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EUB SuperHub - A harmonization of KPIs for supporting the next generation of EPCs

ICS:

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Contents

page

Foreword 3
Introduction 4
1 Scope 6
2 Normative references 6
3 Terms and definitions 7
4 Abbreviations 9
5 EUB SuperHub approach: a holistic view of buildings/an integrated framework of indicators of EPCs 11
5.1 Holistic and integrated approach to the energy performance of buildings 11
5.2 A system of interconnected KPIs 12
6 Selection of KPIs: the bottom-up approach 14
7 KPIs selected 17
7.1 General 17
7.2 Presentation of the KPIs template 19
7.3 KPIs Assessment Guideline 20
7.4 KPIs Assessment Report 117
7.4.1 General 117
7.4.2 Building data 117
7.4.3 KPI reporting format 118
8 EUB e-Passport 129
8.1 Subclause title 129
8.1.1 Subclause title 129
Bibliography 131

Foreword

This document (prCWA XXXX:XXXX) has been prepared by CEN/WS “EUB SuperHub - A harmonization of KPIs for supporting the next generation of EPCs”, the secretariat of which is held by UNI.

This document is currently submitted to the CEN Enquiry.

Introduction

This CEN Workshop Agreement (CWA) is based on the results of the European Building Sustainability performance and energy certification Hub (EUB SuperHub) project, funded under the Horizon2020 framework programme of the European Union. The EUB SuperHub platform will allow for calculating and/or collecting the building assessment criteria defined in the EUB SuperHub passport.

European buildings' current weighted annual energy renovation rate stands at low levels. The Renovation Wave Strategy, published in October 2020 by the European Commission, draws the way to reach EU-wide climate neutrality by 2050 by increasing the number of deep renovations, speeding up the integration of renewables in building and promoting broader use of waste heat and circularity principles, and doubling the annual energy renovation rate of residential and non-residential buildings by 2030.

The Renovation Wave Strategy stresses that building renovations can generate social, environmental, and economic benefits alongside the energy and cost reductions at the building use stage.

There are many novelties introduced with the proposal for a recast of the directive on the energy performance of buildings (EPBD) published by the European Commission in December 2021, amended by the European Parliament and the Council of the European Union in a “compromise text” made public in December 2023 in view of the formal and final vote, such as:

- the introduction of minimum energy performance standards for existing buildings,
- a definition of zero-emission buildings referring to new buildings,
- calculation of the life-cycle global warming potential for all new buildings as of 2030,
- calculation of the Smart Readiness Indicator (SRI) for large non-residential buildings as of 2027,
- addressing the issues of healthy indoor climate conditions, adaptation to climate change, fire safety, risks related to intense seismic activity and accessibility for persons with disabilities.

The main objectives of this EPBD revision are to increase the rate and depth of building renovations, improve information on energy performance and sustainability of buildings, and ensure that all buildings will be in line with the 2050 climate neutrality requirements. The proposal for the EPBD revision that “*buildings are responsible for greenhouse gas emissions before, during and after their operational lifetime*” leads that the whole life-cycle emissions must be considered.

Lack of information in the construction sector is one of the many barriers that prevent the renovation rate from growing. As a solution, the Renovation Wave Strategy introduced first the concept of a digital building logbook. The proposal for the EPBD revision defines a digital building logbook. Moreover, the EUB SuperHub project noted differences between the EPC issued in the different Member States (MS) in terms of their quality (inputs, outputs, data, methodologies, experts), visibility (awareness, communication, image, perception of certifications, range, how certifications call to action, advertising) and usability (information, how triggers lead to action, choices made, interoperability). This low level of EPC harmonization between the MS hinders the creation of unified EU EPC and constrains the EPC application to the national and sometimes regional boundaries.

From the above-mentioned, further evolvement of the existing Energy Performance Certification schemes encompassing environmental, social, and economic aspects of buildings’ life-cycle and whole life carbon thinking by applying a holistic view of buildings is necessary to build a solid foundation for accelerating building renovations by ensuring at the same time consistency throughout the Member States.

EUB SuperHub project provides a description of a core set of transnational Key Performance Indicators of the next generation of EPCs, which are transferred in this CEN Workshop Agreement, covering the following key thematic areas:

1. Energy consumption
2. Renewable energy
3. GHG emissions
4. Thermal comfort
5. Indoor air quality
6. Costs
7. Smart buildings
8. Resilience to overheating
9. E-mobility
10. Daylight sufficiency

Several activities have been performed by the EUB SuperHub project consortium aiming to identify a harmonised system of comprehensive and robust indicators for evaluating the energy performance, sustainability, and smartness of buildings in the next generation of Energy Performance Certificates. Indicators selected result from a recognition of the existing transnational set of indicators (see https://eubsuperhub.eu/), such as the initiatives of the European Community (SBA, Level(s), EPBD recast proposal), the outputs of European Projects already concluded (CESBA MED, FASUDIR, NewTREND, etc.) and the standardisation process (CEN).

Many consultation activities with the key stakeholders operating in the field of energy performance (market players, professionals, public administration employees, energy certifiers, standardization experts, etc.) have been carried out, capitalising their knowledge and their suggestions. In this regard, many key suggestions have been collected by the EUB SuperHub project consortium through the mapping of the National Energy Performance Certificates and Sustainability Certification systems in the EUB SuperHub participating countries, assessing their role and impact in the real estate market.

Thanks to all these reconnaissance activities and subsequent accurate analysis, the EUB SuperHub project consortium finally get a list of 21 KPIs which are:

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

This information, aggregated to the building logbook, can be entered in a specific database, with the possible support of other IT tools, through a process of digitization so that they can be used by professionals and public administration for any energy and sustainable requalification interventions and verification of existing assets.

The purpose of this CWA is to transfer the results of the EUB Superhub project into a consensual reference document at European level, in order to support the next generation of EPCs.

1 Scope

This document defines and describes a system 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, which help to form a digital building logbook and a harmonized "building e-passport" as will be defined by this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE: Additional references are listed in the Bibliography.

CWA 17939:2022, *TRAIN4SUSTAIN Competence Quality Standard*

EN 15978, *Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method*

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 - Module M1-6*

EN ISO 16890-1, *Air filters for general ventilation. Part 1: Technical specifications, requirements and classification system based upon particulate matter efficiency (ePM)*

EN 17037, *Daylight in buildings*

EN 17423, *Energy performance of buildings – Determination and reporting of Primary Energy Factors (PEF) and CO_2 emission coefficient – General Principles, Module M1-7*

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

EN ISO 52010-1, *Energy performance of buildings - External climatic conditions - Part 1: Conversion of climatic data for energy calculations*

EN ISO 52016-1, *Energy performance of buildings - Energy needs for heating and cooling, internal temperatures, and sensible and latent heat loads*

EN ISO 52120-1, *Energy performance of buildings - Contribution of building automation, controls and building management*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 52000-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1

area unit

one square meter of useful floor area of the building, which represents the basic reference unit used in the normalization of the energy performance and some other KPIs described in this document.

Note 1 to entry: The useful floor area is the chosen reference floor area for the building size used in the present document. A description (default choices) can be found in Tables B.20 to B.22 in EN ISO 52000-1:2017.

Note 2 to entry: The specifications of the reference floor area may have a strong effect on the normalized energy performance.

3.2

existing building

building in the use phase with at least three years of long-term use data, for which both methods, calculated (asset) and measured (operational) methods can be applied to calculate specific indicators

3.3

new building

building in the design/construction/'as built' phase without long-term use data, for which only calculated (asset) method can be applied to calculate specific indicators

3.4

renovated building

existing building under a renovation process or project, in the design/construction/'as built' phase without long-term use data, for which only calculated (asset) method can be applied to calculate specific indicators

Note 1 to entry: the term "design" is the design of the renovation project, "construction" corresponds to the renovation process, and "as built" means "as renovated".

3.5

key performance indicator
KPI

Indicator of performance giving prominence and attention to certain aspects of operations, management, conditions or impacts.

[SOURCE: ISO 14050:2020, 3.2.25, modified]

Note 1 to entry: In the present document, the KPIs are defined at the scale of a building or a building unit.

3.6

pre-cabling
all measures that are necessary to enable the installation of recharging points, including data transmission, cable routes, spaces for transformers and electricity meters, and upgrade of the electrical board.

[SOURCE: Amendments adopted by the European Parliament on 14 March 2023 on the proposal for a Directive of the European Parliament and of the Council on the energy performance of buildings (recast)]

4 Abbreviations

In the following table are listed the abbreviations used in this document.

Table 01 - Abbreviations

BACS	Building Automation and Control System
BoM	Bill of Materials
BoQ	Bill of Quantities
BTS	Building Technical Services
CHP	Combined Heat and Power
CMR VOC	Carcinogenic, Mutagenic, Reprotoxic Volatile Organic Compound
cr	Carrier
DBL	Digital Building Logbook
DHW	Domestic Hot Water
DT	Target Daylight Factor
DTM	Minimum Target Daylight Factor
EPBD	Energy Performance of Buildings Directive
EPB services	Energy Performance of Buildings services
EPC	Energy Performance Certificate
EPD	Environmental Product Declaration
EUB e-passport	European Building electronic passport
EUB SuperHub	European Building Sustainability performance and energy certification Hub (H2020 European Project, 2021-2024)
FID	Flame Ionisation Detector
GC	Gas Chromatographic
GHG	Greenhouse Gas
GWP	Global Warming Potential
IAQ	Indoor Air Quality
IPCC	Intergovernmental Panel on Climate Change (United Nations body)
IPMVP	International Performance Measurement and Verification Protocol
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LCI	Lowest Concentration of Interest
LOs	Learning Outcomes
MS	Mass Spectrometric
ODA	Outdoor Air
PEF	Product Environmental Footprint
PMV	Predicted Mean Vote
PPD	Predicted Percentage of Dissatisfied
PV	Photovoltaic
RER	Renewable Energy Ratio
RSP	Reference Study Period
SRI	Smart Readiness Indicator

SUP	Supply Air
SVOC	Semi-Volatile Organic Compound
T4S	TRAIN4SUSTAIN
TD	Thermal Desorption
TVOC	Total Volatile Organic Compound
UV	Ultraviolet
VOC	Volatile Organic Compound
VVOC	Very Volatile Organic Compound

5 EUB SuperHub approach: a holistic view of buildings/an integrated framework of indicators of EPCs

5.1 Holistic and integrated approach to the energy performance of buildings

The evolving landscape of building energy performance mandates a comprehensive and integrated methodology for the evaluation and next generation certification of buildings. This necessity is precipitated by a confluence of factors, including the escalating complexity of building systems, an enhanced consciousness regarding sustainability ramifications, technological progressions, and modifications in regulatory frameworks.

Below are elucidated reasons advocating for an expansive evaluation and energy certification paradigm:

- Environmental Stewardship and Climate Change

  Amidst burgeoning cognizance of climatic changes impacts and the imperative for sustainable stewardship, there is an exigency to mitigate the environmental footprint of buildings, which are substantial consumers of energy and resources. An expansive approach transcends mere energy consumption, encompassing energy generation, material utilization, and the overall carbon footprint, thereby aligning with broader sustainability objectives.

- Technological Evolution

  Technological evolution has transformed buildings from static structures to dynamic entities equipped with intelligent systems capable of real-time modulation to optimize energy utilization, comfort, and operational efficacy. Evaluating such intelligent capabilities necessitates an approach that extends beyond traditional metrics.

- Occupant Health and Well-being

  The reconceptualization of buildings as human habitats has shifted the focus towards indoor environmental quality, encompassing air quality, thermal comfort, and illumination. These factors significantly influence occupant health and productivity, necessitating the inclusion of a broader spectrum of KPIs in the certification process to ensure that buildings foster well-being.

- Energy Security and Autonomy

  The transition towards renewable energy sources and the incorporation of energy storage and generation within buildings necessitate a revised framework for evaluation. Buildings can now contribute to the energy grid, warranting assessments that account not only for energy consumption but also for generation and storage capabilities.

- Regulatory and Policy Imperatives

  In response to stringent EU regulations on building energy performance and environmental impact, certification processes must evolve to encompass a wider array of performance indicators to ensure adherence to these evolving standards.

- Economic Considerations

  Operational expenditures, inclusive of energy, maintenance, and repairs, significantly influence the total cost of ownership of a building. An expansive evaluation approach considers these aspects, offering a more precise depiction of a building's efficiency and long-term economic value.

- Interconnected System

  Buildings feature interconnected systems wherein alterations in one system can impact multiple others. For instance, augmenting insulation can reduce heating demands but may necessitate enhanced mechanical ventilation due to the reduction of natural air infiltration, underscoring the necessity for an integrated evaluation approach.

- Resilience and Adaptability

  In light of climate changes, buildings must exhibit resilience and adaptability. A comprehensive certification shall examine how buildings can adapt to climatic hazards, including their capacity to accommodate emergent technologies or shifts in usage.

- Sustainable materials

  A heightened level of embodied energy (KPI 4), indicative of the quantum of energy expended during the material production, directly bears upon the building's aggregate Life Cycle Global Warming Potential (GWP, KPI 8). Moreover, initiatives undertaken to mitigate embodied energy inherently correspond with objectives pertaining to energy efficiency (KPIs 1-3), facilitated by the adoption of materials that augment insulation properties or diminish operational energy requisites. The selection of sustainable materials, influenced by KPI 4, further exhibits a correlation with indoor environmental quality KPIs (KPIs 9-16) by potentially ameliorating air quality and enhancing occupant comfort through the incorporation of non-toxic, low-emission materials.

In consequence of the above considerations, the system of KPIs described in the CWA EUB SuperHub furnishes a comprehensive perspective on the building's overall functionality and its implications on sustainability, occupant welfare, and operational efficacy. The CWA EUB SuperHub supports the adoption of a holistic and integrated approach for the appraisal of building energy performance, in contrast to the segmented evaluation of individual issues. This integrated modus operandi is deemed superior for manifold reasons:

- buildings embody intricate, interrelated systems wherein alterations in one domain can substantially influence others. An integrated approach acknowledges these interdependencies, ensuring that advancements in one sphere do not inadvertently compromise performance in another;
- an holistic approach provides an aggregate depiction of a building's performance, facilitating more informed decision-making processes. Stakeholders can prioritize interventions that proffer the greatest cumulative benefit, ensuring that investments in building energy performance optimization yield maximal returns across a range of KPIs, from energy savings and reduced GHG emissions to augmented occupant satisfaction;
- prioritizing the holistic performance of buildings places the well-being of occupants at the forefront. Integrating considerations of thermal comfort, indoor air quality, and daylight provision with energy efficiency measures ensures that buildings provide healthier, more comfortable, and productive environments for their users.

5.2 A system of interconnected KPIs

The CWA EUB SuperHub outlines a comprehensive framework of 21 Key Performance Indicators (see Table 02) designed to support the next generation of Energy Performance Certificates (EPCs). These KPIs are organized into 10 thematic areas: Energy Consumption, Renewable Energy, GHG Emissions, Thermal Comfort, Indoor Air Quality, Costs, Smart Buildings, Resilience to Overheating, E-mobility, and Daylight Sufficiency. The development of these indicators stems from a bottom-up approach (see clause 6), incorporating feedback from stakeholders and aligning with European Commission policies, notably the recast of the Energy Performance of Buildings Directive (EPBD).

The EUB SuperHub system of KPIs promotes and facilitate an integrated approach to buildings' design, construction and operation that acknowledges the interactions among various energy -related issues leading to the realization of buildings that are more sustainable, efficient, and conducive to occupant well-being.

The interrelation among the EUB SuperHub Key Performance Indicators (KPIs) within the domain of building energy performance encapsulates the multifaceted and interdependent associations between disparate facets of a building's design and operational dynamics. These interrelations indicate that modifications or enhancements in one KPI can exert influence on the outcomes of other KPIs, manifesting either as positive or negative impacts. The EUB SuperHub CWA supports the management of these interrelations for an all-encompassing approach to the design and operation of high performance buildings.

The principal interrelations among KPIs pertinent to building energy certification are elucidated as follows (refer to Table 02 for KPIs numbers):

- Energy Efficiency and Environmental Consequences

  Augmentations in energy efficiency KPIs, exemplified by diminished energy consumption per unit area (KPI 1), exhibit a direct interrelation with KPIs pertaining to environmental consequences, such as reduced GHG emissions (KPI 7 and KPI 8). Enhancements in energy efficiency typically lead to a diminution in the requisite energy derived from non-renewable sources, thereby mitigating the building's carbon footprint.

- Renewable Energy Integration

  The incorporation of renewable energy sources (KPI 5, KPI 6) is intrinsically connected to KPIs related to energy consumption and GHG emissions. The utilization of renewable energy not only curtails reliance on non-renewable energy but also reduces GHG emissions, demonstrating a positive interrelation between these KPIs.

- Indoor Environmental Quality and Energy Consumption

  KPIs related to indoor environmental quality, such as thermal comfort (KPI 9) and indoor air quality (KPI 10 to KPI 16), possess intricate interrelations with energy consumption KPIs. Enhancements in thermal insulation or ventilation efficiency can concurrently ameliorate occupant comfort and air quality while reducing the energy demand for heating, cooling, and air purification.

- Smart Building Technologies

  The deployment of intelligent building technologies (KPI 18) exhibits correlations with various KPIs across the spectrum. Intelligent systems can optimize energy utilization, enhance indoor environmental quality, and even facilitate renewable energy integration. The employment of automated controls and intelligent systems can result in significant improvements across multiple performance dimensions.

- Daylight Provision

  The KPI associated with the capacity of a building to provide adequate daylight (KPI 21) holds a multifaceted correlation with other Key Performance Indicators (KPIs) within the realm of energy performance. The provision of adequate daylight within a building not only influences the occupants' well-being and productivity but also impacts various aspects of energy consumption and environmental sustainability.

- Adaptation to Climate Change

  KPIs associated with the building's resilience to overheating (KPI 19) due to climate changes, exerts an influence on the building's energy performance framework by mitigating reliance on artificial cooling mechanisms, thereby positively affecting the energy consumption metrics delineated in KPIs 1 through 3. This attribute of resilience ensures that buildings are aptly fortified to sustain temperate conditions without inordinate energy expenditure, directly amplifying the thermal comfort of occupants as encapsulated in KPI 9.

- Economic Implications

  Operational energy expenditures (KPI 17) are directly impacted by a building's energy efficiency, renewable energy utilization, and integration of smart technologies. A reduction in energy consumption or on-site generation of renewable energy can culminate in substantial economic savings, underscoring the economic ramifications of energy-centric KPIs.

- Integration with E-Mobility

  The provision for e-mobility infrastructure (KPI 20) exhibits a correlation with a building's energy profile, particularly as electric vehicles become increasingly integrated into the energy systems of buildings. The availability of charging infrastructure can amplify the building's energy demands but also presents avenues for renewable energy utilization and intelligent energy management.

6 Selection of KPIs: the bottom-up approach

Indicators selected result from a recognition of the existing transnational set of indicators. The final selection contains indicators which have the prerogatives and the potential to become Key Performance Indicators (KPIs) and they represent the starting point of the activity related to the definition of common transnational indicators and assessment metrics for the EUB e-Passport.

Several activities have been carried out to get this selected list of indicators; the conclusion highlights the relevant aspects to be highly considered for the next generation EPC in relation to the policies of the European Commission and hence, the need for introducing additional related indicators, not existing in the transnational set of indicators analyzed. The relevant transnational sets of indicators, considering the initiatives of the European Commission (SRI, Level(s)), the outputs of European Projects already concluded (CESBA MED, FASUDIR, NewTREND, etc.), the European standardization (CEN), the works of the Sustainable Building Alliance (SBA, now closed), etc. have been investigated and further analyzed. Several indicators have been collected thanks to this reconnaissance and properly catalogued according to a fixed template.

Through a “bottom-up” approach, the thematic areas considered the most relevant for the next generation of EPCs have been identified. The activity followed two different approaches, including desk research and field activity with relevant stakeholders. The selection has been built on:

- Results arising from a concise user-friendly Survey, prepared and distributed in by the EUB consortium, with the aim to get feedback from the stakeholders, whose suggestions about next generation of EPC are considered very relevant for the activity, about the priority of each of the thematic areas identified.
- An in-depth analysis related to the proposal included in the document released from the European Commission about the revision of the Energy Performance of Buildings Directive (EPBD) in December 2021.

Results achieved through this “bottom-up” approach have been discussed among technical partners mainly involved in the activity. The internal consortium consultation has contributed to the final selection of the thematic areas of interest and the key aspects to be included in the EUB SuperHub e-Passport for the next generation of EPCs. Once detected the key thematic areas of interest, indicators belonging to them have been identified, starting from the transnational frameworks analyzed at the beginning. According to a prioritization activity, based on an approach focused on the rank of importance of priority elements considered for the selection (standard, European strategies, compliance with the EPBD recast, etc.), in an objective way the activity has been able to define the list of indicators which have the characteristics to become KPIs.

The list of potential KPIs thus obtained, is made up of indicators relevant according to the objectives established by the European Commission in relation to the next generation of EPCs and coherent with the sustainability strategies defined for buildings. This procedure has highlighted the indicators which have the prerogatives and the potential to become Key Performance Indicators (KPIs).

To further details the potential KPIs identified, a qualitative analysis has been carried out with the aim to define, for each of them, the indicator's affordability rating. This activity has enabled to give, to each indicator selected, an affordability score classifying them depending on their characteristics, areas of application, availability of data, cost and other parameters extensively described in the deliverable.

The final objective of this activity was to establish a taxonomy classification of the fundamental indicators for the next generation of EPCs to be included in the EUB SuperHub e-Passport, returning a catalogue of indicators very closed to the needs of market actors. At the end of the work process carried out, a direct comparison among the suggestions for the next generation of EPCs expressed by the European Commission in the EPBD recast has been performed and the potential KPIs which can fulfil them have been identified, highlighting the aspects still uncovered by the indicators selected.

Figure 01 represents a schematic summary of the key steps followed by EUB SuperHub project, with some indication about the implementation timeline and the activity description.

