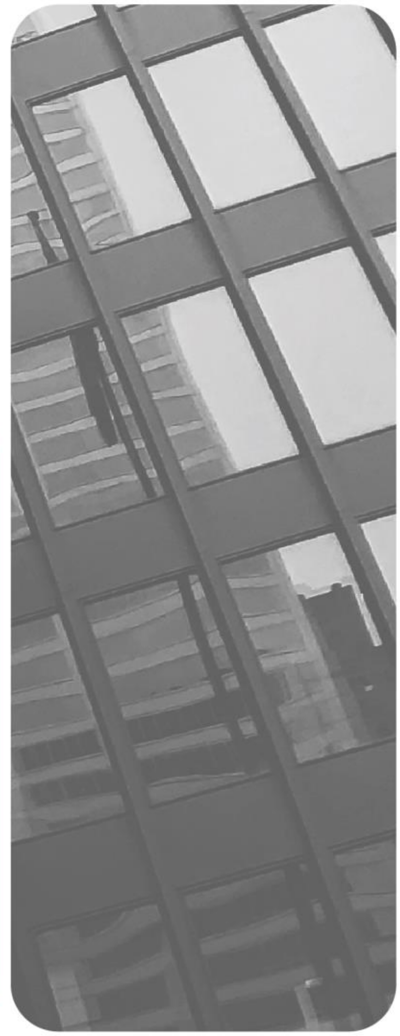
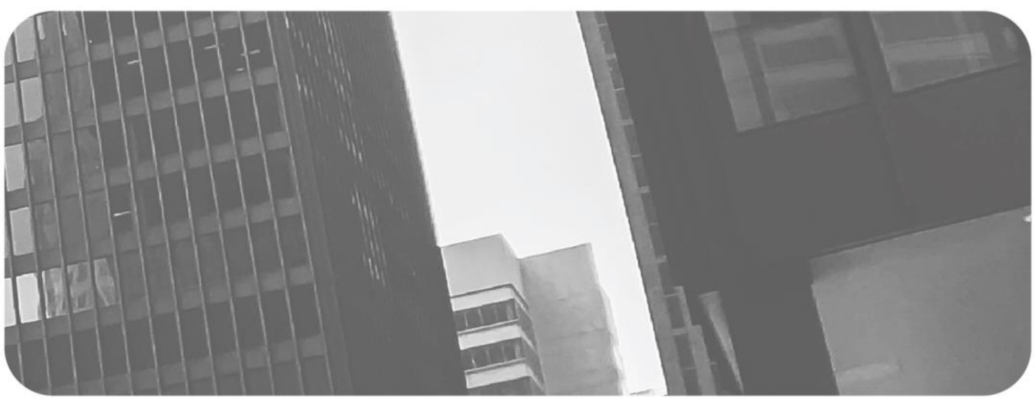


# D4.1 Detailed common calculation and measurement protocols of U-CERT EPC-s for the cases



U-CERT
User-Centred Energy Performance Assessment and Certification

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreement number 839937. The European Union is not liable for any use that may be made of the information contained in this document, which is merely representing the authors' view.

**Project duration:** 1st September 2019 – 31st August 2022
**Grant Agreement number:** 839937 (Coordination and Support Action)
**WP:** 4 **Deliverable:** 4.1
**Lead beneficiary**: REHVA
**Submission Date:** 31 May 2020
**Dissemination Level**: Public
**Due date**: M9
**U-CERT Website**: [www.u-certproject.eu](http://www.u-certproject.eu)

