Workshop participants	UNI
3	Workshop objectives and scope	CSTB + GEO
3.1	Background	EIHP + iiSBE + CSTB
3.2	Scope	CSTB + HM
3.3	Related activities	iiSBE + UNI
4	Workshop programme	UNI
4.1	General	UNI
4.2	Workshop schedule	UNI
4.3	Work already delivered	UNI
5	Resource planning	UNI
6	Workshop structure and rules of cooperation	UNI
6.1	Participation in the Workshop	UNI
6.2	Workshop responsibilities	UNI
6.3	Decision making process	UNI
7	Dissemination and participation strategy	UNI
8	Contacts	UNI

In order to arrive in September 2022 with the Project Plan ready to be submitted to CEN for final approval, UNI scheduled a series of meetings with all project partners with the aim of verifying the drafted Project Plan sections and agreeing on their content.

The calendar of the meetings organised is shown in the image below:

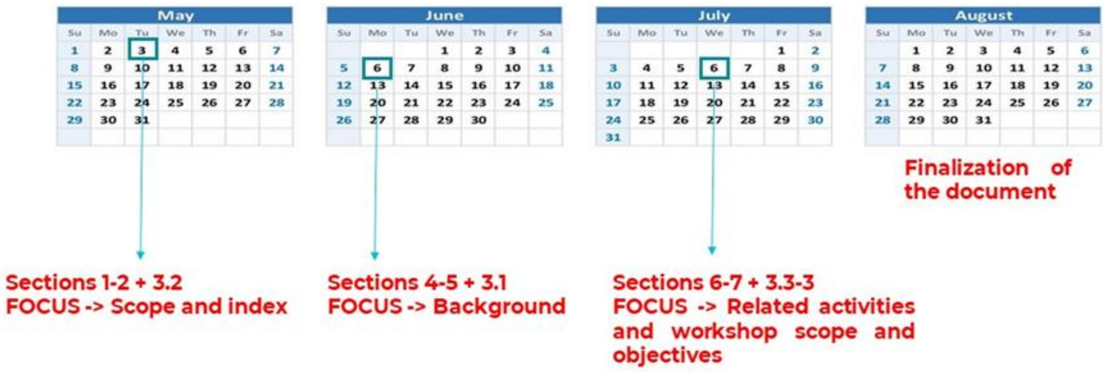


Figure 3 - Calendar of the preparation meetings

UNI was the main responsible of sections 1, 2, 3, 4, 5, 6, 7 and 8 as outlined in the table of contents ; while sections 3.1, 3.2 and 3.3 were mainly drafted by the other partners with relevant technical expertise necessary to write the scope, motivation and background of the CWA (see table 4). The drafted sections were then read and commented by all partners during the scheduled meetings.

The meetings were actively attended by at least one representative from each relevant Work Package leader of the project. On average, about 20 people have participated to each meeting.

During the meetings, the key points for the development of the Project Plan were defined, with the contribution of all participants, while UNI was in charge of updated the document with all agreed changes after each meeting .

During the first meeting, the assignment to the partners and the roles they might have in the future Workshop were discussed: in particular, the "Chairperson" (HM), "Vice chairman" (iiSBE Italia) and "Project Leader" (CSTB) were chosen.

During the meetings considerable attention has been paid to the definition of the scope, the background and the related activities of the future CWA, together with all the other points indicated in the table of contents and which will be useful for CEN to receive all the information needed to grant the authorisation to start with the standardisation work by developing a CEN Workshop.

5.4 Next steps

Once the Project Plan may be approved by CEN and the 30-day consultation period has elapsed, a kick-off meeting will be held, which in this specific case (unless otherwise indicated) will be online.

This meeting formally will start the CEN/WS activity and is aimed in particular at approving the Project Plan and the proposed organisational structure for the management of the Workshop activities.

The aim will be to have as wide an involvement of experts as possible, opening the table to all those interested in the topic and in particular to other European projects doing research in the same field.

The material developed within the EUB SuperHub project will be of fundamental importance for defining the contents of the CWA. Starting from the project Deliverables (in particular D2.2), it will be possible to define the contents of the pre-standard, bringing together the results of a research and innovation project within a Standardisation document that can be applied and verified by anyone wishing from the market.

The future development of the CWA, following CEN approval, should be coherent within the timeframe of the EUB SuperHub project lifetime.

6 Conclusions

The work done under Task 2.2 has led to a proposal of 21 KPIs and their description in a homogeneous format, based on existing frameworks. Attention has been paid to the overall coherence of this system of indicators, even if it is perfectible.