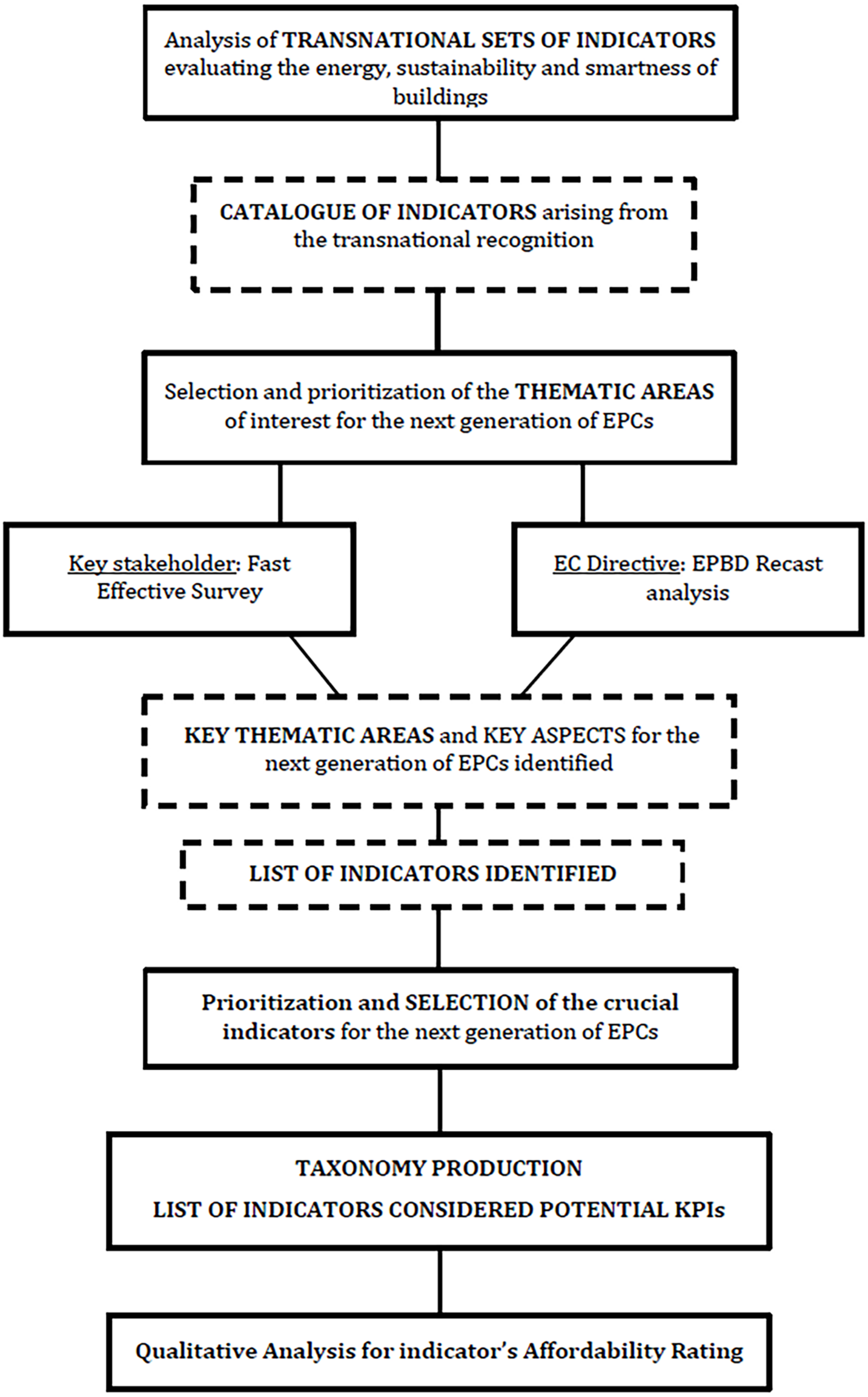

Figure 01 - Summary of the key steps followed by EUB SuperHub project

7 KPIs selected

7.1 General

The approach presented in the previous chapter ended in a list of 21 KPIs, distributed in the following ten thematic areas:

- Energy consumption
- Renewable energy
- GHG emissions
- Thermal comfort
- Indoor air quality
- Costs
- Smart buildings
- Resilience to overheating
- E-mobility
- Daylight sufficiency

The reference frameworks of the KPIs are diverse, as Level(s) which is the European Framework for Sustainable Buildings (mainly based on EU policy and strategy, referring to CEN or ISO standards), CEN standards, European projects, European Union or Commission texts (official or in project). For the next generation of EPCs and building e-passport, the two crucial frameworks are Level(s) and the revised EPBD (to be published in 2024).

It's important to note that the revised EPBD (2024) introduces the need for sub-hourly data in energy performance calculations. However, there's currently no consensus on a standardized hourly or sub-hourly calculation procedure across the mentioned standards and national energy performance calculation methods. Which is reflected in the fact that currently most EU countries still use monthly energy performance assessment procedures. The CWA members, recognizing the limitations of this approach, have opted to continue with monthly assessments for now. This approach does not fully account for fluctuations in primary energy factors and carbon emissions of energy carriers, and it inadequately rewards the self-use of renewable energy sources like solar thermal, PV, and wind. A significant limitation is also seen in how exported renewable energy is not included in energy performance declarations (K_{exp} = 0).

Looking forward, there's a recognized need to shift from monthly to sub-hourly (10 to 15 minutes) energy performance calculations. This change is essential to accurately reflect the impact of dynamic systems (such as heat pumps and energy storage) and elements (like solar blinds) on a building's energy performance. A sub-hourly approach would also enable a more precise evaluation of how building technical services (BTS) and electrical storage systems, including smart car charging, interact with the energy grid.

Table 02 – List of the 21 KPIs according to the thematic areas

Thematic area	Key Performance Indicator (KPI)		Unit	Reference framework
Energy consumption	KPI 1	Delivered annual energy per area unit	[kWh/(m²y)]	1.1 Level(s)

Thematic area	Key Performance Indicator (KPI)		Unit	Reference framework
	KPI 2	Total annual primary energy use per area unit (self-used)	[kWh/(m²y)]	1.1 Level(s)
	KPI 3	Non-renewable annual primary energy use per area unit (self-used)	[kWh/(m²y)]	1.1 Level(s)
	KPI 4	Embodied energy	[kWh/m²] or [MJ]	EN 15978
Renewable energy	KPI 5	Renewable annual primary energy use per area unit (self-used)	[kWh/(m²y)]	1.1 Level(s)
	KPI 6	Renewable energy ratio (on-site, nearby)	[%]	B1.4 CESBA MED
GHG emissions	KPI 7	Operational greenhouse gas emissions	[kg CO_2 eq./ m²] for a reference study period of 50 years or [kg CO_2 eq. / (m²y)]	C1.3 CESBA MED
	KPI 8	Life Cycle Global Warming Potential (GWP)	[kg CO_2 eq./ m²] for a reference study period of 50 years	1.2 Level(s)
Thermal comfort	KPI 9	Percentage of time outside of thermal comfort range	[%]	4.2 Level(s)
Indoor air quality	KPI 10	Ventilation rate	[l/s/m²]	4.1 Level(s)
	KPI 11	CO_2 concentration	[ppm]	
	KPI 12	Relative humidity	[%]	
	KPI 13	Total VOCs	[µg/m³]	
	KPI 14	CMR VOCs concentration	[µg/m³]	
	KPI 15	R value	[decimal ratio]	
	KPI 16	Formaldehyde concentration	[µg/m³]	
Costs	KPI 17	Operational energy cost	[€/(m²y)]	10.1 NewTREND
Smart buildings	KPI 18	Smart Readiness Indicator (SRI)	[%]	Commission Delegated Regulation (EU) 2020/2155 of 14 Oct. 2020 and Commission Implementing Regulation (EU) 2020/2156 of 14 Oct. 2020 EN ISO 52120-1
Resilience to overheating	KPI 19	Summer thermal discomfort in 2050	[%] of time in 2050 in which the operative indoor temperature exceeds 27 °C during the cooling season	5.1 Level(s)

Thematic area	Key Performance Indicator (KPI)		Unit	Reference framework
E-mobility	KPI 20	Percentage of recharging points and installed pre-cabling in relation to the number of parking spaces	[%]	EPBD recast (Article 12)
Daylight sufficiency	KPI 21	Daylight provision	[%]	EN 17037

7.2 Presentation of the KPIs template

A template has been defined to document in detail each KPI and to give assessment guidelines to the assessor.

The following table explains each item of this template.

Table 03 – Template for the description of KPIs

Item of the template	Explanation and/or questions to ask
Name of the KPI	Full name of the KPI
Description	What does the indicator measure and how?
Scope	Does the KPI address residential buildings, non-residential buildings, or both?
System boundary	Where is the system or assessment boundary set? Building, site, location?
Unit of measure	How the KPI is measured/expressed
Applicability	Certification case: - New building - Renovated building - Existing building (occupied from more than 3 years) Building use: - Residential - Non residential Project stage: - Design - Construction / As Built - In Use

Reference Standards	EU, national or regional reference standards available for the KPI calculation or measurement
Assessment method	- Calculation process (Step by step instructions) - Measurement process (Step by step instructions)
Comparability of results	What are the conditions of comparability of KPI results between buildings, at national or transnational level? The comparability can be reached with different methodologies depending on the nature of indicators and done based on a functional equivalency. The functional equivalent is a description of technical characteristics and functionalities of the building. This description forms the basis for transparent comparison. The functional equivalent of a building shall include at least the following information: building category, relevant technical and functional requirements, pattern of use (occupancy), required service life, exposure to climate.
Data	Data source It depends on the type of source investigated to find the required data. It's important to check the reliability of the source, the updating of the data, the accuracy of the information, etc. Data quality It relies on different factors: - Databases: it's fundamental to check the quality of the data contained in databases, their updating, reliability, availability, etc. - Accuracy of the measurements: the instruments used to perform the measurements, the number of measurements performed, etc. - Software used: its compliance with the regulation, its accuracy, etc.
Assessors and auditor' required competences	Minimum level of competence in relation to the Areas of Expertise and Learning Outcomes of the CWA 17939:2022, TRAIN4SUSTAIN

7.3 KPIs Assessment Guideline

Each of the 21 KPIs is described in Tables from 04 to 24, according to the template in 7.2.

Table 04 - KPI 1 - Delivered annual energy per area unit

Name of the KPI	**Delivered annual energy per area unit**
Description	Delivered energy means energy, expressed per energy carrier, supplied to the technical building systems through the assessment boundary, to satisfy the uses taken into account or to produce the exported energy. Assessment boundary is the boundary where the delivered or exported energy are measured or calculated. For example, solar PV panels installed on the roof of a building, are considered as outside the assessment boundary, and all the electricity produced on the roof is considered as delivered energy to a building. The same rule applies for other onsite sources such as wind turbines, solar thermals, heat pumps using geothermal or aerothermal heat as a heat source. Energy can be delivered to the building and exported from the building through the assessment boundary. The renewable energy generated on-site reduces non-renewable delivered energy used in a building and, when exported, it reduces the overall primary energy use. If energy is exported from the building, this should also be considered. NOTE: The exported energy is to be reported separately as a benefit beyond the building's system boundary, under module D of the building life cycle (see EN 15978). NOTE: Delivered/exported energy can be calculated or measured.
Scope	This KPI addresses residential and non-residential buildings with the default energy performance of buildings (EPB) services (see Table B.18 in EN ISO 52000-1:2017). List of minimum EPB services for residential buildings: heating, cooling, ventilation, humidification, dehumidification, and domestic hot water. The minimum EPB services for non-residential buildings are the same, plus built-in lighting (indoor). This KPI addresses the following module of the building life cycle (see EN 15978): - B6 – Operational energy use
System boundary	Calculation or measurement of the energy flows (delivered and exported energy) is performed at the assessment boundary (see definition and Figure 1 in EN ISO 52000-1:2017). Inside the assessment boundary, the energy losses are taken into account by technical building system efficiency factors and thus are already accounted for in delivered energy values.

Unit of measure	Delivered annual energy per area unit E_{del} is expressed in [kWh/(m²y)]
Applicability	Certification case: - New building - Existing building - Renovated building Building use: - Residential - Non residential Project stage: - Design - Construction / As Built - In Use
Reference Standards	The energy calculation method for energy performance available across the EU includes: - use of national standards for the calculation of energy needs for heating and cooling (e.g., EN ISO 13790, EN ISO 52016-1), - use of national standards still applied for the calculation of delivered energy to the building (e.g., EN 15603 [1] and its associated standards - EN 15316 series), - use of calculation methods compliant with the EN ISO 52000 series and standards developed under mandate 480, - use of national or regional calculation methods and associated software tools (which must comply with Annex I of the EPBD).
Assessment method	According to EN ISO 52000-1:2017 (Table 3), there are two types/methods of the energy performance of building assessment: - calculated (asset) assessment method, - measured (operational) assessment method – only applicable to existing buildings in the use phase. Subtypes of calculated (asset) assessment method: design, as built, actual, and tailored. Subtypes of measured (operational) assessment method: actual, climate corrected, use corrected, and standard. The assessment type and subtype used should be reported in all cases for the purposes of comparability. **Calculation process**

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

	The calculation direction goes from the needs (e.g. for space heating/cooling, ventilation, domestic hot water preparation, lighting) to the delivered energy expressed per energy carrier and per building service. Calculations are based on the standard use and climate data set. **Calculated delivered annual energy per area unit $\boldsymbol{E_{\mathrm{del,calc}}}$** in **kWh/(m²y)** through the assessment boundary required to satisfy the uses taken into account or to produce the exported energy: $E_{\mathrm{del,calc}} = \frac{\sum E_{\mathrm{del},cr,\mathrm{calc}}}{A}$ where: $E_{\mathrm{del},cr,\mathrm{calc}}$ is the calculated annual delivered energy per energy carrier (*cr*) and per building service [kWh/y] *A* – is the reference floor area [m²] **Calculated (asset) assessment method for calculating the delivered annual energy per area unit:** 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 per energy carrier (*cr*) and per building service required to satisfy the uses taken into account or to produce the exported energy, 3. calculate the **delivered annual energy per area unit $\boldsymbol{E_{\mathrm{del,calc}}}$** in **kWh/(m²y)** to the building site by summing up the calculated annual delivered energy (from step 2) and then dividing by reference floor area. **Measurement process** The measured delivered annual energy per area unit $\boldsymbol{E_{\mathrm{del,meas}}}$ in kWh/(m²y) to satisfy the uses taken into account or to produce the exported energy is calculated in the same way as the calculated delivered annual energy per area unit $E_{\mathrm{del,calc}}$ in kWh/(m²y) using the measured delivered energy amount $E_{\mathrm{del};cr,\mathrm{meas}}$ instead of the corresponding calculated amounts $E_{\mathrm{del};cr,\mathrm{calc}}$.: $E_{\mathrm{del,meas}} = \frac{\sum E_{\mathrm{del},cr,\mathrm{meas}}}{A}$ where: $E_{\mathrm{del},cr,\mathrm{meas}}$ is the measured annual delivered energy for energy carrier (*cr*) corrected to standard use and climate data set, excluding non-EPB uses [kWh/y] *A* – is the reference floor area [m²]

	NOTE: The actual measured annual delivered energy for energy carrier (*cr*) under actual conditions needs to be corrected to standard use (correction from actual to standard occupancy pattern and conditions of use) and climate data set (correction from the actual to the standard weather). Also, only desired EPB services should be considered excluding non-EPB uses (e.g., appliances and lighting in the case of residential buildings). **Measured (operational) assessment method - delivered annual energy per area unit:** 1. measure annual amount of each energy carrier (*cr*) required delivered to the building site through the assessment boundary to satisfy the uses taken into account or to produce the exported energy, 2. convert the measured amount of energy carriers into delivered energy, 3. if non-EPB services are included in the raw measured data, perform separation procedures to get measured annual delivered energy for EPB services only, 4. to get the measured annual delivered energy for energy carrier (*cr*) corrected to standard use and climate data set perform the following corrections: - correction from actual to standard occupancy pattern and conditions of use, - correction from the actual to the standard weather, 5. calculate the **delivered annual energy per area unit** $E_{\text{del,meas}}$ in **kWh/(m²y)** to the building site by summing up measured annual delivered energy for each energy carrier (*cr*) corrected to standard use and climate data set (from step 4) and then dividing by the reference floor area. Note: In order to allow the calculation of some other KPIs using this KPI 1, it is necessary to keep available the intermediate results about all the delivered energy values linked to each energy carrier (*cr*).
Comparability of results	The results of this indicator are comparable between the buildings: - if the buildings are of the same building categorybuilding category at the same European climate zone (5 European climate zones based on global radiation, heating degree-days, cooling degree-days and cooling potential by night ventilation), - if the same assessment method (either calculated or measured) and subtype is used, - if the same building services are considered when calculating this indicator, - if the reference floor area is defined with the same conventions

Data	<u>**Data source (for calculation)**</u> For the evaluation of the **calculated delivered annual energy per area unit $E_{del,calc}$ in kWh/(m²y) to satisfy the uses taken into account or to produce the exported energy**, the following values are required: - conditions of use and occupancy, - thermal envelope description, - building services description (efficiencies of building technical systems), - reference year climate file, - internal temperature set points, - ventilation and infiltration rate, - internal gains, - technical building system characteristics and capacities, - reference floor area A in [m²] <u>**Data source (for measurement)**</u> For the calculation of the **measured delivered annual energy per area unit $E_{del,meas}$ in kWh/(m²y) to satisfy the uses taken into account or to produce the exported energy**, the following values are required: - $\Sigma E_{del,cr,meas}$ 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 in [kWh/y] - A is the reference floor area in [m²]
Assessors and auditor' required competences	Listed below the learning outcomes belonging to the CWA 17939:2022 of TRAIN4SUSTAIN for the **delivered annual energy per area unit**: - EN3.1 Heating and cooling systems (EN3.1.1, EN3.1.2, EN3.1.3, EN3.1.4, EN3.1.5, EN3.1.7, EN3.1.10, EN3.1.11,) - EN3.2 Ventilation systems (EN3.2.1, EN3.2.2, EN3.2.3, EN3.2.4, EN3.2.5, EN3.2.7, EN3.2.10, EN3.2.11) - EN3.3 Hot water systems (DHW) (EN3.3.1, EN3.3.2, EN3.3.3, EN3.3.4, EN3.3.5, EN3.3.7, EN3.3.10, EN3.3.11) - EN3.4 Electric heating systems (EN3.4.1, EN3.4.2, EN3.4.3, EN3.4.4, EN3.4.5, EN3.4.7, EN3.4.10, EN3.4.11) - EN3.5 Heat pump systems and geothermal energy systems (EN3.5.1, EN3.5.2, EN3.5.3, EN3.5.4, EN3.5.5, EN3.5.7, EN3.5.10, EN3.5.11) - EN3.6 Solar thermal energy systems for heating, cooling and DHW (EN3.6.1, EN3.6.2, EN3.6.3, EN3.6.4, EN3.6.5, EN3.6.7, EN3.6.10, EN3.6.11) - EN3.7 Solar power systems for electric generation (EN3.7.1, EN3.7.2, EN3.7.3, EN3.7.4, EN3.7.5, EN3.7.7, EN3.7.10, EN3.7.11)

	- EN3.8 Combined Heat and Power (CHP) generation (EN3.8.1, EN3.8.2, EN3.8.3, EN3.8.4, EN3.8.5, EN3.8.7, EN3.8.10, EN3.8.11) - EN3.9 Mini wind power generation (EN3.9.1, EN3.9.2, EN3.9.3, EN3.9.4, EN3.9.5, EN3.9.7, EN3.9.10, EN3.9.11) - EN3.10 Energy storage systems (EN3.10.1, EN3.10.2, EN3.10.3, EN3.10.4, EN3.10.5) - EN4.1 Thermal insulation (EN4.1.1, EN4.1.2, EN4.1.3, EN4.1.4, EN4.1.5, EN4.1.9) - EN4.2 Building air tightness (EN4.2.1, EN4.2.2, EN4.2.3, EN4.2.4, EN4.2.5, EN4.2.9) - EN4.3 Window and glazing systems (EN4.3.1, EN4.3.2, EN4.3.3, EN4.3.4, EN4.3.5, EN4.3.9) - EN4.4 Solar shading systems (EN4.4.1, EN4.4.2, EN4.4.3, EN4.4.4, EN4.4.5, EN4.4.9) - EN4.5 Passive systems for cooling and heating (EN4.5.1, EN4.5.2, EN4.5.3, EN4.5.4, EN4.5.5, EN4.5.9) - EN4.6 Energy savings strategies for lighting (EN4.6.1, EN4.6.2, EN4.6.3, EN4.6.4, EN4.6.5) - CO3.2 Indoor lighting (CO3.2.1, CO3.2.2, CO3.2.3, CO3.2.4, CO3.2.5, CO3.2.9) - ID5.1 Smart meters (ID5.1.1, ID5.1.2, ID5.1.3, ID5.1.4, ID5.1.7, ID5.1.8)

Table 05 - KPI 2 - Total annual primary energy use per area unit (self-used)

Name of the KPI	**Total annual primary energy use per area unit (self-used)**
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 use is calculated based on the calculated or measured delivered energy expressed per each energy carrier required to meet the building energy demand of considered EPB services (see KPI 1), and the total primary energy factors associated with each energy carrier, without accounting for any export of non-renewable/renewable energy generated on-site (e.g., cogeneration, solar PV).