**Revision History:**

| DATE | VERSION | AUTHOR/CONTRIBUTOR [1)] | REVISION BY[1)] | COMMENTS |
|---|---|---|---|---|
| 08/05/2020 | 0.0 | Pablo CARNERO MELERO, IVE | - | First draft version |
| 15/05/2020 | 0.1 | Pablo CARNERO MELERO, IVE | EnEffect, IRI-UL, DTU, AiCARR, TalTech, Tipee | Involved partners' revision |
| 18/05/2020 | 1.0 | Pablo CARNERO MELERO, IVE | EPBC, TNO | Methodology developers' revision |
| 20/05/2020 | 1.1 | Pablo CARNERO MELERO, IVE | Simona D'OCA, HIA | First version revised from the Project Coordinator |
| 27/05/2020 | 1.2 | Pablo CARNERO MELERO, IVE | Andrei Vladimir LIȚIU, REHVA & KTH | WP2 & WP6 revision Involved partners' revision |
| 06/05/2021 | 1.3 | Pablo CARNERO MELERO, IVE | - | Updated to WP3 progress, inclusion of additional case study in France |
| 31/01/2022 | 2 | Pablo CARNERO MELERO, IVE; Borja PALLAS VÁZQUEZ, IVE; Niccolò MIGNANI, ISSO | - | Updated to WP3 progress, upgrade of testing phase |



**Acknowledgements:**

U-CERT Consortium would like to acknowledge the financial support of the European Commission under the H2020 programme. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement number 839937.



[1] Name SURNAME, ORGANIZATION

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U-CERT
User-Centred Energy Performance Assessment and Certification

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# Introduction to U-CERT

Under the Energy Performance of Buildings Directive (EPBD), all EU countries have established independent energy performance certification systems supported by independent mechanisms of control and verification. These Energy Performance Certification (EPC) schemes have stood in the past as one of the most important sources of knowledge on the energy performance (EP) of the European building stock. However, there are still several barriers to overcome towards a widely supported and successful implementation of the Energy Performance Certificates (EPCs) as effective tools to support the revised EPBD [1]. One of the main obstacles is users' understanding and acceptance of EPCs, nowadays held back by the lack of user-friendliness, reliability – and therefore lack of credibility – and cost effectiveness. Another barrier is that some implementations of the certification and assessment schemes seem to be not fully compliant with EU legislation, which is necessary to instill trust in the market and to incite investments and to support decision making, both on new energy efficient buildings as on deep renovation. Moreover, EPCs often fail in evaluating the impact of innovative technical solutions on buildings' energy performances. Current calculation methods used in EPCs typically do not enable realistic prediction of performances of innovative technologies, so that building designers and EPCs assessors are led to miscalculate or even discard daring design options, thus hindering their market uptake.

Since 2017, there is a new opportunity as the EPCs can rely on the new set of EPB standards for their assessment methodology. These standards address the afore-mentioned challenges by proposing a holistic and modular approach. In principle, this modular approach can enable a step-by-step implementation, starting with the overarching EPB standard and other key modules. However, there is still a clear need for guidance and support with respect to the structure of the set of EPB standards and the application of individual standards or clusters of standards, both on a local and a national level. The standards and technical reports provide a lot of information, but based on the feedback received so far, it appears difficult to find or recognize the information that is searched for. Information must be made accessible and applicable for the Member States (MS) to support them in their investigation on how the EPB standards can be used.

Summarizing, current practices and tools of EPB Assessment and certification applied across Europe, clearly face several challenges [2]. To meet them they should become more reliable, by being compliant with EU legislation and facilitating convergence of EPCs across EU. They also should become more user-friendly, by offering support in decision making; and more cost-effective, increasingly reflecting the smart dimension of buildings and ensuring a technology neutral approach.

In this context is where the U-CERT project is developed.

# Executive Summary

The U-CERT project is focused on introducing a next generation of user-centered EPCs to value buildings in a holistic and cost-effective manner by means of five measurable objectives:

- Stimulating and enabling the co-creation and implementation of the new generation of EPC Schemes with a wide based support.
- Enhancing the new certification schemes to be more practical, reliable, understandable, and desirable by a holistic and user-centered approach.
- Making the new certification schemes easily accessible for a wide range of users and stakeholders by the services of the EPB Center.
- Providing evidence of applicability and usefulness developed schemes by testing the U-CERT approach in selected cases.
- To foster the EU-wide uptake by motivating and activating EU interest groups and national certifying and standardization bodies.