These 21 key indicators are not at the same level of applicability / operationality. In the future European Building Passport, it will be difficult to include all of the 21 KPIs at a first step, but, even if some of them will be optional during a certain period (not determined yet), this core set of 21 KPIs give a medium-term vision of what should be a building passport accompanying the life of a building.

In order to increase the legitimacy of this core set of indicators, and to enlarge the audience of stakeholders, including more countries and experts, a CEN Workshop Project Plan has been prepared by UNI, so as to lead to a CWA (CEN Workshop Agreement) within the end of the EUB SuperHub project. The main parts of the present report constitute the entry point of the CEN Workshop work.

A future challenge is to be able to articulate the next tasks of the EUB SuperHub project and the progress, and then the results, of the CEN Workshop, both running in parallel. On the one hand, the next tasks of EUB SuperHub will deal with data requirements linked to a building logbook, certification process, case studies, web platform development, training and communication, and on the other hand, the CEN Workshop could modify the set of KPIs or bring certain recommendations for their use in a passport. A crucial external factor is the progress of the EPBD revision until its final approval by the EU political institutions, also running more or less in parallel with the CEN workshop and EUB SuperHub, with the necessity to articulate all these processes.

Finally, we insert here the first conclusion on KPIs, at the end of chapter 3:

At this point of work, coherence / consistency and homogeneity have progressed during T 2.2 work, but needs to continue to progress in T 2.5 and during the CEN workshop process. The deliverable D2.5 will constitute an improvement on D2.2. Then, the CWA, final document on the KPIs, will constitute the more advanced, coherent and consensual document, continuation of EUB SuperHub project. In the future, EUB SuperHub KPIs will have the opportunity to evolve from a CWA to another type of normative document.

As standards are evolutive texts (every 5 years a revision is proposed) the description and assessment (by calculation or measurement) of KPIs is supposed to evolve. This is a more accurate issue when standards are currently under revision, as EN 15978, with on-going methodological discussions, and when the coherence / consistency with recently revised standards is not yet ensured. This is particularly the case between EN 15804 on construction products LCA, revised in 2019, and EN 15978 on building LCA, which is still under revision mid-2023, while depending of / relying on EN 15804. So, the description of KPIs must be flexible enough to allow adaptation due to standardization evolution.

Flexibility in result reporting is also necessary, so as to welcome diverse maturity levels of KPIs assessment, when testing the 21 KPIs through EU. Clear reporting formats (with sub-indicators) will be necessary, together with transparency in methodology and system boundary compliance explanations.

Last but not least, as EPBD recast process is still ongoing, the documents on which we can rely on are proposal or intermediate texts, not final, so the list of KPIs and the contents on the EUB e-Passport will need to be reviewed and up-dated at the end of the EUB SuperHub project.

D2.2 constitutes an important step towards European harmonized KPIs for EPCs and building passport, and future EUB SuperHub results (D 2.5 for instance) and CWA will constitute the next steps.

7 ANNEX - List of indicators constituting national sustainability certification frameworks

This list of indicators is based on Task 1.1 outcomes. It deals with certification frameworks in Germany, France, Austria and Italy.

Table 3 - List of indicators constituting national sustainability certification frameworks based on T1.1 output "Mapping of EPCs and sustainability certifications"

Germany (residential: DGNB NKW, BNK, NaWoh, DGNB NOW) National Mandatory (non-residential: BNB) National Not Mandatory **DIN 18599**	Global Energy Performance Indicators	• Total primary energy (kWh/m²), • Share of renewable primary energy (kWh/m²), • Share of non-renewable primary energy (kWh/m²)
	Social indicators	BNK: • Indoor air hygiene • Drinking water hygiene • Summer heat protection • Availability of daylight • Noise protection • Ease of use and information content of the control system • Preventive protective measures against burglary • Fire detection and fire fighting • Barrier-free building BNB: • Thermal comfort • Indoor air quality • Acoustic comfort • Visual comfort • User control / Possibility of influence by users • Quality of spaces (outdoor) • Safety and security • Public access / Barrier free • Accessibility • Mobility infrastructure • Design and urban development quality • Integrated public art / Art on the building