	NOTE 1: The exported energy is to be reported separately as a benefit addressed by the module D of the building life cycle (see EN 15978). NOTE 2: The measured delivered energy for energy carrier (cr) needs to be corrected to standard use and climate data set excluding non-EPB uses (see KPI 1).NOTE 3: Self-used means energy delivered to the building as part of the building operation. This includes all energy delivered from all sources, including onsite sources for EPB services, such as PV panels and solar thermal installations and ignores any excess of renewable energy from onsite sources that is exported.
Scope	This KPI addresses residential and non-residential buildings with the default energy performance of buildings (EPB) services (see Table B.18 in ISO 52000-1:2017). This KPI addresses the following module of the building life cycle (see EN 15978): B6 – Operational energy use
System boundary	Delivered energy to the building is calculated or measured at the assessment boundary (see definition in ISO 52000-1:2017). Multiplying total primary energy factors associated with each energy carrier, with the delivered energy expressed per each energy carrier to calculate total primary energy use follows **outside the assessment boundary**.
Unit of measure	Total annual primary energy use per area unit E_{Ptot} is expressed in [kWh/(m^{2}y)]
Applicability	Certification case: - New building - Existing building - Renovated building Building use: - Residential - Non residential Project stage: - Design - Construction / As Built - In Use
Reference Standards	The energy calculation method for energy performance available across the EU include:

	- use of national standards still applied (e.g., EN 15603[2] and its associated standards - EN 15316 series), - use of calculation methods compliant with the EN ISO 52000 series and standards developed under mandate 480, - use of national or regional calculation methods and associated software tools (which must comply with Annex I of the EPBD), - EN 17423:2020 Energy performance of buildings – Determination and reporting of Primary Energy Factors (PEF) and CO_2 emission coefficient – General Principles, Module M1-7 (the equivalent ISO standard is ISO 52000-3:2023).
Assessment method	According to EN ISO 52000-1:2017 (Table 3), there are two types/methods of the energy performance of building assessment: - calculated (asset) assessment method, - measured (operational) assessment method. The assessment type and subtype used specified in Table 3 of EN ISO 52000-1:2017 should be reported in all cases for the purposes of comparability. The formula used for calculating total primary energy use is the same for both calculated (asset) and measured (operational) rating methods. **The total annual primary energy use per area unit (self-used)** $\boldsymbol{E_{\mathrm{Ptot}}}$ in **kWh/(m²y)** to satisfy the uses taken into account or to produce the exported energy, represents the sum of non-renewable and renewable primary energy use: $\boldsymbol{E_{\mathrm{Ptot}} = E_{\mathrm{Pnren}} + E_{\mathrm{Pren}}}$ where: E_{Pnren} – is non-renewable annual primary energy use per area unit (self-used) [kWh/(m²y)] (see KPI 3) E_{Pren} – is renewable annual primary energy use per area unit (self-used) [kWh/(m²y)] (see KPI 5)
Comparability of results	The results of this indicator are comparable between the buildings: - if the buildings are of the same building categorybuilding category at the same European climate zone (5 European climate zones based on global radiation, heating degree-days, cooling degree-days and cooling potential by night ventilation), - if the same assessment method (either calculated or measured) and subtype is used, - if the same building services are considered when calculating this indicator,

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

	- if the reference floor area is defined with the same conventions.
Data	Data required for the calculation of **the total annual primary energy use per area unit** E_{Ptot} in **kWh/(m²y)**: - E_{Pnren} – is non-renewable annual primary energy use per area unit [kWh/(m²y)] (see KPI 3) - E_{Pren} – is renewable annual primary energy use per area unit [kWh/(m²y)] (see KPI 5) Primary energy factors (total, non-renewable, renewable) are defined at a national level.
Assessors and auditor' required competences	Listed below the learning outcomes belonging to the CWA 17939:2022 of TRAIN4SUSTAIN for the **total annual primary energy use per area unit**: - EN3.1 Heating and cooling systems (EN3.1.1, EN3.1.2, EN3.1.3, EN3.1.4, EN3.1.5, EN3.1.7, EN3.1.10, EN3.1.11,) - EN3.2 Ventilation systems (EN3.2.1, EN3.2.2, EN3.2.3, EN3.2.4, EN3.2.5, EN3.2.7, EN3.2.10, EN3.2.11) - EN3.3 Hot water systems (DHW) (EN3.3.1, EN3.3.2, EN3.3.3, EN3.3.4, EN3.3.5, EN3.3.7, EN3.3.10, EN3.3.11) - EN3.4 Electric heating systems (EN3.4.1, EN3.4.2, EN3.4.3, EN3.4.4, EN3.4.5, EN3.4.7, EN3.4.10, EN3.4.11) - EN3.5 Heat pump systems and geothermal energy systems (EN3.5.1, EN3.5.2, EN3.5.3, EN3.5.4, EN3.5.5, EN3.5.7, EN3.5.10, EN3.5.11) - EN3.6 Solar thermal energy systems for heating, cooling and DHW (EN3.6.1, EN3.6.2, EN3.6.3, EN3.6.4, EN3.6.5, EN3.6.7, EN3.6.10, EN3.6.11) - EN3.7 Solar power systems for electric generation (EN3.7.1, EN3.7.2, EN3.7.3, EN3.7.4, EN3.7.5, EN3.7.7, EN3.7.10, EN3.7.11) - EN3.8 Combined Heat and Power (CHP) generation (EN3.8.1, EN3.8.2, EN3.8.3, EN3.8.4, EN3.8.5, EN3.8.7, EN3.8.10, EN3.8.11) - EN3.9 Mini wind power generation (EN3.9.1, EN3.9.2, EN3.9.3, EN3.9.4, EN3.9.5, EN3.9.7, EN3.9.10, EN3.9.11) - EN3.10 Energy storage systems (EN3.10.1, EN3.10.2, EN3.10.3, EN3.10.4, EN3.10.5) - EN4.1 Thermal insulation (EN4.1.1, EN4.1.2, EN4.1.3, EN4.1.4, EN4.1.5, EN4.1.9) - EN4.2 Building air tightness (EN4.2.1, EN4.2.2, EN4.2.3, EN4.2.4, EN4.2.5, EN4.2.9) - EN4.3 Window and glazing systems (EN4.3.1, EN4.3.2, EN4.3.3, EN4.3.4, EN4.3.5, EN4.3.9) - EN4.4 Solar shading systems (EN4.4.1, EN4.4.2, EN4.4.3, EN4.4.4, EN4.4.5, EN4.4.9)

	- EN4.5 Passive systems for cooling and heating (EN4.5.1, EN4.5.2, EN4.5.3, EN4.5.4, EN4.5.5, EN4.5.9) - EN4.6 Energy savings strategies for lighting (EN4.6.1, EN4.6.2, EN4.6.3, EN4.6.4, EN4.6.5) - CO3.2 Indoor lighting (CO3.2.1, CO3.2.2, CO3.2.3, CO3.2.4, CO3.2.5, CO3.2.9) - ID5.1 Smart meters (ID5.1.1, ID5.1.2, ID5.1.3, ID5.1.4, ID5.1.7, ID5.1.8)

Table 06 - KPI 3 - Non-renewable annual primary energy use per area unit (self-used)

Name of the KPI	**Non-renewable annual primary energy use per area unit (self-used)**
Description	Non-renewable primary energy means energy from non-renewable sources which has not undergone any conversion or transformation process required to meet the building energy demand of considered EPB services, without accounting for any export of non-renewable energy generated on-site (e.g., from cogeneration). The indicator uses non-renewable primary energy factors defined for each energy carrier to calculate the non-renewable primary energy use based on the calculated or measured delivered energy (see KPI 1). NOTE 1: The exported energy is to be reported separately as a benefit addressed by the module D of the building life cycle (see EN 15978). NOTE 2: The measured delivered energy for energy carrier (*cr*) needs to be corrected to standard use and climate data set, excluding non-EPB uses (see KPI 1). NOTE 3: Delivered energy means energy delivered to the building as part of the building operation. This includes all energy delivered from all sources, including onsite sources for EPB services, such as PV panels and solar thermal installations and ignores any excess of renewable/non-renewable energy from onsite sources that is exported.
Scope	This KPI addresses residential and non-residential buildings with the default energy performance of buildings (EPB) services (see Table B.18 in ISO 52000-1:2017). This KPI addresses the following module of the building life cycle (see EN 15978): B6 – Operational energy use
System boundary	Delivered energy to the building is calculated or measured at the assessment boundary (see definition in ISO 52000-1:2017). Multiplying non-renewable primary energy factors associated with each energy carrier with the delivered energy expressed per

	each energy carrier to calculate non-renewable primary energy use follows **outside the assessment boundary**.
Unit of measure	Non-renewable annual primary energy use per area unit E_{Pnren} in [kWh/(m²y)]
Applicability	Certification case: - New building - Existing building - Renovated building Building use: - Residential - Non residential Project stage: - Design - Construction / As Built - In Use
Reference Standards	The energy calculation method for energy performance available across the EU include: - use of national standards still applied (e.g., EN 15603[3] and its associated standards - EN 15316 series), - use of calculation methods compliant with the EN ISO 52000 series and standards developed under mandate 480, - use of national or regional calculation methods and associated software tools (which must comply with Annex I of the EPBD), - EN 17423:2020 Energy performance of buildings – Determination and reporting of Primary Energy Factors (PEF) and CO2 emission coefficient – General Principles, Module M1-7 (the equivalent ISO standard is ISO 52000-3:2023).
Assessment method	According to EN ISO 52000-1:2017 (Table 3), there are two types/methods of the energy performance of building assessment: - calculated (asset) assessment method, - measured (operational) assessment method. The assessment type and subtype used specified in Table 3 of EN ISO 52000-1:2017 should be reported in all cases for the purposes of comparability. The formula for calculating non-renewable primary energy use is the same for both the calculated (asset) and measured (operational) assessment methods. The non-renewable primary energy use is obtained using the calculated amounts of delivered energy carriers, whereas the

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

measured non-renewable primary energy use is calculated using the measured amounts of delivered energy carriers instead of calculated ones.

Calculation process

Non-renewable annual primary energy use per area unit $\boldsymbol{E}_{\mathbf{Pnren}}$ in **kWh/(m²y)** is calculated by multiplying calculated delivered energy for each energy carrier (*cr*) with the non-renewable primary energy factors corresponding to each energy carrier and then dividing by the reference floor area:

$$\boldsymbol{E}_{\mathbf{Pnren}} = \frac{\sum \left(E_{\mathrm{del},cr,\mathrm{calc}} \cdot f_{\mathrm{Pnren,del},cr} \right)}{\mathrm{A}}$$

where:

$E_{\mathrm{del};cr,\mathrm{calc}}$ – is the calculated delivered annual energy for energy carrier (*cr*) [kWh/y] → it is an intermediate result from KPI 1

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

A – reference floor area [m²]

Format for reporting the results of an assessment using the calculation method specified in Level(s) (*Level(s) indicator 1.1: Use stage energy performance*) could be used.

Measurement process

Non-renewable annual primary energy use per area unit $\boldsymbol{E}_{\mathbf{Pnren}}$ in **kWh/(m²y)** is calculated by multiplying measured delivered energy for each energy carrier (*cr*) with the non-renewable primary energy factors corresponding to each energy carrier and then dividing by the reference floor area:

$$\boldsymbol{E}_{\mathbf{Pnren}} = \frac{\sum \left(E_{\mathrm{del},cr,\mathrm{meas}} \cdot f_{\mathrm{Pnren,del},cr} \right)}{A}$$

where:

$E_{\mathrm{del},cr,\mathrm{meas}}$ – is the measured delivered annual energy for energy carrier (*cr*) corrected to standard use and climate data set excluding non-EPB uses [kWh/y] → it is an intermediate result from KPI 1

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

A – reference floor area [m²]

Format for reporting the results of an assessment using the measured (operational) assessment method specified in Level(s) (*Level(s) indicator 1.1: Use stage energy performance*) could be used.

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.
Comparability of results	The results of this indicator are comparable between the buildings: - if the buildings are of the same building category at the same European climate zone (5 European climate zones based on global radiation, heating degree-days, cooling degree-days and cooling potential by night ventilation), - if the same assessment method (either calculated or measured) and subtype is 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, - if the reference floor area is defined with the same conventions.
Data	**<u>Data source (for calculation)</u>** For the calculation of the **non-renewable annual primary energy use per area unit** for EPB services $\boldsymbol{E}_{\mathbf{Pnren}}$ in **kWh/(m²y)** the following values are required: - $E_{\mathrm{del},cr,\mathrm{calc}}$ – the calculated delivered annual energy for energy carrier (*cr*) [kWh/y] → it is an intermediate result from KPI 1 - $f_{\mathrm{Pnren,del},cr}$ – non-renewable primary energy factor for the delivered energy carrier (*cr*) [–] - A – reference floor area [m²] **<u>Data source (for measurement)</u>** For the calculation of the **non-renewable annual primary energy use per area unit** for EPB services $\boldsymbol{E}_{\mathbf{Pnren}}$ in **kWh/(m²y)** the following values are required: - $E_{\mathrm{del},cr,\mathrm{meas}}$ – is the measured delivered annual energy for energy carrier (*cr*) <u>corrected to standard use and climate data set excluding non-EPB uses</u> [kWh/y] → it is an intermediate result from KPI 1 - $f_{\mathrm{Pnren,del},cr}$ – non-renewable primary energy factor for the delivered energy carrier (*cr*) [–] - A – reference floor area [m²]
Assessors and auditor' required competences	Listed below the learning outcomes belonging to the CWA 17939:2022 of TRAIN4SUSTAIN for the **non-renewable annual primary energy use per area unit**: - EN3.1 Heating and cooling systems (EN3.1.1, EN3.1.2, EN3.1.3, EN3.1.4, EN3.1.5, EN3.1.7, EN3.1.10, EN3.1.11,) - EN3.2 Ventilation systems (EN3.2.1, EN3.2.2, EN3.2.3, EN3.2.4, EN3.2.5, EN3.2.7, EN3.2.10, EN3.2.11)

	- EN3.3 Hot water systems (DHW) (EN3.3.1, EN3.3.2, EN3.3.3, EN3.3.4, EN3.3.5, EN3.3.7, EN3.3.10, EN3.3.11) - EN3.4 Electric heating systems (EN3.4.1, EN3.4.2, EN3.4.3, EN3.4.4, EN3.4.5, EN3.4.7, EN3.4.10, EN3.4.11) - EN3.5 Heat pump systems and geothermal energy systems (EN3.5.1, EN3.5.2, EN3.5.3, EN3.5.4, EN3.5.5, EN3.5.7, EN3.5.10, EN3.5.11) - EN3.6 Solar thermal energy systems for heating, cooling and DHW (EN3.6.1, EN3.6.2, EN3.6.3, EN3.6.4, EN3.6.5, EN3.6.7, EN3.6.10, EN3.6.11) - EN3.7 Solar power systems for electric generation (EN3.7.1, EN3.7.2, EN3.7.3, EN3.7.4, EN3.7.5, EN3.7.7, EN3.7.10, EN3.7.11) - EN3.8 Combined Heat and Power (CHP) generation (EN3.8.1, EN3.8.2, EN3.8.3, EN3.8.4, EN3.8.5, EN3.8.7, EN3.8.10, EN3.8.11) - EN3.9 Mini wind power generation (EN3.9.1, EN3.9.2, EN3.9.3, EN3.9.4, EN3.9.5, EN3.9.7, EN3.9.10, EN3.9.11) - EN3.10 Energy storage systems (EN3.10.1, EN3.10.2, EN3.10.3, EN3.10.4, EN3.10.5) - EN4.1 Thermal insulation (EN4.1.1, EN4.1.2, EN4.1.3, EN4.1.4, EN4.1.5, EN4.1.9) - EN4.2 Building air tightness (EN4.2.1, EN4.2.2, EN4.2.3, EN4.2.4, EN4.2.5, EN4.2.9) - EN4.3 Window and glazing systems (EN4.3.1, EN4.3.2, EN4.3.3, EN4.3.4, EN4.3.5, EN4.3.9) - EN4.4 Solar shading systems (EN4.4.1, EN4.4.2, EN4.4.3, EN4.4.4, EN4.4.5, EN4.4.9) - EN4.5 Passive systems for cooling and heating (EN4.5.1, EN4.5.2, EN4.5.3, EN4.5.4, EN4.5.5, EN4.5.9) - EN4.6 Energy savings strategies for lighting (EN4.6.1, EN4.6.2, EN4.6.3, EN4.6.4, EN4.6.5) - CO3.2 Indoor lighting (CO3.2.1, CO3.2.2, CO3.2.3, CO3.2.4, CO3.2.5, CO3.2.9) - ID5.1 Smart meters (ID5.1.1, ID5.1.2, ID5.1.3, ID5.1.4, ID5.1.7, ID5.1.8)

Table 07 - KPI 4 - Embodied energy

Name of the KPI	**Embodied energy**
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. It is interesting to note that this indicator is not as such among the EN 15978 tables of indicators, it may be considered as 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-

<table>
<tr><td></td><td>of-life, considering the life cycle of these materials, products, and services.

It includes non-renewable primary energy uses and non-renewable primary energy resources used as raw materials.

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, taken at the scale of the building (or building unit), 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.</td></tr>
<tr><td>**Scope**</td><td>This KPI addresses both residential and non-residential buildings.

This indicator supposes a good knowledge of construction products and services (technical equipment) attached to the building.

So, it is adapted to **new** construction and to **renovated** buildings.

The life cycle of the building is considered, together with the life cycle of the construction products it is made of.</td></tr>
<tr><td>**System boundary**</td><td>All the construction elements are considered: from foundations to finishings.

The minimum scope/perimeter of the indicator includes the following building parts and elements:

<table>
<tr><th>Building parts</th><th>Related building elements</th></tr>
<tr><td colspan="2">Shell (substructure and superstructure)</td></tr>
<tr><td>Foundations (substructure)</td><td>• Piles
• Basements
• Retaining walls</td></tr>
</table>
</td></tr>
</table>

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
Table drawn from Level(s) framework, 2021	

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

Notes:

- Detailed tables are available in Level(s) Indicator 1.2 Manual and in User Manual 2 document, chapter on building description,
- Furniture and equipment brought by the building occupants are not included.

The life cycle perimeter for calculating this indicator covers the "cradle to grave" processes (raw materials extraction or acquisition, transport to manufacturing facilities, manufacturing processes, transport to the construction site, construction processes, maintenance, repair, replacement, end-of-life stages until final disposal), for all the construction materials, products, components, and services used in the construction of the building, its service life (50 years by default) and its end-of-life. The rules for determining their impacts and aspects through a life cycle assessment are defined in EN 15804 and EN 15978. For electric and electronic devices, the product category rules for LCAs are defined in EN 50693.

Theoretically, the full life cycle of the building and its immediate surroundings on its site (plot of land / curtilage), 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 assessment boundary description and in results presentation. This enables results understanding and comparability.
Unit of measure	Embodied energy is measured as: [kWh/m^2] or [MJ] (net calorific value) Note: The EN 15978 standard mentions MJ unit for all energy indicators, but for ensuring homogeneity with the other energy KPIs of the present document, it is preferable to use [kWh / m^2] (per area unit and for building RSP = 50 years).
Applicability	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** (<u>with long-term use data of at least three years</u>) In the case of existing buildings in the use phase, this indicator is generally <u>not</u> 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. **Renovated buildings** <u>(without long-term use data)</u> 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, to be published at the end of 2024). Note: Different approaches or methods might be used for this 3rd case. The chosen one should be clearly identified/described in the assessment report Building use: - Residential - Non residential Project stage: - Design: preferably at detailed design stage for a precise calculation (or at an early stage with default assumptions, for a rough estimation) - Construction / As Built - In Use: not relevant if the building has not been recently built or renovated
Reference Standards	**EN 15978**:2011, Sustainability of construction works - Assessment of environmental performance of buildings – Calculation method (revised version to be published at the end of 2024). **EN 15804**:2012+A2:2019, Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products. **EN 50693**:2019 - Product category rules for life cycle assessments of electronic and electrical products and systems. **ISO 14067**:2018, Greenhouse gases - Carbon footprint of products - Requirements and guidelines for quantification.
Assessment method	Embodied energy is obtained through a **calculation process**, not a measurement process. 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). 1. **Use of a Bill of Materials (BoM)** (see Level(s) framework) The following steps should be followed to compile the BoM:

	- Compile the Bill of Quantities (BoQ): 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). - Consider the non-renewable primary energy. - The results are then aggregated at the building scale. - A reporting format with sufficient detailed interim figures is recommended. 2. **Use of a database of EPDs compliant with EN 15804** (for a calculation at the building scale, compliant with EN 15978) - Compile the Bill of Quantities (BoQ): A BoQ comprises the building elements accounting for at least 99% of the mass of the building. - Identify in the database the EPDs (from cradle to grave) 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 non-renewable primary energy indicator. - Multiply the quantities and the value of the primary non-renewable energy for each product. - If some EPDs are not available, use realistic default values instead of “zero” (and precise their number and source). - Aggregate at the scale of the building, keeping available interim results (e.g. per life cycle module and per family of products).

Comparability of results	The results of this indicator are comparable between the buildings: - If the buildings are of the same building category, with a similar pattern of use - If the calculation method or software is compliant with EN 15978, with, as far as possible, product LCI data compliant with EN 15804+A2 - If the same life cycle modules are taken into account - If the same method is used (1 or 2) - If the data quality is similar - if the use of default values (in absence of actual data) is not too high - if the completeness of building description is comparable (same product families taken into account) - if the building reference study period (RSP) is the same
Data	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 **EN 15941**:2024 Sustainability of construction works - Data quality for environmental assessment of products and construction work - Selection and use of data.
Assessors and auditor' required competences	Listed below the LOs belonging to the CWA 17939:2022 of TRAIN4SUSTAIN for the **embodied energy**: - MA1.1 Materials and components for ease of disassembly (MA1.1.5, MA1.1.9) - MA1.2 Adaptive reuse (MA1.2.1, MA1.2.2, MA1.2.3, MA1.2.6) - MA2.1 Life Cycle Assessment (MA2.1.2, MA2.1.3, MA2.1.4, MA2.1.5, MA2.1.6) - MA 2.2 Recycled and reused materials (MA2.2.6) - MN1.3 Building degradation diagnosis (MN1.3.1)

Table 08 - KPI 5 - Renewable annual primary energy use per area unit (self-used)

Name of the KPI	**Renewable annual primary energy use per area unit (self-used)**
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 to meet the building energy demand of considered EPB services, without accounting for any export of renewable energy generated on-site (e.g., from solar PV). The indicator uses renewable primary energy factors defined for each energy carrier to calculate the renewable primary energy use based on the calculated or measured delivered energy (see KPI 1). 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 use with subscript following the chosen perimeters: $E_{\mathrm{Pren,onst}}$ – renewable primary energy use produced on-site $E_{\mathrm{Pren,nrby}}$ – renewable primary energy use produced nearby $E_{\mathrm{Pren,dist}}$ – renewable primary energy use produced distant NOTE 1: The exported renewable energy is to be reported separately as a benefit addressed the module D of the building life-cycle (see EN 15978). NOTE 2: The measured delivered energy for energy carrier (*cr*) needs to be corrected to standard use and climate data set excluding non-EPB uses (see KPI 1). NOTE 3: Delivered energy means energy delivered to the building as part of the building operation. This includes all energy delivered from all sources, including onsite sources for EPB services, such as PV panels and solar thermal installations and ignores any excess of renewable energy from onsite sources that is exported.

Scope	This KPI addresses residential and non-residential buildings with the default energy performance of buildings (EPB) services (see Table B.18 in ISO 52000-1:2017). This KPI addresses the following module of the building life cycle (see EN 15978): - B6 – Operational energy use
System boundary	Delivered energy to the building is calculated or measured at the assessment boundary (see definition in ISO 52000-1:2017). Multiplying renewable primary energy factors associated with each energy carrier with the delivered energy to calculate renewable primary energy use follows **outside the assessment boundary**.
Unit of measure	Renewable annual primary energy use per area unit E_{Pren} in [kWh/(m^{2}y)]
Applicability	Certification case: - New building - Existing building - Renovated building Building use: - Residential - Non residential Project stage: - Design - Construction / As Built - In Use
Reference Standards	The energy calculation method for energy performance available across the EU include: - use of national standards still applied (e.g., EN 15603[4] and its associated standards - EN 15316 series), - use of calculation methods compliant with the EN ISO 52000 series and standards developed under mandate 480, - use of national or regional calculation methods and associated software tools (which must comply with Annex I of the EPBD), - EN 17423:2020 Energy performance of buildings – Determination and reporting of Primary Energy Factors (PEF) and CO2 emission coefficient – General Principles, Module M1-7 (the equivalent ISO standard is ISO 52000-3:2023).