Providing evidence of applicability and usefulness developed schemes (WP2, 3 and 5) by testing the U-CERT EPC approach, in selected cases is WP4's main contribution to U-CERT. Thus, the results and analyses of the realistic cases will be used as feedback for WP2, 3 and 5 to adjust and fine-tune the methodologies, tools, services and supporting business models. Therefore, study cases act as 'field labs' for testing and validating the use of the U-CERT's value proposition.

The general fitting of WP4 within U-CERT project is the following.

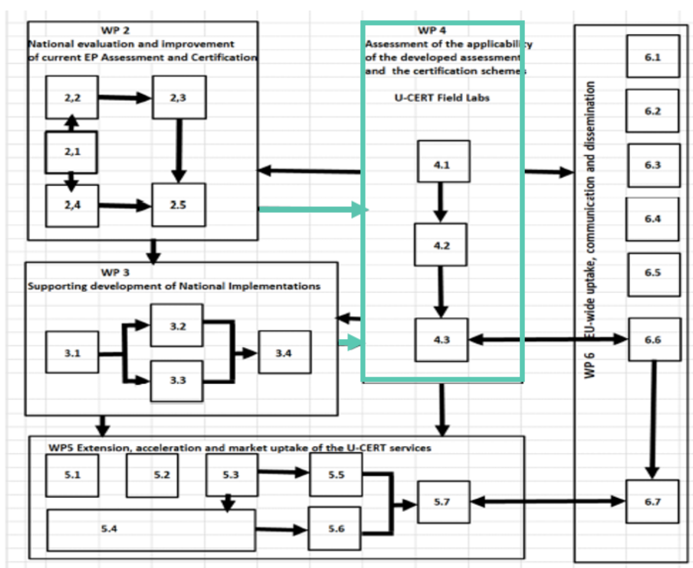



Figure 1. Synergies between Work Packages within U-CERT. Source: U-CERT's GA

As stated in U-CERT's Grant Agreement (GA), *"the objective of WP4 is to test and demonstrate the methodology as developed in WP2 and WP3 through the practical implementation of the procedures by cases from 11 countries".*

Thus, WP4 tasks are strongly intertwined with tasks from other WPs. The analysis of the state of the art regarding current EPC implementation in Task 2.1 will provide the baseline of knowledge of the different state of EPC development in U-CERT partner countries. Task 2.2 will develop the methodology to assess users' perception about

EPC schemes, providing valuable knowledge of the user needs and expectations towards next generation EPC schemes. Relevant inputs are also expected from Task 2.4, and its review of holistic indicators for measured data inclusion in advanced EPC schemes. Moreover, the core of U-CERT EPC framework is to be developed in WP3, specially in Task 3.1, with the development of converged set of national data sheets for the set of EPB standards, which should define the basic structure of U-CERT EPB Assessment. Also in Task 3.2, where the main U-CERT indicators for next-generation EPCs will be defined. Furthermore, U-CERT methodology will have an echo in the U-CERT supporting tools development in WP5, which, in turn, may need to perform some testing in the case studies and, therefore, should also be accounted for in this protocol. It is within this framework that this deliverable is created.

This deliverable has been updated to reflect the latest developments in the methodology-developing WPs.

## Definitions

The underlying document uses certain concepts which may be unfamiliar to the public and for EPB assessors without deep knowledge of the EPB standards.

For deeper knowledge of the terms and definitions used in the scope of energy performance calculations, refer to EN ISO 52000-1 section 3 [1], EN ISO 52016-1 section 3 [2], and EN ISO 52018-1 section 3 [3].