	Economic indicators	BNK: • Selected costs in the life cycle costs BNB: • Building-related costs in the life cycle • Area / Space efficiency • Adaptability
	Environmental indicators	BNK: • Life cycle assessment: global warming potential and other related environmental impacts • Life cycle assessment: primary energy • Decentralized generation of regenerative energy • Use of wood from sustainable forest management • Use of water-saving fittings • Efficient use of space BNB: • Global warming potential (GWP) • Ozone depletion potential (ODP) • Ozone creation potential • Acidification potential (AP) • Eutrophication potential (EP) • Risks for the local environment • Sustainable material extraction / biodiversity • Primary energy demand • Drinking water demand and waste water volume • Land use
	Additional Indicators	BNK: • Consultation and target agreement • Building documentation including user manual • Quality assurance BNB: • Sound insulation

		• Thermal Insulation and condensation protection • Cleaning and maintenance • Deconstruction and disassembly • Building envelope quality / Resilience against natural risks • Maintenance and operation of Mechanical Electrical and Plumbing systems • Comprehensive project brief • Integrated design • Design concept • Tendering and awarding • Documentation for facility management / Prerequisite for optimal management • Construction process • Construction quality assurance • Systematic commissioning • Risks at the microsite • Quality of Local environment • Neighborhood features / Public image and social conditions • Transport access • Access to amenities • Access to media/infrastructure
France (HQE) National Not Mandatory **RE2020**	Global Energy Performance Indicators	• Heating, Cooling and Lighting energy needs linked to building's envelope characteristics, • Total primary energy in-use consumptions, • Non-renewable primary energy in-use consumption, • Non-renewable primary energy consumption calculated over the entire life cycle of the building.
	Social indicators	• Safety and security, • Indoor air quality, • Water quality, • Risk resilience,

		• Functionality of spaces, • Hygrothermal comfort, • Acoustic quality, • Visual comfort, • Services and Transport, • Connected Buildings
	Economic indicators	• Maintenance cost and durability of the envelope, • Control of Consumption and Charges, • Life Cycle Cost, • Deconstruction • Valorising local resources
	Environmental indicators	• Reduction of Water Consumption, • Land use, • Material Resources, • Waste products, • Climate Change (GHG emissions), • GHG emissions during the life cycle of the building • Resilience to climate change • Biodiversity
Austria (Kommunalgebäudeausweis) Regional Not Mandatory **OIB 6 or PHPP**	Global Energy Performance Indicators	
	Social indicators	• Comfort and indoor air quality • Climate impact adaptation
	Economic indicators	• Simplified calculation of economic efficiency (incl. CO2 follow-up costs)
	Environmental indicators	• Close-to-nature construction, • product management: use of regional, low-pollutant and low-emission building products, • avoidance of critical substances and recycling management, • ecology of building materials and construction, • avoidance of PVC and biocides, • use of recycled concrete
	Additional Indicators	• Bicycle parking, building service concept,

<table>
<tr><td></td><td></td><td>Indoor air quality measurement</td></tr>
<tr><td rowspan="4">Italy
(Protocollo Itaca)
National and Regional
Not Mandatory

DM 26/05/2015:
Interministerial Decree of 26 June 2015 - Application of the methodologies for calculating energy performance and defining the prescriptions and minimum requirements for buildings.
EN 13790:2008
EN 15603:2008
UNI 11300:2014
UNI 15193-1:2017</td><td>Global Energy Performance Indicators</td><td>Non-renewable global primary energy;
Total primary energy;
renewable energy for thermal uses;
Energy produced for electrical uses;
Useful thermal energy for heating;
Useful thermal energy for cooling.</td></tr>
<tr><td>Social indicators</td><td>Design for All</td></tr>
<tr><td>Economic indicators</td><td></td></tr>
<tr><td>Environmental indicators</td><td>Global non-renewable primary energy;
Total primary energy;
Renewable energy for thermal uses;
Energy produced for electrical uses;
Certified materials;
Eco-friendly materials;
Recycled/recovered materials;
Potable water for irrigation purposes;
Potable water for indoor use;
Useful thermal energy for heating;
Useful thermal energy for cooling;
Emissions expected in the operational phase;
Solid waste in the operational phase;
Soil permeability;
Heat island effect;
Ventilation and air quality;
Summer thermal comfort in air-conditioned rooms;
Operating temperature in the summer period;</td></tr>
</table>

		• Winter thermal comfort in air-conditioned rooms; • Natural lighting; • Reverberation time; • Acoustic quality of the building; • Magnetic fields.
	Additional Indicators	• Reuse of the territory; • Accessibility to public transport; • Functional mix of the area; • Adjacency to infrastructures; • Equipped outdoor areas for common use; • Support for the use of bicycles; • B.A.C.S .; • Home automation systems; • Availability of technical documentation of buildings.