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

Assessment method	According to EN ISO 52000-1:2017 (Table 3), there are two types/methods of the energy performance of building assessment: - calculated (asset) assessment method, - measured (operational) assessment method. The assessment type and subtype used specified in Table 3 of EN ISO 52000-1:2017 should be reported in all cases for the purposes of comparability. The formula for calculating renewable annual primary energy use per area unit is the same for both calculated (asset) and measured (operational) assessment methods. The calculated renewable primary energy use 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. **Calculation process** **Renewable annual primary energy use per unit 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 area unit: $$E_{\mathrm{Pren}} = \frac{\sum(E_{\mathrm{del},cr,\mathrm{calc}} \cdot f_{\mathrm{Pren,del},cr})}{A}$$ where: $E_{\mathrm{del},cr,\mathrm{calc}}$ – the calculated delivered annual energy for energy carrier (*cr*) [kWh/y] $f_{\mathrm{Pren,del},cr}$ – renewable primary energy factor for the delivered energy carrier (*cr*) [–] *A* – reference floor area [m²] Format for reporting the results of an assessment using the calculation method specified in Level(s) (*Level(s) indicator 1.1: Use stage energy performance*) could be used. **Measurement process** **Renewable annual primary energy use per area unit 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 area unit: $$E_{\mathrm{Pren}} = \frac{\sum(E_{\mathrm{del},cr,\mathrm{meas}} \cdot f_{\mathrm{Pren,del},cr})}{A}$$ where:

	$E_{del,cr,meas}$ – is the measured delivered annual energy for energy carrier (*cr*) corrected to standard use and climate data set, excluding non-EPB uses [kWh/y] → it is an intermediate result from KPI 1 $f_{Pren,del,cr}$ – renewable primary energy factor for the delivered energy carrier (*cr*) [–] *A* – reference floor area [m²] Format for reporting the results of an assessment using the measured (operational) assessment method specified in Level(s) (*Level(s) indicator 1.1: Use stage energy performance*) could be used. 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.
Comparability of results	The results of this indicator are comparable between the buildings: - if the buildings are of the same building category - if the buildings are at the same European climate zone (5 European climate zones based on global radiation, heating degree-days, cooling degree-days and cooling potential by night ventilation), - if the same assessment method (either calculated or measured) and subtype is 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, - if the reference floor area is defined with the same conventions.
Data	**Data source (for calculation)** For the calculation of the **renewable annual primary energy use per area unit** E_{Pren} in **kWh/(m²y)** the following values are required: - $E_{del,cr,calc}$ – the calculated delivered annual energy for energy carrier (*cr*) [kWh/y] - $f_{Pren:del;cr}$ – renewable primary energy factor for the delivered energy carrier (*cr*) [–] - *A* – reference floor area [m²] **Data source (for measurement)** For the calculation of the **renewable annual primary energy use per area unit** for EPB services E_{Pren} in **kWh/(m²y)** the following values are required:

	- $E_{del,cr,meas}$ – is the measured delivered annual energy for energy carrier (*cr*) corrected to standard use and climate data set, excluding non-EPB uses [kWh/y] - $f_{Pren,del,cr}$ – renewable primary energy factor for the delivered energy carrier (*cr*) [–] - *A* – reference floor area [m²]
Assessors and auditor' required competences	Listed below the learning outcomes belonging to the CWA 17939:2022 of TRAIN4SUSTAIN for the **renewable annual primary energy use per area unit**: - EN3.1 Heating and cooling systems (EN3.1.1, EN3.1.2, EN3.1.3, EN3.1.4, EN3.1.5, EN3.1.7, EN3.1.10, EN3.1.11,) - EN3.2 Ventilation systems (EN3.2.1, EN3.2.2, EN3.2.3, EN3.2.4, EN3.2.5, EN3.2.7, EN3.2.10, EN3.2.11) - EN3.3 Hot water systems (DHW) (EN3.3.1, EN3.3.2, EN3.3.3, EN3.3.4, EN3.3.5, EN3.3.7, EN3.3.10, EN3.3.11) - EN3.4 Electric heating systems (EN3.4.1, EN3.4.2, EN3.4.3, EN3.4.4, EN3.4.5, EN3.4.7, EN3.4.10, EN3.4.11) - EN3.5 Heat pump systems and geothermal energy systems (EN3.5.1, EN3.5.2, EN3.5.3, EN3.5.4, EN3.5.5, EN3.5.7, EN3.5.10, EN3.5.11) - EN3.6 Solar thermal energy systems for heating, cooling and DHW (EN3.6.1, EN3.6.2, EN3.6.3, EN3.6.4, EN3.6.5, EN3.6.7, EN3.6.10, EN3.6.11) - EN3.7 Solar power systems for electric generation (EN3.7.1, EN3.7.2, EN3.7.3, EN3.7.4, EN3.7.5, EN3.7.7, EN3.7.10, EN3.7.11) - EN3.8 Combined Heat and Power (CHP) generation (EN3.8.1, EN3.8.2, EN3.8.3, EN3.8.4, EN3.8.5, EN3.8.7, EN3.8.10, EN3.8.11) - EN3.9 Mini wind power generation (EN3.9.1, EN3.9.2, EN3.9.3, EN3.9.4, EN3.9.5, EN3.9.7, EN3.9.10, EN3.9.11) - EN3.10 Energy storage systems (EN3.10.1, EN3.10.2, EN3.10.3, EN3.10.4, EN3.10.5) - EN4.1 Thermal insulation (EN4.1.1, EN4.1.2, EN4.1.3, EN4.1.4, EN4.1.5, EN4.1.9) - EN4.2 Building air tightness (EN4.2.1, EN4.2.2, EN4.2.3, EN4.2.4, EN4.2.5, EN4.2.9) - EN4.3 Window and glazing systems (EN4.3.1, EN4.3.2, EN4.3.3, EN4.3.4, EN4.3.5, EN4.3.9) - EN4.4 Solar shading systems (EN4.4.1, EN4.4.2, EN4.4.3, EN4.4.4, EN4.4.5, EN4.4.9) - EN4.5 Passive systems for cooling and heating (EN4.5.1, EN4.5.2, EN4.5.3, EN4.5.4, EN4.5.5, EN4.5.9) - EN4.6 Energy savings strategies for lighting (EN4.6.1, EN4.6.2, EN4.6.3, EN4.6.4, EN4.6.5)

	- CO3.2 Indoor lighting (CO3.2.1, CO3.2.2, CO3.2.3, CO3.2.4, CO3.2.5, CO3.2.9) - ID5.1 Smart meters (ID5.1.1, ID5.1.2, ID5.1.3, ID5.1.4, ID5.1.7, ID5.1.8)

Table 09 - KPI 6 - Renewable energy ratio (on-site, nearby)

<table>
<tr><th>Name of the KPI</th><th>Renewable energy ratio (on-site, nearby)</th></tr>
<tr><td>Description</td><td>Renewable energy ratio (on-site, nearby) is the ratio of the renewable primary energy use produced on-site and nearby to the total primary energy use. According to the EN ISO 52000-1:2017 (Table B.24), this KPI excludes distant produced primary energy use.
<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.

One main sustainability target within the European Union is to increase the share of renewable primary energy use in total primary energy use to lower the dependency of the EU on fossil energy sources and to reduce the greenhouse gas emissions caused by fossil energy sources.</td></tr>
<tr><td>Scope</td><td>This KPI addresses residential and non-residential buildings with the default energy performance of buildings (EPB) services (see Table B.18 in ISO 52000-1:2017).

This KPI addresses the following module of the building life cycle (see EN 15978):
B6 – Operational energy use</td></tr>
<tr><td>System boundary</td><td>Dividing the renewable primary energy use with the total primary energy use follows outside the assessment boundary (see definition in ISO 52000-1:2017).</td></tr>
<tr><td>Unit of measure</td><td>Renewable energy ratio (on-site, nearby) $RER_{onst,nrby}$ in [%]</td></tr>
<tr><td>Applicability</td><td>Certification case:
- New building
- Existing building
- Renovated building</td></tr>
</table>

	Building use: - Residential - Non residential Project stage: - Design - Construction / As Built - In Use
Reference Standards	The energy calculation method for energy performance available across the EU include: - use of national standards still applied (e.g., EN 15603[5] and its associated standards - EN 15316 series), - use of calculation methods compliant with the EN ISO 52000 series and standards developed under mandate 480, - use of national or regional calculation methods and associated software tools (which must comply with Annex I of the EPBD), - EN 17423:2020 Energy performance of buildings – Determination and reporting of Primary Energy Factors (PEF) and CO2 emission coefficient – General Principles, Module M1-7 (the equivalent ISO standard is ISO 52000-3:2023).
Assessment method	According to EN ISO 52000-1:2017 (Table 3), there are two types/methods of the energy performance of building assessment: - calculated (asset) assessment method, - measured (operational) assessment method. The assessment type and subtype used specified in Table 3 of EN ISO 52000-1:2017 should be reported in all cases for the purposes of comparability. **Calculation process** The renewable energy ratio (onsite, nearby) $RER_{\text{onst,nrby}}$ in % is calculated by formula: $\boldsymbol{RER}_{\textbf{onst,nrby}} = \frac{\boldsymbol{E}_{\textbf{Pren,onst,nrby}}}{\boldsymbol{E}_{\textbf{Ptot}}} \cdot \mathbf{100}$ where: E_{Ptot} – is the total annual primary energy use per area unit based on the calculated delivered energy [kWh/(m²y)] $E_{\text{Pren,onst,nrby}}$ – is the renewable annual primary energy use per area unit in [kWh/(m²y)] for the purpose of *RER*

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

	calculation, including the on-site and the nearby produced renewable primary energy use <u>based on the calculated renewable energy</u>. **<u>Measurement process</u>** The renewable energy ratio (onsite, nearby) $RER_{\text{onst,nrby}}$ in % is calculated by formula: $$\boldsymbol{RER_{\text{onst,nrby}}} = \frac{\boldsymbol{E_{\text{Pren,onst,nrby}}}}{\boldsymbol{E_{\text{Ptot}}}} \cdot \mathbf{100}$$ where: E_{Ptot} – is the total primary annual energy demand per area unit <u>based on the measured delivered energy</u> [kWh/(m²y)] $E_{\text{Pren,onst,nrby}}$ – is the renewable annual primary energy use per area unit in [kWh/(m²y)]for the purpose of *RER* calculation, including the on-site and the nearby produced renewable primary energy use <u>based on the measured renewable energy</u>. NOTE 1: The renewable energy ratio $RER_{\text{onst,nrby}}$ 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 ratio $RER_{\text{onst,nrby}}$ can be calculated using the same above given formula based on measured value only in case all contributions of renewable sources are measured! NOTE 2: 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) [%] $RER_{\text{onst, nrby}}$ – renewable energy ratio (on-site, nearby) [%] – default choices according to EN ISO 52000-1:2017 $RER_{\text{onst, nrby, dist}}$ – renewable energy ratio (on-site, nearby, and distant) [%]
Comparability of results	The results of this indicator are comparable between the buildings: - if the buildings are of the same building category at the same European climate zone (5 European climate zones based on global radiation, heating degree-days, cooling degree-days and cooling potential by night ventilation),

	- if the same assessment method (either calculated or measured) and subtype is 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.
Data	**<u>Data source (for calculation)</u>** For the calculation of the **renewable energy ratio (onsite, nearby)** $\boldsymbol{RER_{\mathrm{onst,nrby}}}$ in **%** the following values are required: - E_{Ptot} – the total annual primary energy use per area unit based on the <u>calculated</u> delivered energy [kWh/(m²y)] - $E_{\mathrm{Pren,onst,nrby}}$ – the renewable annual primary energy use per area unit for the purpose of *RER* calculation, including the on-site and the nearby produced renewable primary energy use based on the <u>calculated</u> renewable energy [kWh/(m²y)] For the calculation of the renewable annual primary energy use per area unit $\boldsymbol{E_{\mathrm{Pren,onst,nrby}}}$ in [kWh/(m²y)] the following values are required: - $E_{\mathrm{del},cr,\mathrm{calc,onsite}}$ – the <u>calculated</u> annual on-site delivered energy for energy carrier (*cr*) [kWh/(m²y)] - $E_{\mathrm{del},cr,\mathrm{calc,nrby}}$ – the <u>calculated</u> annual nearby delivered energy for energy carrier (*cr*) [kWh/(m²y)] - $f_{\mathrm{Pren,del},cr}$ – renewable primary energy factor for the delivered energy carrier (*cr*) [–] **<u>Data source (for measurement)</u>** For the calculation of the **renewable energy ratio (onsite, nearby)** $\boldsymbol{RER_{\mathrm{onst,nrby}}}$ in **%** the following values are required: - E_{Ptot} – is the total annual primary energy use per area unit based on the <u>measured</u> delivered energy [kWh/(m²y)] - $E_{\mathrm{Pren,onst,nrby}}$ – the renewable annual primary energy use per area unit for the purpose of *RER* calculation, including the on-site and the nearby produced renewable primary energy use based on the <u>measured</u> renewable energy [kWh/(m²y)] For the calculation of the renewable annual primary energy use per area unit $\boldsymbol{E_{\mathrm{Pren,onst,nrby}}}$ in [kWh/(m²y)] the following values are required: - $E_{\mathrm{del},cr,\mathrm{meas,onsite}}$ is the <u>measured</u> annual on-site delivered energy for energy carrier (*cr*) [kWh/(m²y)] - $E_{\mathrm{del},cr,\mathrm{meas,nrby}}$ is the <u>measured</u> annual nearby delivered energy for energy carrier (*cr*) [kWh/(m²y)]

	- $f_{\mathrm{Pren,del},cr}$ – renewable primary energy factor for the delivered energy carrier *cr* [–]
Assessors and auditor' required competences	Listed below the learning outcomes belonging to the CWA 17939:2022 of TRAIN4SUSTAIN for the **renewable energy ratio**: - EN3.1 Heating and cooling systems (EN3.1.1, EN3.1.2, EN3.1.3, EN3.1.4, EN3.1.5, EN3.1.7, EN3.1.10, EN3.1.11,) - EN3.2 Ventilation systems (EN3.2.1, EN3.2.2, EN3.2.3, EN3.2.4, EN3.2.5, EN3.2.7, EN3.2.10, EN3.2.11) - EN3.3 Hot water systems (DHW) (EN3.3.1, EN3.3.2, EN3.3.3, EN3.3.4, EN3.3.5, EN3.3.7, EN3.3.10, EN3.3.11) - EN3.4 Electric heating systems (EN3.4.1, EN3.4.2, EN3.4.3, EN3.4.4, EN3.4.5, EN3.4.7, EN3.4.10, EN3.4.11) - EN3.5 Heat pump systems and geothermal energy systems (EN3.5.1, EN3.5.2, EN3.5.3, EN3.5.4, EN3.5.5, EN3.5.7, EN3.5.10, EN3.5.11) - EN3.6 Solar thermal energy systems for heating, cooling and DHW (EN3.6.1, EN3.6.2, EN3.6.3, EN3.6.4, EN3.6.5, EN3.6.7, EN3.6.10, EN3.6.11) - EN3.7 Solar power systems for electric generation (EN3.7.1, EN3.7.2, EN3.7.3, EN3.7.4, EN3.7.5, EN3.7.7, EN3.7.10, EN3.7.11) - EN3.8 Combined Heat and Power (CHP) generation (EN3.8.1, EN3.8.2, EN3.8.3, EN3.8.4, EN3.8.5, EN3.8.7, EN3.8.10, EN3.8.11) - EN3.9 Mini wind power generation (EN3.9.1, EN3.9.2, EN3.9.3, EN3.9.4, EN3.9.5, EN3.9.7, EN3.9.10, EN3.9.11) - EN3.10 Energy storage systems (EN3.10.1, EN3.10.2, EN3.10.3, EN3.10.4, EN3.10.5) - EN4.1 Thermal insulation (EN4.1.1, EN4.1.2, EN4.1.3, EN4.1.4, EN4.1.5, EN4.1.9) - EN4.2 Building air tightness (EN4.2.1, EN4.2.2, EN4.2.3, EN4.2.4, EN4.2.5, EN4.2.9) - EN4.3 Window and glazing systems (EN4.3.1, EN4.3.2, EN4.3.3, EN4.3.4, EN4.3.5, EN4.3.9) - EN4.4 Solar shading systems (EN4.4.1, EN4.4.2, EN4.4.3, EN4.4.4, EN4.4.5, EN4.4.9) - EN4.5 Passive systems for cooling and heating (EN4.5.1, EN4.5.2, EN4.5.3, EN4.5.4, EN4.5.5, EN4.5.9) - EN4.6 Energy savings strategies for lighting (EN4.6.1, EN4.6.2, EN4.6.3, EN4.6.4, EN4.6.5) - CO3.2 Indoor lighting (CO3.2.1, CO3.2.2, CO3.2.3, CO3.2.4, CO3.2.5, CO3.2.9) - ID5.1 Smart meters (ID5.1.1, ID5.1.2, ID5.1.3, ID5.1.4, ID5.1.7, ID5.1.8)

Table 10 - KPI 7 - Operational greenhouse gas emissions

Name of the KPI	**Operational greenhouse gas emissions**
Description	This indicator gives a measurement of the quantity of greenhouse gases (GHG) of the building, emitted directly (on-site) and indirectly (off-site) during its use stage, due to energy consumption for a list of uses or services (called EPB services), knowing the energy sources/carriers involved and their location. 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. This result in a quantity of GHG expressed in kg CO_2 eq. (equivalent). The indicator is an **extension of indicator "Delivered annual energy per area unit" (KPI 1)** in terms of GHG emissions. The knowledge of the energy sources/carriers linked to the flows of delivered energy is necessary. Note that this KPI is based on delivered energy, that is final energy, not on primary energy. Nevertheless, the CO_2 emission coefficients that are used in the calculation method include the GHG emissions due to the upstream processes of each energy carrier. As explained in the description of KPI 1: - only "delivered energy" (input) is considered here, without considering exported energy (output), nor a balance between them, - delivered energy can be calculated or measured. The present indicator is obtained through a calculation process, not a measurement process. It can be based on calculated or measured delivered energy, according to the application case.
Scope	This KPI addresses residential and non-residential buildings with the default energy performance of buildings (EPB) services (see Table B.18 in ISO 52000-1:2017). This KPI addresses the following module of the building life cycle (see EN 15978):

	- B6 – Operational energy use NOTE: When calculating this indicator, the building services considered must always be clearly declared if they differ from default choices.
System boundary	The system boundary is the same as for indicator KPI 1 - Delivered annual energy per area unit, for consistency reasons. Other systems than energy-related ones can contribute to operational greenhouse gas emissions, as the provision of potable water, wastewater treatment or refrigerants leakage, but here they are excluded from the assessment boundary.
Unit of measure	2 possibilities: - kg CO_2 eq./m^2 area unit, for a reference study period (RSP) of 50 years - kg CO_2 eq./ (m^{2}y) (per area unit and per year)
Applicability	Certification cases: - **New building** in the design/construction/'as built' phase (without long-term use data) – The indicator is based on calculated delivered energy per carrier. - **Existing building** in the use phase (with long-term use data of at least three years) - The indicator is based on calculated or measured delivered energy per carrier. - **Renovated building** in the design/construction/'as built' phase (without long-term use data) - The indicator is based on calculated delivered energy per carrier. Building use: - Residential - Non-residential Project stage: - Design - Construction / As Built - In Use
Reference Standards	- **ISO 16745-1**:2017 - Sustainability in buildings and civil engineering works - Carbon metric of an existing building during use stage - Part 1: Calculation, reporting and communication - **EN 15978:**2011 - Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method (a revision will be published at the end of 2024)

	- **ISO 14067**:2018 - Greenhouse gases - Carbon footprint of products - Requirements and guidelines for quantification (note: a product may be a good or a service) - **ISO 52000-3**:2023 - Energy performance of buildings - Overarching EPB assessment - Part 3: General principles for determination and reporting of primary energy factors (PEF) and CO_2 emission coefficients.
Assessment method	**<u>Calculation method:</u>** The starting point is the annual delivered energy per energy carrier and per use. Each type of energy flow is multiplied by a CO_2 emission coefficient drawn from an official national database and multiplied by the RSP of the building (50 years) or kept per year. It is assumed that CO_2 emission coefficients are constant during the RSP, representing the current situation. Note: In some countries, this KPI is calculated by multiplying the primary energy use (per energy carrier) by a CO_2 emission coefficient that is defined for 1 kWh of primary energy. So, the calculation method has to be adapted consequently, using the right CO_2 emission coefficients, not those applying to delivered (final) energy. **<u>Assessment approach:</u>** During the design stage (new building or building under renovation) the indicator can't be calculated if the energy sources are not chosen yet. **<u>Results reporting</u>:** Transparency is required, and sub-indicators should be visible.
Comparability of results	The results of this indicator are comparable between the buildings: - if the delivered energy figures coming from KPI 1 respect its comparability conditions - if the building category, its main functionalities, and the conditions of use are the same (included in the "functional equivalent" of the building under assessment) - if the buildings are located in the same climate zone (5 European climate zones based on global radiation, heating degree-days, cooling degree-days and cooling potential by night ventilation),

	- if the assessment boundaries are the same (spatial and temporal) - if the reference floor area is defined with the same conventions - if the CO_2 emissions coefficients per energy carrier are of the same (good) quality level - if the main assumptions and scenarios are the same - if the greenhouse gases taken into account are the same (at least for the significant ones) - if the same standards and assessment methods are used
Data	The necessary data are: - Calculated delivered energy per use and per energy carrier (from indicator KPI 1) - Measured delivered energy per energy carrier (from indicator KPI 1) corrected to standard use and climate data set, excluding non-EPB uses - CO_2 emission coefficients for energy carriers For electricity consumptions from the grid, beyond the nature of the energy carriers producing electricity, it is sometimes important to distinguish use by use because the CO_2 emission coefficients may differ according to the use. For instance, they may be specific, and so different, for heating, domestic hot water, cooling, etc., because the temporality or seasonality implies different combinations of energy sources, more or less carbon intensive, in the electricity mix. Note: The existence of a Building Logbook can facilitate data collection
Assessors and auditor' required competences	Listed below the learning outcomes belonging to the CWA 17939:2022 of TRAIN4SUSTAIN for the **operational greenhouse gas emissions**: - EN3.1 Heating and cooling systems (EN3.1.1, EN3.1.2, EN3.1.3, EN3.1.4, EN3.1.5, EN3.1.7, EN3.1.10, EN3.1.11,) - EN3.2 Ventilation systems (EN3.2.1, EN3.2.2, EN3.2.3, EN3.2.4, EN3.2.5, EN3.2.7, EN3.2.10, EN3.2.11) - EN3.3 Hot water systems (DHW) (EN3.3.1, EN3.3.2, EN3.3.3, EN3.3.4, EN3.3.5, EN3.3.7, EN3.3.10, EN3.3.11) - EN3.4 Electric heating systems (EN3.4.1, EN3.4.2, EN3.4.3, EN3.4.4, EN3.4.5, EN3.4.7, EN3.4.10, EN3.4.11) - EN3.5 Heat pump systems and geothermal energy systems (EN3.5.1, EN3.5.2, EN3.5.3, EN3.5.4, EN3.5.5, EN3.5.7, EN3.5.10, EN3.5.11)

	- EN3.6 Solar thermal energy systems for heating, cooling and DHW (EN3.6.1, EN3.6.2, EN3.6.3, EN3.6.4, EN3.6.5, EN3.6.7, EN3.6.10, EN3.6.11) - EN3.7 Solar power systems for electric generation (EN3.7.1, EN3.7.2, EN3.7.3, EN3.7.4, EN3.7.5, EN3.7.7, EN3.7.10, EN3.7.11) - EN3.8 Combined Heat and Power (CHP) generation (EN3.8.1, EN3.8.2, EN3.8.3, EN3.8.4, EN3.8.5, EN3.8.7, EN3.8.10, EN3.8.11) - EN3.9 Mini wind power generation (EN3.9.1, EN3.9.2, EN3.9.3, EN3.9.4, EN3.9.5, EN3.9.7, EN3.9.10, EN3.9.11) - EN3.10 Energy storage systems (EN3.10.1, EN3.10.2, EN3.10.3, EN3.10.4, EN3.10.5) - EN4.1 Thermal insulation (EN4.1.1, EN4.1.2, EN4.1.3, EN4.1.4, EN4.1.5, EN4.1.9) - EN4.2 Building air tightness (EN4.2.1, EN4.2.2, EN4.2.3, EN4.2.4, EN4.2.5, EN4.2.9) - EN4.3 Window and glazing systems (EN4.3.1, EN4.3.2, EN4.3.3, EN4.3.4, EN4.3.5, EN4.3.9) - EN4.4 Solar shading systems (EN4.4.1, EN4.4.2, EN4.4.3, EN4.4.4, EN4.4.5, EN4.4.9) - EN4.5 Passive systems for cooling and heating (EN4.5.1, EN4.5.2, EN4.5.3, EN4.5.4, EN4.5.5, EN4.5.9) - EN4.6 Energy savings strategies for lighting (EN4.6.1, EN4.6.2, EN4.6.3, EN4.6.4, EN4.6.5) - CO3.2 Indoor lighting (CO3.2.1, CO3.2.2, CO3.2.3, CO3.2.4, CO3.2.5, CO3.2.9) - ID5.1 Smart meters (ID5.1.1, ID5.1.2, ID5.1.3, ID5.1.4, ID5.1.7, ID5.1.8)

Table 11 - KPI 8 - Life Cycle Global Warming Potential (GWP)

Name of the KPI	**Life Cycle Global Warming Potential (GWP)**
Description	This indicator measures the building's potential 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 elements (materials, construction products, technical systems, often simply called 'products') to the end of the building's service life, and the subsequent building demolition and end-of-life of its elements, are summed up. In this indicator, GHG emissions embodied in building products life cycles are brought together with direct (on-site) and indirect (off-site) GHG emissions from use stage performance (linked to operational energy and water consumption). This KPI is the same as the eponymous **indicator 1.2** of **Level(s)** European framework.