# Introduction

Case Studies are the environments where U-CERT value propositions should be tested for applicability and user-friendliness. The foreseen actions related to the testing activities in Case Studies can be clustered according to the following sequence:

- Characterisation of national EPB Assessments and Certification schemes:
  - Collection of information on national EPCs;
  - Assessment of user friendliness of national EPCs;
- Testing applicability of methodology of U-CERT EPB Assessment and Certification scheme:
  - Calculated EPB Assessment;
  - Measured EPB Assessment;
  - U-CERT EPC.
- Testing applicability of U-CERT's digital solutions:
  - U-CERT Comparison and calculation toolkit for National Annexes;
  - U-CERT Open Data Solution;
  - U-CERT Building Operational Rating Solution.

Each testing activity calls for certain requirements to be demonstrated, so such requirements will determine the eligibility of each case study.

As exposed in Deliverable 1.2, the U-CERT has suffered some setbacks, which have prevented the project from providing the expected results in due time and proposed course. Apart from the already known (i.e., COVID-19 outbreak, lockdown, restrictions in mobility, etc.), the **lack of access to partner countries' National Annexes** has caused a delay in many methodology developing tasks. This has forced to take on adaptation measures, which have specially affected to U-CERT methodology development and, in turn, to case study testing.

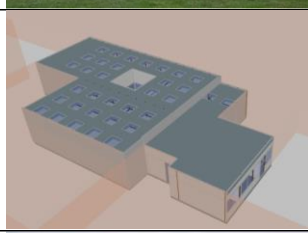
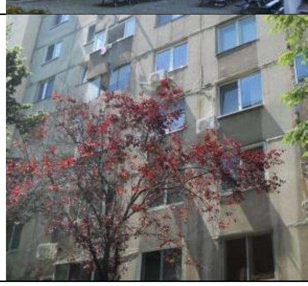
## Case Studies description

The case studies for the U-CERT project were selected when developing the proposal. Originally, they were a total of 15 from 11 different countries, representing different climatic conditions, building typologies, regulatory frameworks, official EPB assessment definitions, etc. They allow the project to test the consistency of the methodologies developed in a very mottled environment.

Table 1. U-CERT Case Studies

| Case Study | Image | Name | Country | Category | Construction Year | Last renovation | EPC release Year | Heated area ($m^2$) |
|---|---|---|---|---|---|---|---|---|
| 1 |  | Larisa Nursing Home | The Netherlands | Residence for the elderly | 2016 | N/A | 2013 | 6.627 |
| 2a |  | Entré Lindhagen Hus C | Sweden | Offices | 2013 | N/A | 2018 | 21.244[1] |
| 2b |  | Hagaporten III | Sweden | Offices | 2008 | N/A | 2019 | 33.265[1] |
| 3 |  | J7B office building | Estonia | Offices | 2018 | N/A | 2018 | 2.170[2] |
| 4 |  | University | Hungary | Educational building | 1877 | 2014 | 2018 | 2.243[3] |

[1] Heated area, excluding heated garage.
[2] Net surface.
[3] Undetermined.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4b |  | Budapest Office | Hungary | Offices | | N/A | 2019 | 997[3] |
| 5a |  | Quart 33 | Spain | Multi-family building | 2009 | N/A | 2013 | 3.098[4] |
| 5b |  | UMH Rectorate | Spain | Office | 2008 | 2018 | 2017 | 8.520[4] |
| 5c |  | IVE headquarters | Spain | Office | 1970 | 2021 | 2021 | 482.41 [5] |
| 6a |  | Computer and Information Science, University of Ljubljana | Slovenia | Educational building | 2014 | N/A | 2014 | 24.985[6] |
| 6b |  | Faculty of Economics, University of Ljubljana | Slovenia | Educational building | 1976 | 2014 | 2015 | 6.012 |
| 7 |  | Apartment Building 21 | Romania | Multi-family building | 1983 | 2017 | - | 8.058[5] |