	Regarding building products, this KPI considers the full life cycle of 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. this is similar to **KPI 4** (embodied energy). Regarding building operation, direct (on-site) and indirect (off-site) GHG emitted from energy-related services (called EPB services) are considered, like for **KPI 7** (operational greenhouse gas emissions), but also GHG emissions from processes linked to water provision and sewage. So the use-stage perimeter of this indicator is <u>broader</u> than for KPI 7. Global Warming Potential indicator (GWP) 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). GWP is supposed to represent the potential contribution of a system to the earth's global warming and the associated effects on climate change. This result in a quantity of GHG expressed in kg CO_2 eq. (equivalent).
Scope	This KPI addresses both residential and non-residential buildings. This indicator supposes a good knowledge of construction products and services (technical equipment) attached to the building. Therefore, it is adapted to **new** construction and to **renovated** buildings. The full life cycle of the building is considered, together with the full life cycle of the construction products it is made of.
System boundary	The assessment boundary is set at the building and its site (plot of land) including: - **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 Notes: - Detailed tables are available in Level(s) Indicator 1.2 Manual and in User Manual 2 document, chapter on building description, - Furniture and equipment brought by the building occupants are not included. The **full life cycle** is considered, “from cradle to grave” as defined in EN 15978. The results are 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 Note: If calculated, the part of the produced on-site energy that is exported 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/initial production (A1-3) and construction (A4-5) are ignored). The assessment boundary shall be specified in the assessment report, because it may differ from one case to another, from one country to another, depending on available data and tools, and possible national regulation. If there exists, a national method may be used, provided it is compliant with the reference standards hereafter listed. The assessment boundary of this KPI includes those of KPI 4 (embodied energy) and KPI 7 (operational greenhouse gas emissions), but includes more processes, as water-related ones, upstream and downstream of the building use phase. For the calculation of the use stage water consumption, it is recommended to follow the methodology and practical tool of Level(s) indicator 3.1 (2021). In order to enable a correct interpretation of results and valid comparisons, the assessment boundary shall be described.
Unit of measure	kg CO_2 eq. / m^2 area unit, for a reference study period (RSP) of 50 years. (same unit as Level(s) indicator 1.2)
Applicability	Certification case: 1. **New buildings after construction – new buildings 'as built'** (without long-term use data) In the case of new buildings after construction, the indicator must be calculated considering all the products, equipment and materials used for the building construction, and potential replacements of products in the future (during RSP), following EN 15978. Regarding operational energy and water use, the indicator is based on calculated delivered energy demand per carrier, and calculated water consumption. 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 generally 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. **Renovated buildings** (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 in the assessment report Regarding operational energy and water use, the indicator is based on calculated delivered energy per carrier, and calculated water consumption. Building use: - Residential - Non residential Project stage: - Design: preferably at detailed design stage for a precise calculation (or at an early stage with default assumptions, for a rough estimation) - Construction / As Built
Reference Standards	- **EN 15804**:2012+A2:2019, Sustainability of construction works — Environmental product declarations — Core rules for the product category of construction products - **EN 50693**:2019 - Product category rules for life cycle assessments of electronic and electrical products and systems. - **EN 15978**:2011, Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method (revised version to be published at the end of 2024) - **ISO 14067**:2018 - Greenhouse gases - Carbon footprint of products - Requirements and guidelines for quantification (note: a product may be a good or a service) - **ISO 14040**:2006, Environmental management -- Life cycle assessment -- Principles and framework - **ISO 14044**: 2006, Environmental management -- Life cycle assessment -- Requirements and guidelines - European Commission's **Product Environmental Footprint** (**PEF**) method - **EN 15941**:2024, Sustainability of construction works - Data quality for environmental assessment of products and construction works - Selection and use of data - **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 and EN 50693 (the latest versions or the previous ones) are more numerous than those compliant with the Product Environmental Footprint method.
Assessment method	The present indicator is obtained through a calculation process, not a measurement process. The main reference for the calculation method is EN 15978. The protocol is defined step by step (according to Level(s) methodology for indicator 1.2): 1. Compiling detailed and complete information about the building description (shell, core, etc.) 2. Selecting software tools and databases (compliant with EN 15978, EN 15804 and EN 50693) 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:** GWP is calculated as follows: - Life cycle of products: linear combinations based on the bill of quantities (BoQ) for initial construction, the number of replacements, and the corresponding EPDs. Data gaps should be filled by conservative assumptions with average, generic or default data. - GWP linked to delivered energy (per energy carrier and per use) and water consumption: each type of flow is multiplied by an GHG emission coefficient 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, EN 50693 and EN 15978 shall be followed.

In case this approach is not feasible, 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 1 (extract from Level(s) user manual for indicator 1.2).

Table 1 – Reporting format for Life Cycle GWP, according to Level(s)

Indicator	Unit	Product (A1-3)	Construction process (A4-5)	Use stage (B1-7)	End of life (C1-4)	Beneftis 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 yearsarea						

In recent EPDs, GWP is divided into 3 components according to the origin of the GHG: fossil, biogenic or land use and land use change (luluc). The total GWP is the sum of these 3 components. Some EPDs databases are not yet so detailed, including only a single figure for GWP indicator.

Regarding use stage results, it is advised to display separately B1-B5 (linked to products life cycle), B6 (linked to operational energy use) and B7 (linked to operational water use), for analysis and comparison purpose.

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

Comparability of results

The results of this indicator are comparable between buildings:

	- if the building category, its main functionalities and the conditions of use are the same (included in the "functional equivalent" of the building under assessment) - if the reference study period is the same (included in the "functional equivalent") - if the buildings are located in the same climate zone (5 European climate zones based on global radiation, heating degree-days, cooling degree-days and cooling potential by night ventilation) - if the same standards and assessment methods are used - if the assessment boundaries are the same (spatial and temporal) for products and their life cycle, and for energy and water uses - if the main assumptions and scenarios are the same - If the reference floor area is defined with the same conventions - if the quality and completeness of input data (e.g. bill of quantities, EPDs quality) is of the same (good) level - if the greenhouse gases taken into account are the same (at least for the significant ones) - if the delivered energy figures coming from KPI 1 respect its comparability conditions - if the GHG emissions coefficients per energy carrier and water are official or scientific-based - if, in case of renovation projects, the renovation level is similar (light, medium, deep) - if the assessments are made by trained/qualified assessors
Data	Data source - Bill of quantities (complete and detailed) - Lifespan of each product or element - EPDs database aligned with EN 15804+A2 and EN 50693 - Generic or default data if specific EPDs are missing (so as to avoid empty boxes) - Delivered annual energy per use and energy carrier - Annual water consumption - GHG emission coefficients for energy carriers and for water (including pre- and post-use treatment) Data quality - Software calculation tool aligned with EN 15978 and approved/validated by national authorities - Completeness of building description, with respect of cut-off rules - Database with recent (5 years maximum) and third-party verified/reviewed EPDs - Official/national/actual GHG emission coefficients for energy and water - Relevant use and good quality of generic or default data (representative, not older than 10 years) - Correct correspondence between the products put in place or installed in the building and EPDs

	- Quality requirements of Level(s) for indicator 1.2 (life cycle GWP), dealing with software tools and environmental data - Quality requirements of EN 15941 Note: The existence of a Building Logbook can facilitate data collection
Assessors and auditor' required competences	Listed below the LOs belonging to the CWA 17939:2022 of TRAIN4SUSTAIN for the **life cycle GWP**: **LCA of construction products / equipment / materials** - MA2.1 Life Cycle Assessment (MA2.1.1, MA2.1.2, MA2.1.3, MA2.1.4, MA2.1.5, MA2.1.6) **Use stage energy-related calculation** - EN3.1 Heating and cooling systems (EN3.1.1, EN3.1.2, EN3.1.3, EN3.1.4, EN3.1.5, EN3.1.7, EN3.1.10, EN3.1.11,) - EN3.2 Ventilation systems (EN3.2.1, EN3.2.2, EN3.2.3, EN3.2.4, EN3.2.5, EN3.2.7, EN3.2.10, EN3.2.11) - EN3.3 Hot water systems (DHW) (EN3.3.1, EN3.3.2, EN3.3.3, EN3.3.4, EN3.3.5, EN3.3.7, EN3.3.10, EN3.3.11) - EN3.4 Electric heating systems (EN3.4.1, EN3.4.2, EN3.4.3, EN3.4.4, EN3.4.5, EN3.4.7, EN3.4.10, EN3.4.11) - EN3.5 Heat pump systems and geothermal energy systems (EN3.5.1, EN3.5.2, EN3.5.3, EN3.5.4, EN3.5.5, EN3.5.7, EN3.5.10, EN3.5.11) - EN3.6 Solar thermal energy systems for heating, cooling and DHW (EN3.6.1, EN3.6.2, EN3.6.3, EN3.6.4, EN3.6.5, EN3.6.7, EN3.6.10, EN3.6.11) - EN3.7 Solar power systems for electric generation (EN3.7.1, EN3.7.2, EN3.7.3, EN3.7.4, EN3.7.5, EN3.7.7, EN3.7.10, EN3.7.11) - EN3.8 Combined Heat and Power (CHP) generation (EN3.8.1, EN3.8.2, EN3.8.3, EN3.8.4, EN3.8.5, EN3.8.7, EN3.8.10, EN3.8.11) - EN3.9 Mini wind power generation (EN3.9.1, EN3.9.2, EN3.9.3, EN3.9.4, EN3.9.5, EN3.9.7, EN3.9.10, EN3.9.11) - EN3.10 Energy storage systems (EN3.10.1, EN3.10.2, EN3.10.3, EN3.10.4, EN3.10.5) - EN4.1 Thermal insulation (EN4.1.1, EN4.1.2, EN4.1.3, EN4.1.4, EN4.1.5, EN4.1.9) - EN4.2 Building air tightness (EN4.2.1, EN4.2.2, EN4.2.3, EN4.2.4, EN4.2.5, EN4.2.9) - EN4.3 Window and glazing systems (EN4.3.1, EN4.3.2, EN4.3.3, EN4.3.4, EN4.3.5, EN4.3.9) - EN4.4 Solar shading systems (EN4.4.1, EN4.4.2, EN4.4.3, EN4.4.4, EN4.4.5, EN4.4.9) - EN4.5 Passive systems for cooling and heating (EN4.5.1, EN4.5.2, EN4.5.3, EN4.5.4, EN4.5.5, EN4.5.9) - EN4.6 Energy savings strategies for lighting (EN4.6.1, EN4.6.2, EN4.6.3, EN4.6.4, EN4.6.5) - CO3.2 Indoor lighting (CO3.2.1, CO3.2.2, CO3.2.3, CO3.2.4, CO3.2.5, CO3.2.9) - ID5.1 Smart meters (ID5.1.1, ID5.1.2, ID5.1.3, ID5.1.4, ID5.1.7, ID5.1.8) **Use stage water-related calculation**

	- WA1.2 Indoor water use management (WA1.2.1, WA1.2.2, WA1.2.3, WA1.2.4, WA1.2.5, WA1.2.6)

Table 12 - KPI 9 – Percentage of time outside of thermal comfort range

Name of the KPI	**Percentage of time outside of thermal comfort range**
Description	This indicator measures the percentage of time of the year, during occupation periods, when building occupiers are not comfortable with the thermal conditions inside a building. This indicator is similar to **Level(s)** European framework Indicator 4.2 “Time outside of thermal comfort range” (V1.1, January 2021). Thermal comfort is supposed to be obtained when the operative indoor temperature in each space or zone that accounts for >10% of the total area unit of a building is (generally) within a range of 18°C to 27°C. See also EN 16798-1:2019, Table B.2 and Figure B.1. 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. The assessment without heating or cooling systems can show the resilience of the building, especially the envelope, in case of a critical situation. 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 (EPBD) 2010/31/UE, amended by directive 2018/844, this indicator primarily focuses on summertime thermal comfort, but it also considers buildings capacity to maintain comfortable operative indoor temperatures in winter. The KPI 19, dealing with summer thermal comfort in 2050, can be used to determine future climate scenarios and report on them to address the possibility that adverse climate circumstances would exacerbate both of these issues in the future.
Scope	The indicator's scope encompasses the assessment of both the internal operating temperature and the comfort levels of the building's occupants. For buildings equipped with full or mixed-mode mechanical cooling systems, the assessment is to be done twice: with and without the use mechanical systems. The reported performance shall apply to the

	conditioned spaces or zones that account for >10% of the total area unit of the building.
System boundary	The assessment boundary is each space or zone that accounts for >10% of the total area unit of a 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. Two building models are considered : with heating and/or cooling systems, as designed or installed, and without.
Unit of measure	The percentage of time [%] in which the indoor operative temperature (to) is out of a range of 18°C to 27°C, (Category III EN 16798-1 Table B.5 / Category C EN ISO 7730) during the occupation periods of the year (heating and cooling seasons), with and without building services
Applicability	Certification cases: - **New building** in the design/construction/'as built' phase - The indicator is calculated with a dynamic simulation tool. - **Existing building** in the use phase - The indicator is calculated with a dynamic simulation tool. An option consists in calculating the Predicted Percentage of Dissatisfied (PPD) according to EN ISO 7730, and to compare it with the results from an occupier survey. - **Renovated building** in the design/construction/'as built' phase - The indicator is calculated with a dynamic simulation tool. Building use: - Residential - Non residential Project stage: - Design - Construction / As Built - In Use
Reference Standards	**EN ISO 52000 series:** The calculation of the reported performance shall be based on a dynamic energy simulation complying with the EN ISO 52000-1 series. **EN ISO 52016-1:** Energy performance of buildings - Energy needs for heating and cooling, internal temperatures and sensible and latent heat loads. **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 (it replaces EN 15251:2007).

	CEN/TR 16798-2:2019 - Energy performance of buildings - Ventilation for buildings - Part 2: Interpretation of the requirements in EN 16798-1. **EN ISO 7730**:2005 - Ergonomics of the thermal environment - Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria (under revision)
Assessment method	The assessment relies on the category II temperatures ranges stipulated in EN 16798-1. Calculation shall be based on a dynamic energy simulation and in accordance with the method described in Annex A.2 of EN 16798-1. 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 EN ISO 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 defined in the standard **EN ISO 7730**. The assessor shall be able to model and document: - the evaluated zones in the building - the building thermal and physical values - the building actual or designed heating and cooling systems - the building usage and occupancy profile - the weather data for one representative year and to document the dynamic simulation method used. **Calculation process:** - 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 percentage of time out of range. If not, a dynamic simulation method and related software tool shall be selected. - 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 or not in a national method. - Establish two models for each building or property typology, one with mechanical heating/cooling systems and one without. - Run the dynamic 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 operative indoor temperature, weighted by the surface areas and the occupancy intensity of the different thermal spaces or zones. - If the simulation does not automatically calculate the percentage of time out of range, the results shall be analyzed in order to derive the percentages for the upper and lower temperature bands. - Use the reporting format for assessment results, and document assumptions, method, weather data, etc. so as to facilitate interpretation and comparison.
Comparability of results	The results of the indicator are comparable between the buildings: - if they share the same usage, with a similar pattern of use - if the climatic zone is the same, with comparable weather data - if the same dynamic simulation method is used, compliant with EN ISO 16798-1 or if the same national/regional calculation method is used , compliant with EN ISO 52000-1 series - if the comfort temperature ranges (high and low thresholds) are the same.
Data	Data source The input data collected by the assessors shall be compliant with the input data required in the ISO EN 52000-1 series, EN ISO 52016-1, EN 16798-1:2019 and if applicable the EN ISO 7730:2005 (under revision). Examples of requested input data are listed below: - Details about building envelope and windows: U values and construction method (for building without an EPC or detailed drawing this can be substituted by data from construction year class for existing buildings) - Building materials and related thermal mass - Building openings and orientation - Building usage and occupancy profiles - Building heating systems - Building cooling systems - Weather data Data quality - Relevance, completeness and accuracy of the building modelling (envelope, materials, systems, occupancy, weather) - Representative and recent weather data (about 20 last years) - Dynamic simulation tool that is recognized/validated by national authorities or scientific community - Trained/qualified assessor in energy and comfort dynamic simulation
Assessors and auditor' required competences	Listed below the learning outcomes belonging to the CWA 17939:2022 of TRAIN4SUSTAIN for the **percentage of time outside of thermal comfort range:**

	- EN1.1 – Energy Simulation (EN1.1.4, EN1.1.5) - EN3.1 Heating and cooling systems (EN3.1.1, EN3.1.2, EN3.1.3, EN3.1.4, EN3.1.5, EN3.1.7, EN3.1.10, EN3.1.11,) - EN3.2 Ventilation systems (EN3.2.1, EN3.2.2, EN3.2.3, EN3.2.4, EN3.2.5, EN3.2.7, EN3.2.10, EN3.2.11) - EN3.3 Hot water systems (DHW) (EN3.3.1, EN3.3.2, EN3.3.3, EN3.3.4, EN3.3.5, EN3.3.7, EN3.3.10, EN3.3.11) - EN3.4 Electric heating systems (EN3.4.1, EN3.4.2, EN3.4.3, EN3.4.4, EN3.4.5, EN3.4.7, EN3.4.10, EN3.4.11) - EN3.5 Heat pump systems and geothermal energy systems (EN3.5.1, EN3.5.2, EN3.5.3, EN3.5.4, EN3.5.5, EN3.5.7, EN3.5.10, EN3.5.11) - EN3.6 Solar thermal energy systems for heating, cooling and DHW (EN3.6.1, EN3.6.2, EN3.6.3, EN3.6.4, EN3.6.5, EN3.6.7, EN3.6.10, EN3.6.11) - EN3.7 Solar power systems for electric generation (EN3.7.1, EN3.7.2, EN3.7.3, EN3.7.4, EN3.7.5, EN3.7.7, EN3.7.10, EN3.7.11) - EN3.8 Combined Heat and Power (CHP) generation (EN3.8.1, EN3.8.2, EN3.8.3, EN3.8.4, EN3.8.5, EN3.8.7, EN3.8.10, EN3.8.11) - EN3.9 Mini wind power generation (EN3.9.1, EN3.9.2, EN3.9.3, EN3.9.4, EN3.9.5, EN3.9.7, EN3.9.10, EN3.9.11) - EN3.10 Energy storage systems (EN3.10.1, EN3.10.2, EN3.10.3, EN3.10.4, EN3.10.5) - EN4.1 Thermal insulation (EN4.1.1, EN4.1.2, EN4.1.3, EN4.1.4, EN4.1.5, EN4.1.9) - EN4.2 Building air tightness (EN4.2.1, EN4.2.2, EN4.2.3, EN4.2.4, EN4.2.5, EN4.2.9) - EN4.3 Window and glazing systems (EN4.3.1, EN4.3.2, EN4.3.3, EN4.3.4, EN4.3.5, EN4.3.9) - EN4.4 Solar shading systems (EN4.4.1, EN4.4.2, EN4.4.3, EN4.4.4, EN4.4.5, EN4.4.9) - EN4.5 Passive systems for cooling and heating (EN4.5.1, EN4.5.2, EN4.5.3, EN4.5.4, EN4.5.5, EN4.5.9) - EN4.6 Energy savings strategies for lighting (EN4.6.1, EN4.6.2, EN4.6.3, EN4.6.4, EN4.6.5) - CO3.2 Indoor lighting (CO3.2.1, CO3.2.2, CO3.2.3, CO3.2.4, CO3.2.5, CO3.2.9) - ID5.1 Smart meters (ID5.1.1, ID5.1.2, ID5.1.3, ID5.1.4, ID5.1.7, ID5.1.8)

Table 13 - KPI 10 - Ventilation rate

Name of the KPI	**Ventilation rate**
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 6. 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.
Scope	KPI addresses both residential and non-residential buildings, but it is important to point out that this KPI is only applicable to buildings equipped with a mechanical ventilation.
System boundary	The assessment boundary of the ventilation rate is the building equipped with a mechanical ventilation.
Unit of measure	Ventilation rate (air flow) is measured as: [l /s/m^2]
Applicability	Certification case: - New building: Based on the calculation of the total ventilation rate as described in the EN 16798-1. - Renovated building: Based on the calculation of the total ventilation rate as described in the EN 16798-1. - Existing buildings (in use): Based on the calculation of the total ventilation rate as described in the EN 16798-1. Or 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.). Building use: - Residential - Non residential

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

	Project stage: - Design - Construction / As Built - In Use
Reference Standards	Ventilation rate indicator is developed in accordance with **Level(s)** [7] (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 **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 method	<u>**Calculation process:**</u> 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 detail below.

Detailed description of Method 1

It is based on the methodological approach to quantify the ventilation rates needed in different zones of the building.

STEP 1: Apply the EN 16798-1 method for designing ventilation rates, based on predefined ventilation airflow rates.

Tables below (example for office building and for residential), taken from of EN 16798-1, provides default airflow rates for the four categories of IAQ (I, II, III and IV) in both units of l/s/person and l/s/m².

These values range from 5.5 to 20 l/s/person and from 0.55 to 2 l/s/m². When applied to a specific building zone situation (in terms of occupant density), the default ventilation rate units that result in the required should be used for a given category.

Through this method, predefined ventilation rates can be referred to, depending on the category of IAQ that is aimed for in the design.

Category	Total design ventilation air flow rate for the room	
	l/(s per person)	l/(s.m²)
I	20	2
II	14	1,4
III	8	0,8
IV	5,5	0,55

Category	Total ventilation including air infiltration (1)		Supply air flow per person (2)	Supply air flow based on perceived IAQ for adapted persons (3)	
	l/(s.m²)	Ach	l/(s per person)	q_P l/(s per person)	q_B l/(s.m²)
I	0,49	0,7	10	3,5	0,25

II	0,42	0,6	7	2,5	0,15
III	0,35	0,5	4	1,5	0,1
IV	0,23	0,4			

Note: the reference floor area [m^2] is defined according to the EN 16798-1.

STEP 2: Define the outdoor air quality categories (ODA(P) and ODA(G)) for the building location.

Category	Description
ODA 1	Pure air which may be only temporarily dusty (e.g. pollen)
ODA 2	Outdoor air with high concentrations of particulate matter and/or gaseous pollutants
ODA 3	Outdoor air with very high concentrations of gaseous pollutants and/or particulate matter

STEP 3: Define an occupation schedule for each building zone. An occupation schedule will be required to help estimate the energy consumption of the ventilation system. These schedules are also relevant for the purposes of calculating design air flows and air changes. Specifically relevant information for the ventilation system in the occupation schedule includes the minimum ventilation rate (in $l/s/m^2$).

STEP 4: (optional) define material specifications and VOC emissions for fit-out and insulation materials. The combination of SUP category and ODA category will inform designers about what filters should be specified.

<u>Measurement process</u>

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. 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** [8].
Comparability of results	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, (m^2), because definition of useful floor area varies according to the country. The reference to standard has to be the same when comparing results.
Data	**Data source (for calculation)** - 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. **Data source (for measurement)**

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.

	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.) **Data quality (for calculation)** - The accuracy of the description of the ventilation system. - The accuracy of the description of the materials used for building insulation and also the fit-out materials. **Data quality (for measurement)** - The accuracy of the measurement instruments used to measure the ventilation rate. - Information about any possible issue that may affect the final result of the measurement.
Assessors and auditor' required competences	Listed below the LOs belonging to the CWA 17939:2022 of TRAIN4SUSTAIN for the ventilation rate: EN3.2.1 - EN3.2.2 - EN3.2.3 - EN3.2.4 - EN3.2.5 – EN3.2.7 - EN3.2.10 – EN3.2.11

Table 14 - KPI 11 - CO_2 concentration

Name of the KPI	**CO_2 concentration**
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). Indoor air quality can have multiple effects on the human health, its quality 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. 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. At design stage, the predictive estimation of CO_2 concentration is very difficult to perform. On the contrary, in the use stage of the building, the CO_2 concentration is a simple parameter to measure. For that reason, this KPI is only metered. The measurement must be in compliance with the requirements of **EN 16798-1: 2019** *Energy performance of buildings - Ventilation for buildings* and of the **CEN/TS 17405: 2020** - *Emissions from fixed source - Determination of the volumetric concentration of carbon dioxide - Reference method: infrared spectrometry.*
Scope	KPI addresses both residential and non-residential buildings.
System boundary	The assessment boundary of the CO_2 concentration is the building.
Unit of measure	CO_2 concentration is measured as: particle per million [ppm].
Applicability	Certification case: - New building: Not applicable. - Renovated building: Not applicable. - Existing buildings (in use): CO_2 concentration in-situ measurement is measured according to EN 16798-1:2019. Building use: - Residential - Non residential Project stage: - In Use
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 standards for the measurement of the CO_2 concentration are the **EN 16798-1:2019** *Energy*

	performance of buildings - Ventilation for buildings and the **CEN/TS 17405: 2020 -** *Emissions from fixed source - Determination of the volumetric concentration of carbon dioxide - Reference method: infrared spectrometry.*
Assessment method	**Calculation process** The KPI is only metered. **Measurement process** For the **measurement of the CO_2 concentration** in 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 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. **Detailed measurement description based on EN 16798-1:2019.** STEP 1: Measure the indoor concentration of CO_2 within the main building rooms, equipped or not with the mechanical ventilation. Calculate the average of the values acquired during the monitoring. STEP 2: measure the external concentration of CO_2 ensuring that the measurement is carried out over the same period of time of the indoor one. Calculate the average of the values acquired during the monitoring. STEP 3: Assess the increasing of CO_2 within the indoor air in relation to the external one, in each room following the formula below:

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

$\Delta C = C_{out} - C_{ext}$ [ppm]

where:

ΔC = difference of CO_2 concentration [ppm];

C_{out} = average value of indoor CO_2 [ppm];

C_{ext} = average value of the external CO_2 [ppm]

STEP 4: Assign the score to the rooms evaluated. Compare the increasing of the CO_2 of the *i-th* environment with the air quality categories defined by the EN 16798-1:2019 standard. Identify the corresponding air quality category and assign the Z category index according to the following table:

Category	**Increasing of the CO_2 in relation to the external concentration [ppm]**	**Z category index**
Category I	≤ 380	5
Category II	≤ 550	3
Category III	≤ 950	0
Category IV	>950	-1

STEP 5: Calculate the Z_m value referred to the building as the weighted average of the Zi category indices assigned to the main rooms on the relative usable surfaces:

$$Zm \frac{\sum Z_i \cdot S_{u,i}}{\sum S_{u,i}} = [-]$$

where:

Z_i = i-th environment category index [−];

$S_{u,i}$ = useful area of the i-th environment [m^2]

STEP 6: compare the average value of the Z_m category index with the performance scale benchmarks and assign the score.

</td></tr>
<tr><td>**Comparability of results**</td><td>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 with a slight variation</td></tr>
</table>

	depending on building category, use and location. More details about CO2 classification are included in EN 16798-1, Table B12. NOTE: depending on the use of the buildings, the CO2 limits may be different.
Data	Data source (for calculation) - Not applicable. Data source (for measurement) - Documentation of the rooms in which the measurement took place (geometry, exposure, etc.). - Documentation about the occupancy of the measured rooms. - Documentation of the CO_2 measurement device (in most cases the carbon dioxide detector) used to perform the measurement and its sensitivity and accuracy. - Documentation about the outdoor CO_2 concentration. - Documentation about the duration of the measurement and external conditions. - Justification of the used measurement systems, rooms, occupancy and measurement duration. - Documentation about ventilation system (if available). Data quality (for calculation) - Not applicable. Data quality (for measurement) - The accuracy of the measurement instruments used to measure the CO_2 concentration. - Information on the ventilation system (if available in the building). - Information about any possible issue that may affect the final result of the measurement.
Assessors and auditor' required competences	Listed below the LOs belonging to the CWA 17939:2022 of TRAIN4SUSTAIN for the CO_2 concentration: - CO1.2 Indoor air pollutants management (CO1.2.1, CO1.2.2, CO1.2.3, CO1.2.4, CO1.2.5, CO1.2.6) - CO1.3 Outdoor air pollutants management (CO1.3.1, CO1.3.6)

Table 15 - KPI 12 - Relative Humidity

Name of the KPI	Relative Humidity
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't be calculated, only measured in the in-use phase. The measurement must be in compliance with the requirements of the **EN 15251: 2007** *Indoor Environmental Criteria* and with **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.* 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[9]. 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[10].
Scope	KPI addresses both residential and non-residential buildings.
System boundary	The assessment boundary of the relative humidity is the building.
Unit of measure	Relative humidity is measured as: [%].

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

[10] 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

Applicability	Certification case: - New building: Not applicable. - Renovated building: Not applicable. - Existing buildings (in use): Relative humidity is measured according to what stated in EN 15251:2007 and EN 16798-1:2019. Building use: - Residential - Non-residential Project stage: - In Use
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 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 is the **EN 16798-1: 2019** *Energy performance of buildings - Ventilation for buildings.* **EN ISO 7726:2001**- *Ergonomics of the thermal environment - Instruments for measuring physical quantities,* an International Standard that specifies the minimum characteristics of instruments for measuring physical quantities characterizing an environment.
Assessment method	**Calculation process** The KPI is only metered. **Measurement process** For the **measurement of the relative humidity** 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.
Comparability of results	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.).
Data	Data source (for calculation) - Not applicable. Data source (for measurement) - Documentation of the rooms in which the measurement took place (geometry, exposure, etc.). - Documentation about the occupancy of the measured rooms. - Documentation about the relative humidity devices (psychrometer or hygrometer, datalogger, etc.) used to perform the measurement and its sensitivity and accuracy. - Documentation about the duration of the measurement and the external conditions. - Justification of the used measurement systems, rooms, occupancy and measurement duration. - Documentation about ventilation system (if present). Data quality (for calculation)

	- Not applicable. Data quality (for measurement) - The accuracy of the measurement instruments used to measure the relative humidity. - Information on the ventilation system (if available in the building). - Information about any possible issue that may affect the final result of the measurement.
Assessors and auditor' required competences	Listed below the LOs belonging to the CWA 17939:2022 of TRAIN4SUSTAIN for the **relative humidity**: - CO2.1 Indoor Thermal Comfort (CO2.1.7) - CO2.2 Outdoor Thermal Comfort (CO2.2.4)

Table 16 - KPI 13 - Total VOCs

Name of the KPI	**Total VOCs**
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[11], 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. 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.

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

	This KPI can't be calculated, only measured in the in-use phase. The measurement of TVOCs must be in compliance with what stated in **EN 16516:2017** *Construction products: Assessment of release of dangerous substances - Determination of emissions into indoor air*[12]. 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*[13].
Scope	KPI addresses both residential and non-residential buildings.
System boundary	The assessment boundary of the total VOCs is the building.
Unit of measure	Total VOCs is measured as: [μg/m³].
Applicability	Certification case: - New building: Not applicable. - Renovated building: Not applicable. - Existing buildings (in use): Total VOCs is measured according to what stated in EN 16516:2017 and in the ISO 16000-6:2021. Reference limit values for TVOCs concentration in indoor air are indicated within the WHO Guidelines. Building use: - Residential - Non residential Project stage: - In Use

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

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 16516:2017**, 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 16516:2017), 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**.
Assessment method	**Calculation process** The KPI is only metered. **Measurement process** For the **measurement of the Total VOCs** in the in-use phase, it is necessary to measure the internal air TVOCs concentration level for the occupant's health. The measurement of the TVOCs could be performed both in presence of mechanical ventilation and in case of natural ventilation. 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). **Detailed measurement description.** STEP 1: Measure the indoor concentration of each pollutant (Benzene - Toluene - Styrene - Tetrachlorethylene - Trichlorethylene) within the selected main rooms. STEP 2: Measure the absolute concentration of each pollutant outside the building, with the same method of analysis used for the indoor selection. STEP 3: For each pollutant "i", measure the absolute concentration (Ci) of the indoor air compared to the external one, using the following formula: $Ci = \| C_{out} - C_{ext} \|$ [$\mu g/m^3$] where: C_{out} = value of the individual indoor VOC [$\mu g/m^3$]; C_{ext} = value of the individual external VOC [$\mu g/m^3$] STEP 4: For each pollutant "i", calculate the average increase of pollutant (ΔCmi) as the average of the results of the measures carried out inside the building, as follow: $\Delta Cmi = \Sigma(Ci) / \Sigma ni$ where: Σ ni = total number of measurements. STEP 5: Calculate the average index of the pollutant "i" (Ki) as the ratio between the average concentration ΔCmi of substance "i" and the relative reference value VGi, as follow:

<table>
<tr>
<td></td>
<td>
$Ki = \Delta Cmi/VGi$
STEP 6: Sum the indices determined for each pollutant to calculate the building index K_a.
$K_a = \Sigma Ki$
Based on the sum of the results, it is possible to define the building performance scale according to the following table:
<table>
<tr><th>Building K_b index*</th><th>Performance scale</th></tr>
<tr><td>< 0,1</td><td>5</td></tr>
<tr><td>0,1 and 0,3</td><td>3</td></tr>
<tr><td>0,3 and 0,5</td><td>0</td></tr>
<tr><td>0,5 and 1</td><td>-1</td></tr>
</table>
*K_b index is equal to the main index building
</td>
</tr>
<tr>
<td>Comparability of results</td>
<td>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.).</td>
</tr>
<tr>
<td>Data</td>
<td>
Data source (for calculation)
Not applicable.
Data source (for measurement)

Documentation of the rooms in which the measurement took place (geometry, exposure, etc.).
Documentation about the occupancy of the measured rooms.
Documentation about the relative total VOCs devices (VOCs detectors are used, located on tripod) used to perform the measurement and its sensitivity and accuracy.
Documentation about the duration of the measurement and the external conditions.

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

	- Justification of the used measurement systems, rooms, occupancy and measurement duration. - Documentation about ventilation system (if present). Data quality (for calculation) - Not applicable. Data quality (for measurement) - The accuracy of the measurement instruments used to measure the total VOCs. - Information on the ventilation system (if available in the building). - Information about any possible issue that may affect the final result of the measurement.
Assessors and auditor' required competences	Listed below the LOs belonging to the CWA 17939:2022 of TRAIN4SUSTAIN for the **Total VOCs**: - CO1.1 Low Emitting materials (CO1.1.1, CO1.1.2, CO1.1.3, CO1.1.4, CO1.1.5) - CO1.2 Indoor air pollutants management (CO1.2.1, CO1.2.2, CO1.2.3, CO1.2.4, CO1.2.5, CO1.2.6)

Table 17 - KPI 14 - CMR VOCs concentration

Name of the KPI	**CMR VOCs concentration**
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[14]. Concentrations of CMR VOCs are consistently higher indoors than outdoors. **WHO guidelines**[15] 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.

[14] 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.

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

	CMR VOCs can't be calculated, only metered. The measurement of CMR VOCs must be in compliance with what stated in **EN 16516**:2017 *Construction products: Assessment of release of dangerous substances - Determination of emissions into indoor air*[16]. 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*[17]. People are exposed to air pollutants both outdoors and indoors and they 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, vapors), 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.
Scope	KPI addresses both residential and non-residential buildings.
System boundary	The assessment boundary of the CMR VOCs concentration is the building.
Unit of measure	CMR VOCs concentration is measured as: [$\mu g/m^3$].
Applicability	Certification case: - New building: Not applicable. - Renovated building:

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

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

	Not applicable. - Existing buildings (in use): CMR VOCs is measured according to what stated in EN 16516:2017 and the ISO 16000-6:2021. Reference limit values for CMR VOCs concentration in indoor air are indicated within the WHO Guidelines. Building use: - Residential - Non-residential Project stage: - In Use
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 16516:2017** *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 method	**Calculation process** The KPI is only metered. **Measurement process** For the **measurement of the CMR VOCs** in the in-use phase could be performed both in presence of mechanical ventilation and in case of natural ventilation. During the occupation of the building (in-use 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. 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. The reference values for the CMR VOCs in indoor air are highlighted in the WHO guidelines. The instrument to be used 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). **Detailed measurement description.** STEP 1: Measure the indoor concentration Carcinogenic, Mutagenic, Reprotoxic pollutants within the selected main rooms. STEP 2: Measure the absolute concentration of each pollutant outside the building, with the same method of analysis used for the indoor selection. STEP 3: For each pollutant "i", measure the absolute concentration (Ci) of the indoor air compared to the external one, using the following formula: $Ci = \| C_{out} - C_{ext} \|$ [µg/m³] where: C_{out} = value of the individual indoor CMR VOCs [µg/m³]; C_{ext} = value of the individual external CMR VOCs [µg/m³] STEP 4: For each pollutant "i", calculate the average increase of pollutant (ΔCmi) as the average of the results of the measures carried out inside the building, as follow:

	$\Delta Cmi = \Sigma(Ci) / \Sigma ni$ where: Σni = total number of measurements. STEP 5: Calculate the average index of the pollutant "i" (Ki) as the ratio between the average concentration ΔCmi of substance "i" and the relative reference value VGi, as follow: $Ki = \Delta Cmi/VGi$ STEP 6: Sum the indices determined for each pollutant to calculate the building index K_a. $K_a = \Sigma Ki$
Comparability of results	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.).
Data	Data source (for calculation) - Not applicable. Data source (for measurement) - Documentation of the rooms in which the measurement took place (geometry, exposure, etc.). - Documentation about the occupancy of the measured rooms. - Documentation about the relative CMR VOCs devices (CMR VOCs detectors are used, located on tripod) used to perform the measurement and its sensitivity and accuracy. - Documentation about the duration of the measurement and the external conditions. - Justification of the used measurement systems, rooms, occupancy and measurement duration. - Documentation about ventilation system (if present). Data quality (for calculation) - Not applicable. Data quality (for measurement)

	- The accuracy of the measurement instruments used to measure the CMR VOCs concentration. - Information on the ventilation system (if available in the building). - Information about any possible issue that may affect the final result of the measurement.
Assessors and auditor' required competences	Listed below the LOs belonging to the CWA 17939:2022 of TRAIN4SUSTAIN for the **CMR VOCs concentration**: - CO1.1 Low Emitting materials (CO1.1.1, CO1.1.2, CO1.1.3, CO1.1.4, CO1.1.5) - CO1.2 Indoor air pollutants management (CO1.2.1, CO1.2.2, CO1.2.3, CO1.2.4, CO1.2.5, CO1.2.6)

Table 18 - KPI 15 - R value

Name of the KPI	**R value**
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[18]. 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 during the in-use phase. The measurement must be in compliance with what stated in **EN 16516**:2017 *Construction products: Assessment of release of dangerous substances - Determination of emissions into indoor* air[19]. This European Standard specifies a horizontal reference method for the determination of emissions of regulated

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

	dangerous substances from construction products into indoor air. 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 indoor*[20]. Concerning the LCI values, the main document to which refer to is the **Agreed EU-LCI values**[21], developed by the European Commission, released in December 2021. 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 harmonized health-based reference values for the assessment of product emissions, based on the so-called 'lowest concentration of interest' (LCI) concept[22]. 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 totaled 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[23].
Scope	KPI addresses both residential and non-residential buildings.
System boundary	The assessment boundary of the R value concentration is the building.
Unit of measure	R value is measured as: [decimal ratio].
Applicability	Certification case: - New building: Not applicable.

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.

	- Renovated building: Not applicable. - Existing buildings (in use): R value is measured according to what stated in EN 16516:2017 and in ISO 16000-6:2021. Building use: - Residential - Non-residential Project stage: - In Use
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 16516:2017** *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 16000-1:2004) using test chambers and test cells. Concerning the LCI values, the main document to which refer to is the **Agreed EU-LCI values.**
Assessment method	**Calculation process** The KPI is only metered. **Measurement process** For the **measurement of the R value** during the occupation of the building (in-use phase), the verification of the mass concentration of pollutants in the indoor air is crucial to ensure health safety of building 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.

	Detailed measurement description. 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-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.
Comparability of results	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
Data	Data source (for calculation) - Not applicable. Data source (for measurement) - Documentation of the rooms in which the measurement took place (geometry, exposure, etc.). - Documentation about the occupancy of the measured rooms. - Documentation about the relative R value devices (CMR VOCs detectors located on tripod and tester pollutant absorbing material) used to perform the measurement and its sensitivity and accuracy. - Documentation about the duration of the measurement and the external conditions. - Documentation concerning the materials used in indoor environments. - Justification of the used measurement systems, rooms, occupancy and measurement duration. - Documentation about ventilation system (if present).

	Data quality (for calculation) - Not applicable. Data quality (for measurement) - The accuracy of the measurement instruments used to measure the R value. - Information on the ventilation system (if available in the building). - Information about any possible issue that may affect the final result of the measurement.
Assessors and auditor' required competences	Listed below the LOs belonging to the CWA 17939:2022 of TRAIN4SUSTAIN for the **R value**: - CO1.1 Low Emitting materials (CO1.1.1, CO1.1.2, CO1.1.3, CO1.1.4, CO1.1.5) - CO1.2 Indoor air pollutants management (CO1.2.1, CO1.2.2, CO1.2.3, CO1.2.4, CO1.2.5, CO1.2.6)

Table 19 - KPI 16 - Formaldehyde concentration

Name of the KPI	**Formaldehyde concentration**
Description	Formaldehyde was reclassified as a category 1B carcinogen and category 2 mutagen in 2015[24]. 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)[25]. Indoor exposure to formaldehyde pollutant through inhalation is a dominant contributor to cause adverse health effects. 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

[24] 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.

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

	emissions, will minimize exposure-related risk. In addition, ventilation can reduce indoor exposure to formaldehyde. The measurement of formaldehyde concentration must be in compliance with **EN 16516**:2017 *Construction products: Assessment of release of dangerous substances - Determination of emissions into indoor air*[26]. 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 indoor*[27]*.* **WHO guidelines**[28] 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 **Opinion of ANSES**, the French Agency for Food, Environmental and Occupational Health & Safety, on the revision of ANSES's reference values for formaldehyde: occupational exposure limits (OELs), derived no-effect levels (DNELs) for professionals, toxicity reference values (TRVs) and indoor air quality guidelines (IAQGs), updated in 2018[29].
Scope	KPI addresses both residential and non-residential buildings.
System boundary	The assessment boundary of the formaldehyde concentration is the building.
Unit of measure	Formaldehyde concentration is measured as: [µg/m³]
Applicability	Certification case: - New building: Not applicable. - Renovated building:

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

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

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

[29] https://www.anses.fr/en/system/files/AIR2017SA0041EN.pdf

	Not applicable. - Existing buildings (in use): Formaldehyde 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 ANSES document. Building use: - Residential - Non-residential Project stage: - In Use
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 16516:2017** *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 16000-1:2004) 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 **ANSES document**.
Assessment method	**Calculation process** The KPI is only metered. **Measurement process** For the **measurement of the formaldehyde concentration** during the occupation of the building (in-use phase), the verification of the formaldehyde concentration must be performed in all the main rooms of the building, in order to be able to ensure the health of the occupants. The measurement could be performed both in case of only natural ventilation and in case of mechanical ventilation. 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. 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 ANSES document. **Detailed measurement description.** STEP 1: Calculate the Zm value referred to the building as a whole as the weighted average of the Zi indices by the number of Ni measures that fall within the single Z category index, as follow: $Z_m = \frac{\sum(Z_i \cdot N_i)}{\sum N_i}$ Where: Z_i = dimensionless category index of the i-th measure N_i = number of measurements that fall within each of the Z_i category indices STEP 2: Compare the average value of the Z_m category index with the performance scale benchmarks and assign the score based on the following table:

Average concentration of formaldehyde	Category index of the area Z_{ia}
< 0,010	5
0,010 and 0,030	3
0,030 – 0,050	0

	0,050 – 0,100 | -1
Comparability of results	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.).
Data	Data source (for calculation) - Not applicable. Data source (for measurement) - Documentation of the rooms in which the measurement took place (geometry, exposure, etc.). - Documentation about the occupancy of the measured rooms. - Documentation about the formaldehyde devices (absorbing material tester for formaldehyde) used to perform the measurement and its sensitivity and accuracy. - Documentation about the duration of the measurement and the external conditions. - Documentation concerning the materials used in indoor environments. - Justification of the used measurement systems, rooms, occupancy and measurement duration. - Documentation about ventilation system (if present). Data quality (for calculation) - Not applicable. Data quality (for measurement) - The accuracy of the measurement instruments used to measure the formaldehyde concentration. - Information on the ventilation system (if available in the building). - Information about any possible issue that may affect the final result of the measurement.