[4] Living spaces area.
[5] Useful area.
[6] This is the area for the whole building complex accounted for in the issued EPC. They are a total of 3 buildings with physical connection and shared heating and cooling technical systems. The specific surface of the Computer and Information Science building is 7.831 m$^2$.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 8 |  | Building 22, Campus Leonardo, Polimi | Italy | Educational building | 1999 | - | - | 2.972[3] |
| 9 |  | Two-family house | Bulgaria | Two-family building | 2002 | 2010 | 2020 | 320 |
| 10a |  | Médiathèque Michel Crépeau | France | Public library | 1997 | - | 2020 | 9.200[7] |
| 10b |  | Individual house | France | Single-family house | 1974 | N/A | 2020 | 94[7] |
| 11a |  | Green Lighthouse | Denmark | Office | 2009 | N/A | 2012 | 972 |
| 11b |  | Home for Life | Denmark | Single-family house | 2009 | N/A | 2010 | 191 |

Note that **some case studies have been modified from the ones listed in the proposal document**, and additional ones have also been included. The main reason behind this decision has been to grant higher quality data to the U-CERT testing phase. Some of the originally proposed buildings were no longer suitable to be used as "testbeds", due to being unoccupied or to occupants being reluctant to provide data, mainly caused by the COVID-19 outbreak. The additional case studies have been included in Table 1,

[7] Gross floor area.

and marked in orange. In the event that they substituted a previous case study, the former has been marked in red.

With a view to easing the reading of the document, the tables referring to case studies details will omit the name of the buildings. The case study identification number, as stated in Table 1, will be used.

## Characterisation of national EPB Assessments and Certification Schemes

The starting point in U-CERT is the assessment of **each partner country status with regards to EPB Assessments and Certification schemes.** For such endeavour, the analysis of EPC schemes implementation in U-CERT partner countries exposed in Deliverable 2.1 [4] is to be used.

With regards to the assessment of users' perception about EPC schemes, the methodology developed by the ethnographers in the consortium and presented in Deliverable 2.2 [5] was used. Such methodology was rolled out independently from WP4 in the scope of Task 2.3. The results can be found in Deliverable 2.3 [6].

### Collection of data for current EPB Assessments and EPCs

The first step is the collection of information on national EPB Assessments and Certification Schemes, performed according to the regional/national methodology for each of the U-CERT case studies. It is important to consider not only the **EPC label**, available in most national and regional EPC databases, as demonstrated by the Enerfund project [3], but also the **EPC report**. This document contains detailed information regarding the building as such and its technical building systems, along with energy performance improvement recommendations for existing buildings [7]. Lastly, if possible, the filled **National Annexes**, detailing the calculation methodology in terms of the applicable EPB standards are also meaningful. In light of the EPBD [8], Member States are obligated to describe their national calculation methodology following the Annex A template of the overarching standards; namely, EN ISO 52000-1, 52003-1, 52010-1, 52016-1 and 52018-1. Thus, collecting such documentation for each of the partner countries is paramount to establish a reliable comparison between national calculation methodologies[1].

Existing EPCs and National Annexes play the role in the U-CERT methodology of serving as benchmark for what is currently being valued in each context, but also to identify the degree to which national methodologies account for innovative technologies and solutions and user-centred indicators or abide by the EPB Standards.