Assessors and auditor' required competences	Listed below the LOs belonging to the CWA 17939:2022 of TRAIN4SUSTAIN for the **formaldehyde concentration**: - CO1.1 Low Emitting materials (CO1.1.1, CO1.1.2, CO1.1.3, CO1.1.4, CO1.1.5) - CO1.2 Indoor air pollutants management (CO1.2.1, CO1.2.2, CO1.2.3, CO1.2.4, CO1.2.5, CO1.2.6)

Table 20 - KPI 17 - Operational energy cost

Name of the KPI	**Operational energy cost**
Description	The indicator measures the economic performance of a building in relation to its energy performance. 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 heating, domestic hot water, space cooling, ventilation, built-in lighting, running the equipment and appliances, etc. The aspects of primary energy conversion to delivered energy are excluded. The starting point to calculate this KPI is based on the calculated or measured energy delivered to the building for each usage and energy carrier as per the methodology used in the **KPI 1 - Delivered annual energy per area unit**.
Scope	This KPI addresses both residential and non-residential buildings. This KPI addresses the following module of the building life-cycle (see EN 15978): - B6 – Operational energy use
System boundary	The assessment boundary of this indicator 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 heating, space cooling, domestic hot water, built-in lighting, ventilation and auxiliary systems. The delivered energy is calculated according to the methodology outlined in the **KPI 1 - Delivered annual energy per area unit.**
Unit of measure	Euro per square metre of area unit per year [€/(m^{2}y)]
Applicability	Certification case: - New building: Not applicable. - Renovated building:

	Not applicable. - Existing buildings (in use): Based on metered energy bills using the measured (operational) assessment method. Analogues to the methods described in the KPI 1. Building use: - Residential - Non-residential Building use: - In use
Reference Standards	International Performance Measurement and Verification Protocol (IPMVP), Level(s) indicator 6.1: Life cycle costs
Assessment method	**Measurement approach (Existing buildings (in use)):** 1. Determine the delivered energy for the buildings based on actual or recent (not older than two calendar years) metered energy bills using the measured (operational) assessment method. Analogues to the methods described in the KPI 1. 2. Calculate the yearly operational energy costs by multiplying the delivered energy for each energy carrier by the actual energy price. 3. Calculate the energy that is locally generated and sold to the grid based on actual bills that cover the identical time period as the ones used in step 1 and subtract the revenue made from the cost 4. 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 5. The resulting operational energy cost will be presented in [€/(m^2·y)].
Comparability of results	The comparability of the indicator results is not possible due to the dynamics of fuel prices in each MS, and within each region and energy provider. The specifics of delivered 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.

Data	- Delivered annual energy for each energy carrier in [kWh/y] (calculated or measured) - Annual generated energy in [kWh/y] (measured) - Revenue generated from sold energy in [€] (measured) - Reference floor area in [m²] (area unit) - Energy prices by fuel type in [€] (measured) – Eurostat data can be used to estimate the energy price in case the energy prices are not accessible, http://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_price_statistics
Assessors and auditor' required competences	Listed below the LOs belonging to the CWA 17939:2022 of TRAIN4SUSTAIN for the **operational energy cost**: - EQ4.1 Operating and maintenance cost management (EQ4.1.2 EQ4.1.3, EQ4.1.4, EQ4.1.5, EQ4.1.6, EQ4.1.7) - EQ4.2 Use stage energy cost management (EQ4.2.2, EQ4.2.3, EQ4.2.4) - EN3.2 Ventilation systems (EN3.2.5)

Table 21 - KPI 18 - Smart Readiness Indicator (SRI)

Name of the KPI	**Smart Readiness Indicator (SRI)**
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. **Building**: which refer to the building systems ability to maintain energy efficiency performance and operation of the building through the adaptation of energy consumption 2. **User**: Which describe the system's 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. **Grid**: which measure the flexibility of the building systems to participate in active and passive as well as implicit and explicit demand-response, in relation to the grid. The Smart Readiness Indicator score is directly related to 7 impact criteria such as: - Energy Efficiency, - Maintenance and fault predictions, - Comfort, - Convenience, - Health, wellbeing and accessibility, - Information to occupants, - Energy flexibility and storage, which are key in the contribution to Thematic areas such as "Energy consumption", "Thermal comfort",

	"Renewable energy", "Green house gas emission", "Indoor air quality", "Costs", "Resilience to overheating", "E-mobility".
Scope	KPI addresses both residential and non-residential buildings. KPI addresses the following module of the building life cycle: B1-B6
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 *Depending on actual availability of the service
Unit of measure	[%] . the smart readiness score of a building or building unit is expressed as a percentage which represents the ratio between the smart readiness of the building or building unit compared to the maximum smart readiness that it could reach
Applicability	Certification case: - New building: Calculation approach based on the SRI3_calculation-sheet_v4_5 - Renovated building: Calculation approach based on the SRI3_calculation-sheet_v4_5 - Existing buildings (in use): Calculation approach based on the SRI3_calculation-sheet_v4_5 Building use: - Residential - Non residential

	Project stage: - Design - Construction / As Built - In Use
Reference Standards	The method for calculating the SRI is based on the multi-criteria assessment method defined in Commission Delegated Regulation (EU) 2020/2155, Commission Implementation Act (EU) 2020/2156/EU, EPBD recast, EN ISO 52120-1.
Assessment method	From the SRI calculation sheet, use Method B with default weighing as defined in the Calculation sheet for SRI assessment method A/B (V4.5). Assign the correct functionality level in each smart ready service of the 9 domains based on the installed and working systems in the building. Indicate 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.
Comparability of results	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.
Data	- Building category, building location (climate zone), construction year and area unit - Technical building systems that are present in the building - Smart ready services available in the building - Functionality level and surface share/coverage for each smart ready service

Assessors and auditor' required competences	Listed below the LOs belonging to the CWA 17939:2022 of TRAIN4SUSTAIN for the **Smart Readiness Indicator (SRI)**: - EN2.1 Smart grid systems (EN2.1.5) - EN2.2 Domotic systems (EN2.2.3) - EN2.3 Building Management Systems (EN2.3.4) - EN2.4 Renewable Energy communities (EN2.4.5) - ID5.1 Smart meters (ID5.1.4) - ID5.2 Smart Building Sensors (ID5.2.4) - MN1.1 Building maintenance (MN1.1.5) - EN3.1 Heating and cooling systems (EN3.1.1, EN3.1.2, EN3.1.3, EN3.1.4, EN3.1.5, EN3.1.7, EN3.1.10, EN3.1.11,) - EN3.2 Ventilation systems (EN3.2.1, EN3.2.2, EN3.2.3, EN3.2.4, EN3.2.5, EN3.2.7, EN3.2.10, EN3.2.11) - EN3.3 Hot water systems (DHW) (EN3.3.1, EN3.3.2, EN3.3.3, EN3.3.4, EN3.3.5, EN3.3.7, EN3.3.10, EN3.3.11) - EN3.4 Electric heating systems (EN3.4.1, EN3.4.2, EN3.4.3, EN3.4.4, EN3.4.5, EN3.4.7, EN3.4.10, EN3.4.11) - EN3.5 Heat pump systems and geothermal energy systems (EN3.5.1, EN3.5.2, EN3.5.3, EN3.5.4, EN3.5.5, EN3.5.7, EN3.5.10, EN3.5.11) - EN3.6 Solar thermal energy systems for heating, cooling and DHW (EN3.6.1, EN3.6.2, EN3.6.3, EN3.6.4, EN3.6.5, EN3.6.7, EN3.6.10, EN3.6.11) - EN3.7 Solar power systems for electric generation (EN3.7.1, EN3.7.2, EN3.7.3, EN3.7.4, EN3.7.5, EN3.7.7, EN3.7.10, EN3.7.11) - EN3.8 Combined Heat and Power (CHP) generation (EN3.8.1, EN3.8.2, EN3.8.3, EN3.8.4, EN3.8.5, EN3.8.7, EN3.8.10, EN3.8.11) - EN3.9 Mini wind power generation (EN3.9.1, EN3.9.2, EN3.9.3, EN3.9.4, EN3.9.5, EN3.9.7, EN3.9.10, EN3.9.11) - EN3.10 Energy storage systems (EN3.10.1, EN3.10.2, EN3.10.3, EN3.10.4, EN3.10.5) - EN4.1 Thermal insulation (EN4.1.1, EN4.1.2, EN4.1.3, EN4.1.4, EN4.1.5, EN4.1.9) - EN4.2 Building air tightness (EN4.2.1, EN4.2.2, EN4.2.3, EN4.2.4, EN4.2.5, EN4.2.9) - EN4.3 Window and glazing systems (EN4.3.1, EN4.3.2, EN4.3.3, EN4.3.4, EN4.3.5, EN4.3.9) - EN4.4 Solar shading systems (EN4.4.1, EN4.4.2, EN4.4.3, EN4.4.4, EN4.4.5, EN4.4.9) - EN4.5 Passive systems for cooling and heating (EN4.5.1, EN4.5.2, EN4.5.3, EN4.5.4, EN4.5.5, EN4.5.9)

	- EN4.6 Energy savings strategies for lighting (EN4.6.1, EN4.6.2, EN4.6.3, EN4.6.4, EN4.6.5) - CO3.2 Indoor lighting (CO3.2.1, CO3.2.2, CO3.2.3, CO3.2.4, CO3.2.5, CO3.2.9) - ID5.1 Smart meters (ID5.1.1, ID5.1.2, ID5.1.3, ID5.1.4, ID5.1.7, ID5.1.8)

Table 22 - KPI 19 - Summer thermal discomfort in 2050

Name of the KPI	**Summer thermal discomfort in 2050**
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 year 2050. And is Aligned with the **Level(s)** European framework Indicator 5.1 "Protection of occupier health and thermal comfort" (V1.1, January 2021). Thermal comfort in summer months is guaranteed when the operative 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. 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 severe in the years 2030, 2040, 2050, etc. 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 KPI 9 (Time outside of thermal comfort range), except that it uses projections for future climate in 2050 to measure the thermal performance of the building instead of past weather data.
Scope	The performance of the building to keep the operative 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. The specified performance must apply to the rooms or zones that account for more than 10% of the total floor area of the building.
System boundary	The assessment boundary includes each space or zone that accounts for >10% of the total area unit of a building. The assessment is made based on projected climate conditions for the year 2050. 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. Two building models are considered: with heating and/or cooling systems, as designed or installed, and without.
Unit of measure	The percentage of time in which the operative indoor temperature exceeds 27 °C during the cooling season (summer months).
Applicability	Certification cases: - New building - Existing building - Renovated building Building use: - Residential - Non residential Project stage: - Design - Construction / As Built - In Use
Reference Standards	- EN ISO 52000 series: The calculation of the reported performance shall be based on a dynamic energy simulation complying with the EN ISO 52000-1 series. - EN ISO 52016-1: Energy performance of buildings - Energy needs for heating and cooling, internal temperatures and sensible and latent heat loads. - 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 (it replaces EN 15251:2007). - EN ISO 52010-1:2017 Energy performance of buildings, External climatic conditions - Part 1: Conversion of climatic data for energy calculations - EN ISO 7730:2005 - Ergonomics of the thermal environment - Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria (under revision)
Assessment method	The indicator's objective is to measure the percentage of time in the year 2050 in which the operative 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 unit. 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 A2 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 use and occupancy profile used. - Document the length of the cooling period for the year 2050. - Document the dynamic simulation method used. **Calculation method:** - Select reliable climate projections for 2050 based on the UN IPCC mitigation emissions scenario SRES A2 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 operative 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.
Comparability of results	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.
Data	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 year 2050 - Building usage and occupancy profiles as per national definitions for the building category 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 2050. The climate projection modeling must be based on the UN IPCC Mitigation emissions scenario (SRES A2 or RCP 6.0).
Assessors and auditor' required competences	Listed below the learning outcomes belonging to the CWA 17939:2022 of TRAIN4SUSTAIN for the **percentage of time outside of thermal comfort range:** - EN1.1 – Energy Simulation (EN1.1.4, EN1.1.5) - EN3.1 Heating and cooling systems (EN3.1.1, EN3.1.2, EN3.1.3, EN3.1.4, EN3.1.5, EN3.1.7, EN3.1.10, EN3.1.11,) - EN3.2 Ventilation systems (EN3.2.1, EN3.2.2, EN3.2.3, EN3.2.4, EN3.2.5, EN3.2.7, EN3.2.10, EN3.2.11)

	- EN3.3 Hot water systems (DHW) (EN3.3.1, EN3.3.2, EN3.3.3, EN3.3.4, EN3.3.5, EN3.3.7, EN3.3.10, EN3.3.11) - EN3.4 Electric heating systems (EN3.4.1, EN3.4.2, EN3.4.3, EN3.4.4, EN3.4.5, EN3.4.7, EN3.4.10, EN3.4.11) - EN3.5 Heat pump systems and geothermal energy systems (EN3.5.1, EN3.5.2, EN3.5.3, EN3.5.4, EN3.5.5, EN3.5.7, EN3.5.10, EN3.5.11) - EN3.6 Solar thermal energy systems for heating, cooling and DHW (EN3.6.1, EN3.6.2, EN3.6.3, EN3.6.4, EN3.6.5, EN3.6.7, EN3.6.10, EN3.6.11) - EN3.7 Solar power systems for electric generation (EN3.7.1, EN3.7.2, EN3.7.3, EN3.7.4, EN3.7.5, EN3.7.7, EN3.7.10, EN3.7.11) - EN3.8 Combined Heat and Power (CHP) generation (EN3.8.1, EN3.8.2, EN3.8.3, EN3.8.4, EN3.8.5, EN3.8.7, EN3.8.10, EN3.8.11) - EN3.9 Mini wind power generation (EN3.9.1, EN3.9.2, EN3.9.3, EN3.9.4, EN3.9.5, EN3.9.7, EN3.9.10, EN3.9.11) - EN3.10 Energy storage systems (EN3.10.1, EN3.10.2, EN3.10.3, EN3.10.4, EN3.10.5) - EN4.1 Thermal insulation (EN4.1.1, EN4.1.2, EN4.1.3, EN4.1.4, EN4.1.5, EN4.1.9) - EN4.2 Building air tightness (EN4.2.1, EN4.2.2, EN4.2.3, EN4.2.4, EN4.2.5, EN4.2.9) - EN4.3 Window and glazing systems (EN4.3.1, EN4.3.2, EN4.3.3, EN4.3.4, EN4.3.5, EN4.3.9) - EN4.4 Solar shading systems (EN4.4.1, EN4.4.2, EN4.4.3, EN4.4.4, EN4.4.5, EN4.4.9) - EN4.5 Passive systems for cooling and heating (EN4.5.1, EN4.5.2, EN4.5.3, EN4.5.4, EN4.5.5, EN4.5.9) - EN4.6 Energy savings strategies for lighting (EN4.6.1, EN4.6.2, EN4.6.3, EN4.6.4, EN4.6.5) - CO3.2 Indoor lighting (CO3.2.1, CO3.2.2, CO3.2.3, CO3.2.4, CO3.2.5, CO3.2.9) - ID5.1 Smart meters (ID5.1.1, ID5.1.2, ID5.1.3, ID5.1.4, ID5.1.7, ID5.1.8)

Table 23 - KPI 20 - Percentage of recharging points and installed pre-cabling in relation to the number of parking spaces

Name of the KPI	**Percentage of recharging points and installed pre-cabling in relation to the number of parking spaces**
Description	This indicator measures the building's readiness for electrical transport, smart energy management and grid flexibility.

Scope	Both residential and non-residential buildings.
System boundary	The system 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.
Unit of measure	Percentage of purpose-built recharging points in relation to the number of parking spaces in %.
Applicability	Electric vehicles combined with an increased share of renewable electricity production play a crucial role for reducing greenhouse gas emissions and for increasing the efficiency and thus the 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 presence of charging infrastructure is essential for buildings frequented by electric vehicles. Slow, smart, and bidirectional charging methods present economical options. Charging stations installed in private spaces can also function as energy reserves. Smart and bidirectional charging seamlessly integrate with building energy systems. Vehicles equipped with bidirectional charging capabilities enhance grid capacity, assisting in balancing power during peak hours, and enabling users to offer these services for compensation. The site selection must ensure safe loading operations at all times, allowing easy vehicle connection without extension cables. Charging stations should be placed near parking spaces, without posing risks. Two main methods for installation are standalone poles or wall-mounted "wall boxes", meeting environmental requirements like strength, weather, UV, corrosion, and vibration resistance. Electric vehicles consume significant energy during charging, necessitating robust infrastructure. Anticipating a surge in electric vehicle sales, planning new constructions or renovations should consider

	increased demand for charging infrastructure based on location and property use. The charging facility is equipped with a supply line capable of handling a continuous current of 32 A, running from either the main distribution board or the meter cabinet to the charging point. To mitigate potential future expenses, it's advisable to incorporate empty conduits in the initial building plans to accommodate such cables. Furthermore, it's recommended to install a separate empty conduit for communication lines, such as network connections, to facilitate future applications for the charging station.
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 etc.).
Assessment method	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.
Comparability of results	The ratio of e-car parking spaces can be compared between the buildings that share the same use and construction status (newly built – in use – major renovation)
Data	Number of parking spaces Number of purpose-built electrical recharging spaces
Assessors and auditor' required competences	Listed below the LOs belonging to the CWA 17939:2022 of TRAIN4SUSTAIN for the **Percentage of recharging points and installed pre-cabling in relation to the number of parking spaces**: - MO1.1 Sustainable mobility strategies (MO1.1, MO1.1.2, MO1.1.3) - SE2.2 Infrastructure and connectivity (SE2.2.8)

Table 24 - KPI 21 – Daylight Provision

Name of the KPI	**Daylight sufficiency**
Description	Daylight is strongly favoured by building occupants as a way to adequately illuminate the indoor surfaces, and to save energy for electrical lighting. Daylight can provide

	significant quantities of light indoors, views and connection to the outside and exposure to sunlight indoors. The daylighting provision is intended as the ratio of time a target illuminance level is achieved across a fraction of the reference plane compared to the duration of daylight time. The main reference standard for daylight provision calculation is the **EN 17037:2018 CEN European Daylight Standard**. This document specifies elements for achieving an impression of lightness indoors and for providing an adequate view out. In addition, recommendations for the duration of sunshine exposure within occupied rooms are given, as well as how to limit glare. It applies to all spaces that may be regularly occupied by people. Concerning the metering of indoor daylight, the reference standard to be taken into account for the measurement in as built and in in use phase is the **UNI 10840:2007** - *Light and lighting - School rooms - General criteria for the artificial and natural lighting*. A specific standard for working places is the **EN 12464-1:2021** - *Light and lighting - Lighting of work places – Part 1: Indoor work places*. Another important reference standard providing key information regarding the devices to be used during the measurement is the **UNI 11142:2004** - *Light and lighting - Portable photometers - Performance characteristics*. Other reference standards for daylight measurement are **BS 667:2005** - *Illuminance meters - Requirements and test methods*, **DIN 5032-7 2017** - *Photometry - Part 7: Classification of illuminance meters and luminance meters* and **CIE 69 (1987)** - *Methods of Characterizing Illuminance Meters and Luminance Meters: Performance, Characteristics and Specifications.* 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 body's circadian system, affecting mood and perception, and by enabling critical chemical reactions in the body.

Scope	The ratio of time a target illuminance level is achieved across a fraction of the reference plane compared to the duration of daylight time.
System boundary	The assessment boundary of the daylight provision is the building (and its exterior geometry) and the external environment close to the building.
Unit of measure	Daylight provision is measured as: [%]
Applicability	Certification case: - New building: The daylight provision is calculated in new buildings according to EN 17037:2018. Paragraph 5.1.3 and Annex B, fully describe the two possible calculation methods (method 2 to be preferred). - Renovated building: The daylight provision is calculated in under major renovation buildings according to EN 17037:2018. Paragraph 5.1.3 and Annex B, fully describe the two possible calculation methods (method 2 to be preferred). - Existing buildings (in use): Daylight provision in-situ measurement is measured according to what is stated in UNI 10840:2007, EN 12464-1:2021 and UNI 11142:2004. Building use: - Residential - Non-residential Project stage: - Design - Construction / As Built - In Use
Reference Standards	Daylight provision indicator is developed in accordance with what stated in EN 17037:2018. Indeed, the main reference standard for the calculation of the daylight provision is, actually, the EN 17037:2018 – Daylighting in buildings. The main reference standards for the measurement of the daylight provision are the UNI 10840:2007 and the EN 12464-1:2021 which describe the measurement

	method for the average daylight factor. Furthermore, the standard UNI 11142:2004 provides relevant information concerning the instruments to be used for the measurement. ***BS 667:2005*** *- Illuminance meters - Requirements and test methods,* ***DIN 5032-7 2017*** *- Photometry - Part 7: Classification of illuminance meters and luminance meters and* ***CIE 69 (1987)*** *- Methods of Characterizing Illuminance Meters and Luminance Meters: Performance, Characteristics and Specifications.*
Assessment method	**Calculation process** The daylight provision is calculated in new buildings and under major renovation buildings accordingly to EN 17037:2018. Paragraph 5.1.3 fully describes the two possible calculation methods: Method 1) Calculation method using daylight factors on the reference plane. Annex A gives values for target daylight factors (DT) and minimum target daylight factors (DTM) to be achieved depending on the given site. Method 2) Calculation method of illuminance levels on the reference plane using climatic data for the given site and an adequate time step. 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. **Measurement process** During the occupation of the building (in-use phase), the verification of the daylight is fundamental to ensure visual well-being of the occupants. For each main room of the building, it is necessary to evaluate the lighting values identifying several measuring points distributed in the space. Some adjusting must be adopted to obtain an accurate measurement (curtains drawn, obstruction resulting from the furniture, absence of occupants, etc.) At the same time of the indoor measurements, the external values are measured (better in overcast conditions with no direct solar radiation). Having these data, it will be possible to calculate the average daylight factor making a ratio between the

	average indoor values measured and the average outdoor values. The sensor to be used to conduct measurements is called luxmeter. For external measurement, if necessary, could be used in addition a shadow ring, to create the proper outdoor measurement conditions.
Comparability of results	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.
Data	Data source (for calculation) - Building's orientation; - Internal geometry of the room (partition and surface reflectance); - External geometry of the building (balconies, obstructions, etc.); - Dimension of the vertical façade windows; - Glazing material. Data source (for measurement) - Documentation of the rooms in which the measurement took place (geometry, exposure, etc.). - Documentation about the occupancy of the measured rooms. - Documentation about devices (luxmeter) used to perform the measurement and its sensitivity, accuracy, resolution, measure range and class. - Documentation about the duration of the measurement and the external conditions. - Documentation concerning the materials used in indoor environments. - Justification of the used measurement systems, rooms, occupancy, and measurement duration. Data quality (for calculation) - The accuracy of the description of the internal geometry of the room. - The accuracy of the external geometry of the building. - The accuracy of the description of the materials used for building construction and also the fit-out materials. Data quality (for measurement)

	- The accuracy of the measurement instruments used to measure the daylight provision. - Information on the weather external condition. - Information about any possible issue that may affect the final result of the measurement.
Assessors and auditor' required competences	Listed below the LOs belonging to the CWA 17939:2022 of TRAIN4SUSTAIN for the **daylight provision**: - EN4.3 Window and/or glazing systems (EN4.3.1, EN4.3.2, EN4.3.3, EN4.3.4, EN4.3.5) - EN4.4 Solar shading systems (EN4.4.1, EN4.4.2, EN4.4.3, EN4.4.5) - EN4.6 Energy saving strategies for lighting (EN4.6.1, EN4.6.2, EN4.6.3, EN4.6.4, EN4.6.5) - CO3.1 Daylighting (CO3.1.1, CO3.1.2, CO3.1.3, CO3.1.4, CO3.1.5, CO3.1.10) - CO3.2 Indoor lighting (CO3.2.1 - CO3.2.2 - CO3.2.3 - CO3.2.4 - CO3.2.10)

7.4 KPIs Assessment Report

7.4.1 General

The KPI assessment report is a technical document prepared by the assessor in the EUB SuperHub certification process, it reports the value of the KPIs and contains all the supporting information for the assessment.

It is made up of two different documents:

- Building data: a document which organises and collects the necessary formal documentation to activate an EUB building certification process. Data refers to the building, to the client who requires the activation of the EUB building certification process and of the assessor in charge of the evaluation.
- KPI reporting format: it organises and collects the necessary documentation to properly perform the calculation or measurement of a specific KPI. The content of the KPI reporting format is different for each KPI.

7.4.2 Building data

The building data document organises and collects the necessary documentation to activate an EUB building certification process. Indeed, it contains the main information related to the building to be assessed, the main data both of the client and the assessor and, of course, the main key documents useful to perform the building certification.

This building information reporting format is also an easy way for data retrieval and organisation.

Much information listed in the building reporting format are available in the EUB SuperHub DBL; the interlinking with those tools is an added value to speed up building data collection and for gathering information on the actors involved in the certification processes.

Table 25 – Building data

BUILDING DATA	
Building code	
Building name/ project denomination	
Building address	
Type of intervention	
CLIENT DATA	
Name of the client	
Contact person	
Phone number and e-mail address	
ASSESSOR DATA	
Name of the technical expert	
Contact person	
Phone number and e-mail address	

7.4.3 KPI reporting format

The KPI reporting format is contained in the KPI assessment report, it organises and collects the necessary documentation to properly perform the calculation or measurement of a specific KPI. Indeed, it contains the main information and the key documents required to proceed in the assessment of the KPI.

It's important to underline the fact that the KPI reporting format is specific to each KPI because each indicator requires different data and documentation to be calculated. For each KPI a specific reporting format is provided.

In Tables from 26 to 46 is provided an example of the content included in the KPI reporting format of each KPI.

Table 26 – KPI 1 reporting format

KPI 1 - Delivered annual energy per area unit	
Calculated values	▪ Name of standard/s used for calculation. ▪ Name of software tool used for calculation. ▪ List of building services (EPB services) considered (e.g., heating, cooling, ventilation, humidification, dehumidification, domestic hot water, lighting). ▪ Subtype of calculated (asses) assessment method used (e.g., design, as built or tailored). ▪ Boundary conditions of use (e.g., usage and operating times, internal set-point temperature for heating/cooling operation, energy need for DHW supply) used in calculation.
Measured values	▪ Technical specification of the meters (electricity meter, gas flow meter, fuel flow meter, calorimeter, etc.) used to measure delivered energy to the building site for each energy carrier. ▪ Boundary conditions that may have affected the measurements. ▪ Measurement report summarising: - values of each measured energy carrier expressed in measured units (e.g., Litres, m^3, kg, etc.), - calorific value (gross or net) of fuel used for calculating delivered energy expressed in kWh, - values of each energy carrier expressed in kWh, - list of all services (EPB and non-EPB services) that each measured energy carrier covers.

Table 27 – KPI 2 reporting format

KPI 2 - Total annual primary energy use per area unit	
Calculated values	▪ Name of standard/s used for calculation. ▪ Name of software tool used for calculation. ▪ List of building services (EPB services) considered (e.g., heating, cooling, ventilation, humidification, dehumidification, domestic hot water, lighting). ▪ Subtype of calculated (asses) assessment method used (e.g., design, as built or tailored). ▪ Boundary conditions of use (e.g., usage and operating times, internal set-point temperature for heating/cooling operation, energy need for DHW supply) used in calculation. ▪ Total primary energy factors at national level.
Measured values	▪ Technical specification of the meters (electricity meter, gas flow meter, fuel flow meter, calorimeter, etc.) used to measure delivered energy to the building site for each energy carrier. ▪ Boundary conditions that may have affected the measurements. ▪ Measurement report summarising: - values of each measured energy carrier expressed in measured units (e.g., Litres, m^3, kg, etc.),

	- calorific value (gross or net) of fuel used for calculating delivered energy expressed in kWh, - values of each energy carrier expressed in kWh, - list of all services (EPB and non-EPB services) that each measured energy carrier covers.

Table 28 – KPI 3 reporting format

KPI 3 - Non-renewable annual primary energy use per area unit	
Calculated values	▪ Name of standard/s used for calculation. ▪ Name of software tool used for calculation. ▪ List of building services (EPB services) considered (e.g., heating, cooling, ventilation, humidification, dehumidification, domestic hot water, lighting). ▪ Subtype of calculated (asses) assessment method used (e.g., design, as built or tailored). ▪ Boundary conditions of use (e.g., usage and operating times, internal set-point temperature for heating/cooling operation, energy need for DHW supply) used in calculation. ▪ Non-renewable primary energy factors at national level.
Measured values	▪ Technical specification of the meters (electricity meter, gas flow meter, fuel flow meter, calorimeter, etc.) used to measure delivered energy to the building site for each energy carrier. ▪ Boundary conditions that may have affected the measurements. ▪ Measurement report summarising: - values of each measured energy carrier expressed in measured units (e.g., Litres, m^3, kg, etc.), - calorific value (gross or net) of fuel used for calculating delivered energy expressed in kWh, - values of each energy carrier expressed in kWh, - list of all services (EPB and non-EPB services) that each measured energy carrier covers - non-renewable primary energy factors at national level.

Table 29 – KPI 4 reporting format

KPI 4 - Embodied energy	
Calculated values	▪ Name of standard/s used for calculation. ▪ Name of software tool used for calculation ▪ List of building elements, services and phases considered ▪ Reference Study Period (RSP is usually 50 years) ▪ Lifespan of each product or element ▪ Bill of Quantities for building elements ▪ Bill of Materials (if method 1 is used) ▪ % of completeness of building description (in mass) ▪ Name of database used for EPDs or embodied energy coefficient (+ URL) ▪ Data quality characteristics of the database

	▪ Embodied energy coefficient per building element, family of products or per material ▪ Embodied energy of the building per life cycle module, per m^2 of area unit ▪ Aggregated embodied energy for the whole building on its RSP, per m^2 of area unit.
Measured values	▪ The KPI is only calculated.

Table 30 – KPI 5 reporting format

KPI 5 - Renewable annual primary energy use per area unit	
Calculated values	▪ Name of standard/s used for calculation. ▪ Name of software tool used for calculation. ▪ List of building services (EPB services) considered (e.g., heating, cooling, ventilation, humidification, dehumidification, domestic hot water, lighting). ▪ Subtype of calculated (asses) assessment method used (e.g., design, as built or tailored). ▪ Boundary conditions of use (e.g., usage and operating times, internal set-point temperature for heating/cooling operation, energy need for DHW supply) used in calculation. ▪ Renewable primary energy factors at national level.
Measured values	▪ Technical specification of the meters (electricity meter, gas flow meter, fuel flow meter, calorimeter, etc.) used to measure delivered energy to the building site for each energy carrier. ▪ Boundary conditions that may have affected the measurements. ▪ Measurement report summarising: - values of each measured energy carrier expressed in measured units (e.g., Litres, m^3, kg, etc.), - calorific value (gross or net) of fuel used for calculating delivered energy expressed in kWh, - values of each energy carrier expressed in kWh, - list of all services (EPB and non-EPB services) that each measured energy carrier covers. - renewable primary energy factors at national level.

Table 31 – KPI 6 reporting format

KPI 6 - Renewable energy ratio	
Calculated values	▪ Name of standard/s used for calculation. ▪ Name of software tool used for calculation. ▪ List of building services (EPB services) considered (e.g., heating, cooling, ventilation, humidification, dehumidification, domestic hot water, lighting).

	▪ Subtype of calculated (asses) assessment method used (e.g., design, as built or tailored). ▪ Boundary conditions of use (e.g., usage and operating times, internal set-point temperature for heating/cooling operation, energy need for DHW supply) used in calculation. ▪ Total primary energy factors at national level. ▪ Renewable primary energy factors at national level. ▪ Perimeter choice (on-site, nearby, distant).
Measured values	▪ Technical specification of the meters (electricity meter, gas flow meter, fuel flow meter, calorimeter, etc.) used to measure delivered energy to the building site for each energy carrier. ▪ Boundary conditions that may have affected the measurements. ▪ Measurement report summarising: - values of each measured energy carrier expressed in measured units (e.g., Litres, m^3, kg, etc.), - calorific value (gross or net) of fuel used for calculating delivered energy expressed in kWh, - values of each energy carrier expressed in kWh, - list of all services (EPB and non-EPB services) that each measured energy carrier covers.

Table 32 – KPI 7 reporting format

KPI 7 - Operational greenhouse gas emissions	
Calculated values	▪ Name of standard/s used for calculation. ▪ Name of software tool used for calculation. ▪ List of building services (EPB services) considered (e.g., heating, cooling, ventilation, humidification, dehumidification, domestic hot water, lighting). ▪ Subtype of calculated (asses) assessment method used (e.g., design, as built or tailored). ▪ Boundary conditions of use (e.g., usage and operating times, internal set-point temperature for heating/cooling operation, energy need for DHW supply) used in calculation. ▪ Emission factors for energy carriers

Measured values	▪ Technical specification of the meters (electricity meter, gas flow meter, fuel flow meter, calorimeter, etc.) used to measure delivered energy to the building site for each energy carrier. ▪ Boundary conditions that may have affected the measurements. ▪ Measurement report summarising: - values of each measured energy carrier expressed in measured units (e.g., Litres, m^3, kg, etc.), - calorific value (gross or net) of fuel used for calculating delivered energy expressed in kWh, - values of each energy carrier expressed in kWh, - list of all services (EPB and non-EPB services) that each measured energy carrier covers. - Emission factors for energy carriers

Table 33 – KPI 8 reporting format

KPI 8 - Life Cycle Global Warming Potential (GWP)	
Calculated values	▪ Name of standard/s used for calculation ▪ Name of LCA software tool used for calculation ▪ List of building elements (and % of completeness of building description in mass), services and phases considered ▪ Reference Study Period (RSP is usually 50 years) ▪ Bill of quantities for building elements or materials ▪ Lifespan of each product or element ▪ EPDs corresponding to products or Generic/default data used if specific EPDs are missing (so as to avoid empty boxes) ▪ Delivered energy consumption per energy carrier (in use phase) ▪ Water consumption (in use phase) ▪ Emission factors for energy carriers and for water ▪ Global warming potential per building element or material ▪ Global warming potential of the building per life cycle module and per family of products, per m2 of area unit ▪ Aggregated Global warming potential for the whole building on its RSP (usually 50 years)
Measured values	▪ The KPI is only calculated.

Table 34 – KPI 9 reporting format

KPI 9 - Percentage of time outside of thermal comfort range	
Calculated values	▪ Name of standard/s used for calculation. ▪ Name of software tool or dynamic simulation method used for calculation. ▪ Indication of the evaluated zones in the building

	▪ Building thermal and physical values ▪ List of building heating or cooling systems considered. ▪ Building's use and occupancy profile used
Measured values	▪ The KPI is only calculated.

Table 35 – KPI 10 reporting format

KPI 10 - Ventilation rate	
Calculated values	▪ Reason for the eventual inapplicability of the criterion. ▪ Graphic drawings of the building with indication of the main rooms verified. The necessary documentation to be included: - plans of each floor of the building with indication of the geometric dimensions of the main rooms subject to verification (assign an identification code to each room); for each main room, report the position of the system terminals; - abacus of the system input/output terminals. ▪ Occupation schedule for each building zone. ▪ Calculation table indicating the total design ventilation air flow rate for each room and the supply air flow per person
Measured values	▪ Technical specification of the instruments (anemometer, flow hood, fan anemometer, etc.) used to perform the measurements. ▪ Boundary conditions that may have affected the measurements. ▪ Measurement report summarising measured values

Table 36 – KPI 11 reporting format

KPI 11 - CO_2 concentration	
Calculated values	▪ The KPI is only measured.
Measured values	▪ Technical specification of the instruments (carbon dioxide detector. etc.) used to perform the measurements. ▪ Information about the mechanical ventilation installed in the building (if present) ▪ Boundary conditions that may have affected the measurements. ▪ Measurement report summarising measured values.

Table 37 – KPI 12 reporting format

KPI 12 - Relative Humidity	
Calculated values	▪ The KPI is only measured.

Measured values	▪ Technical specification of the instruments (hygrometric sensors, psychrometric, dew point, capacitive type) used to perform the measurements. ▪ Information about the mechanical ventilation installed in the building (if present) ▪ Boundary conditions that may have affected the measurements. ▪ Measurement report summarising measured values.

Table 38 – KPI 13 reporting format

KPI 13 - Total VOCs	
Calculated values	▪ The KPI is only measured.
Measured values	▪ Technical specification of the instruments (VOCs detectors and tester pollutant absorbing material) used to perform the measurements. ▪ Information about the mechanical ventilation installed in the building (if present) ▪ Boundary conditions that may have affected the measurements. ▪ Indication concerning the occupation of the building. ▪ Duration of the measurements. ▪ Measurement report summarising measured values.

Table 39 – KPI 14 reporting format

KPI 14 - CMR VOCs concentration	
Calculated values	▪ The KPI is only measured.
Measured values	▪ Technical specification of the instruments (CMR VOCs detectors and tester pollutant absorbing material) used to perform the measurements. ▪ Information about the mechanical ventilation installed in the building (if present) ▪ Boundary conditions that may have affected the measurements. ▪ Indication concerning the occupation of the building. ▪ Information about smoking habit of the occupants, typology of the furniture, materials used in indoor area, etc. ▪ Duration of the measurements. ▪ Measurement report summarising measured values.

Table 40 – KPI 15 reporting format

KPI 15 - R value	
Calculated values	▪ The KPI is only measured.

Measured values	▪ Technical specification of the instruments (VOCs detectors and tester pollutant absorbing material) used to perform the measurements. Check their calibration, resolution, etc. ▪ Information about the mechanical ventilation installed in the building (if present) ▪ Boundary conditions that may have affected the measurements. ▪ Indication concerning the occupation of the building. ▪ Measurement report summarising measured values.

Table 41 – KPI 16 reporting format

KPI 16 - Formaldehyde concentration	
Calculated values	▪ The KPI is only measured.
Measured values	▪ Technical specification of the instruments (absorbing material tester for formaldehyde) used to perform the measurements. ▪ Information about the mechanical ventilation installed in the building (if present) ▪ Boundary conditions that may have affected the measurements. ▪ Indication concerning the occupation of the building. ▪ Information about smoking habit of the occupants, typology of the furniture, materials used in indoor area, etc. ▪ Duration of the measurements. ▪ Measurement report summarising measured values.

Table 42 – KPI 17 reporting format

KPI 17 - Operational energy costs	
Calculated values	▪ Name of the database, source used for estimating the energy prices by fuel type in € ▪ Name of standard/s used for calculating the EPC. ▪ Name of software tool used for calculation. ▪ List of building services (EPB services) considered (e.g., heating, cooling, ventilation, humidification, dehumidification, domestic hot water, lighting). ▪ Subtype of calculated (asset) assessment method used (e.g., design, as built or tailored). ▪ Boundary conditions of use (e.g., usage and operating times, internal set-point temperature for heating/cooling operation, energy need for DHW supply) used in calculation.
Measured values	▪ Invoices from energy provider of at least 12 consecutive calendar months showing the metered imported and exported energy values or ▪ Automatic reading from smart meters, covering all imported and exported energy (thermal and electrical)

	▪ Name of the database, source used for estimating the energy prices by fuel type in €

Table 43 – KPI 18 reporting format

KPI 18 - Smart Readiness Indicator	
Calculated values	▪ Technical information about all the relevant Building Automation and Control Systems (BACS) and other smart systems installed in the building that are declared in the SRI3 calculation-sheet v4_5. ▪ Building EU climate zone and use type based on the EPC. ▪ A filled out SRI3 calculation-sheet v4_5.
Measured values	▪ The KPI is only calculated.

Table 44 – KPI 19 reporting format

KPI 19 - Summer thermal discomfort in 2050	
Calculated values	▪ Name of standard/s used for calculation. ▪ Name of software tool or dynamic simulation method used for calculation. ▪ Indication of the evaluated zones in the building ▪ Indication of the climate projection year, Mitigation emission scenario and weather file used ▪ Building thermal and physical values ▪ Building cooling systems considered ▪ Building's use and occupancy profile used, and the length of the cooling period.
Measured values	▪ The KPI is only calculated.

Table 45 – KPI 20 reporting format

KPI 20 - Percentage of recharging points and installed pre-cabling in relation to the number of parking spaces	
Calculated values	▪ Number of parking spaces at the design stage ▪ Number of purpose built electrical recharging spaces at the design stage
Measured values	▪ Number of existing parking spaces ▪ Number of existing purpose built electrical recharging spaces

Table 46 – KPI 21 reporting format

KPI 21_Daylight Provision

Calculated values	▪ climatic data used to perform the calculation. ▪ Name of software tool used for calculation. ▪ Geometry of the building and the information about the geometry of the windows. ▪ Presence of mobile or fixed solar screens. ▪ Calculation table.
Measured values	▪ Technical specification of the instruments (luxmeter) used to perform the indoor measurements. ▪ Technical specification of the instruments (shadow ring, to create the proper outdoor measurement conditions) used to perform the outdoor measurements. ▪ Outdoor climate conditions. ▪ Indicate the measuring points distributed in the space. ▪ Indicate all the elements that may affect the accuracy of the measurement (curtains drawn, obstruction resulting from the furniture, presence of occupants, etc.) ▪ Boundary conditions that may have affected the measurements. ▪ Indication concerning the occupation of the building. ▪ Measurement report summarising measured values.

8 EUB e-Passport

8.1 Subclause title

8.1.1 Subclause title

8.1.1.1 Subclause title

Text of subclause.

The EUB SuperHub project supports the evolvement of the next generation of building certification: moving towards sustainability and smartness by developing the EUB SuperHub online platform based on the digital building logbook, which contains all relevant building-related data and documentation over the whole lifecycle of a building, providing different types of stakeholders with different information for different purposes at the right time. The final output of the EUB SuperHub project is the EUB e-passport (European Building electronic passport).

It is noteworthy, that this EUB e-passport doesn't represent a renovation passport that provides a clear roadmap for staged deep renovation. The envisioned EUB e-passport assesses a building in the field of energy efficiency, sustainability and smartness built upon the EUB SuperHub digital building logbook (DBL) and based on the proposed system of 21 Key Performance Indicators (KPIs), selected and presented within this document, establishing a comprehensive framework for achieving carbon neutrality in the building sector throughout a building's life cycle. The selected KPIs cover thematic areas such as energy consumption, renewable energy, GHG emissions, thermal comfort, indoor air quality, costs, smart buildings, resilience to climate change, E-mobility, and daylight sufficiency.

Based on the three publicly available proposals for a directive on the energy performance of buildings, published in December 2021, March 2023, and December 2023, it is evident in which direction the energy certification process is heading.

Annex V of the newest version of the proposal published in December 2023 contains lists of elements that future energy performance certificates shall display or may include.

One of the first indicators that should be displayed on the front page of an energy performance certificate, are the value of the operational greenhouse gas emissions expressed in [kg $CO_2/(m^2y)$] and, if available, the value of life cycle GWP. The first element corresponds to KPI 7 - Operational greenhouse gas emissions, and the second element corresponds to KPI 8 - Life Cycle Global Warming Potential (GWP) in this document.

On the list of the elements that a future energy performance certificate may include are the results of the analysis on overheating risk, which is considered in this document by the following two indicators: KPI 9 – Percentage of time outside of thermal comfort range, and KPI 19 - Summer thermal discomfort in 2050.

Furthermore, the importance of considering the indoor environmental quality is evident. It relates to parameters such as temperature, humidity, ventilation rate and presence of contaminants, influencing the health and well-being of the building's occupants. Within the system of KPIs, there is one thematic area wholly devoted to indoor air quality, which comprises in total seven KPIs, namely: KPI 10 - Ventilation rate, KPI 11 – CO2 concentration, KPI 12 – Relative humidity, KPI 13 – Total VOCs, KPI 14 – CMR VOCs concentration, KPI 15 – R value, and KPI 16 – Formaldehyde concentration.

On the list of elements that future energy performance certificate may include is the number and charging points for electric vehicles, which is considered in this document by taking into account KPI 20 - Share of recharging points and installed pre-cabling in relation to the number of parking spaces.

Based on the last publicly available proposal for a directive on the energy performance of buildings, published in December 2023, the energy performance certificate may include the following links with other initiatives:

a) a yes/no indication of whether a smart readiness assessment has been carried out for the building,

b) the value of the smart readiness assessment (if available),

c) a yes/no indication of whether a Digital Building Logbook is available for the building.

On the list of the proposed system of Key Performance Indicators (KPIs) within this document is also KPI 18 – Smart Readiness Indicator.

It is important to stress that the whole envisioned EUB SuperHub platform and the proposed system of 21 Key Performance Indicators (KPIs) are built upon the elaborated EUB SuperHub digital building logbook (DBL), which acts as a repository of all building-related data and documentation throughout a building's life cycle.

There are many other elements on the list of elements in the last publicly available proposal for a directive on the energy performance of buildings, such as the average *U*-value for the opaque elements of the building envelope, the average *U*-value for the transparent elements of the building envelope, type of most common transparent element (e.g. double glazed window), presence, type and size of energy storage systems, expected remaining lifespan of the heating and/or air conditioning systems and appliances, metered energy consumption. Those elements are not considered in the selected system of 21 KPIs, but they are all contained in the elaborated EUB SuperHub digital building logbook and could be pulled out of the DBL at any time.

Containing eight main categories, the elaborated EUB SuperHub digital building logbook data structure stands as the cornerstone of the new building certification process suggested within the EUB SuperHub project, with the EUB e-Passport as the final output of the building certification process. The EUB e-Passport relies on a proposed system of 21 selected Key Performance Indicators (KPIs), establishing a comprehensive framework for achieving carbon neutrality in the building sector throughout a building's life cycle.

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