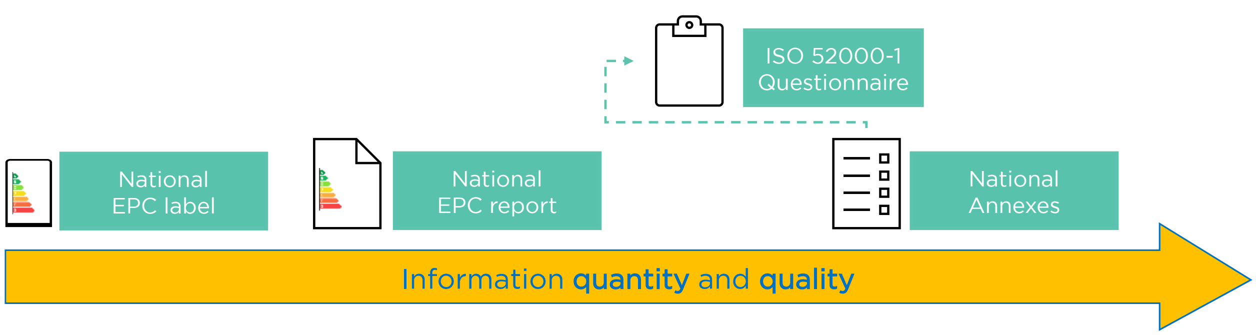



Figure 2. Sources of information on national EPB Assessments

The intended starting point for the work was a collection of National Annexes or National Datasheets, and EPCs from the EU Member States. However, the

[1] Furthermore, they should serve as great base for the development of the Converged set of National Annexes, under Task 3.1, and for the Comparison and Calculation Toolkit for National Annexes, under Task 5.4.

implementation of the set of EPB standards in the EU Member States has been delayed compared to the expectations. Likely causes for these delays are the time needed for each country for the process to change the national assessment procedures and difficulties due to the COVID-19 crisis, among others.

**The project managed to obtain the national EPC for each case study building, and the National Annexes of Italy and Spain**[2]. Thus, with a view of obtaining further information a questionnaire was developed. This questionnaire covered the main EPB Standard, namely, ISO 52000-1. The objective was to try to benefit from the expertise of partners in each of the contexts when defining in a comparative manner the calculation methodology in U-CERT partner countries. However, **not having access to the highest level of information on partner countries' EPB Assessments caused U-CERT methodology to be adapted.**

The resulting available information for each of the case studies and case study countries can be seen in Table 2.

Table 2. Partner country available information on national EPB Assessments and Certification schemes

| Case Study | Information Available | | | |
|---|---|---|---|---|
| | EPC label | EPC report | National Annexes | Questionnaire |
| 1 | X | X | - | X |
| 2a | X | X | - | X |
| 2b | X | X | | X |
| 3 | X | X | - | X |
| 4 | X | X | - | X |
| 4b | X | X | - | X |
| 5a | X | X | X | X |
| 5b | X | X | | X |
| 5c | X | X | | X |
| 6a | X | X | - | X |
| 6b | X | X | | X |
| 7 | X | X | - | X |
| 8 | X | X | X | X |
| 9 | X | X | - | X |
| 10a | X | X | - | X |
| 10b | X | X | | X |
| 11a | X | X | - | X |
| 11b | X | X | | X |

The case studies with the most available information are 5a, 5b and 8. Corresponding to Spain and Italy.

[2] Both available at EPB Center's website: https://epb.center/epb-standards/implementation/national-annexes/examples-na/

## Assessment of user friendliness of national EPCs

The activities related to the assessments of national EPC's user-friendliness and user perception has been performed following the guidelines from Deliverable 2.2 [5], and its results can be found in Deliverable 2.3 [6].

## U-CERT EPB Assessment and Certification Scheme

Case Studies should test, to the best of their ability, the applicability of the methodology behind U-CERT EPB Assessment and Certification scheme. After such testing, a comparative assessment between national status and U-CERT value proposition can be established.

The initial course of action of the project was to rely on the collection of MS National Annexes, to come to a converged set of national data sheets for the overarching EPB Standards. This converged set of national data sheets would in turn constitute the basis for the calculation methodology of the U-CERT EPB Assessment. Such calculation methodology could serve as base for the development of a calculation tool capable of resulting in the U-CERT EPB Assessment software. However, as it was explained in Deliverable 1.2, the strategy changed due to the delay of almost every MS in delivering such National Annexes to DG Energy, which in turn delayed the methodology development of Task 3.1. As stated in section 1 of Deliverable 3.1 [9], the new approach is to use U-CERT consortium expertise to define the U-CERT Data Sheets, which would take the place of the converged set of national data sheets, hence constituting the rationale behind the U-CERT EPB Assessment.

As presented in Deliverable 3.1, from the whole set of EPB standards, only those devoted to preparation of the calculation, pre- and post-processing of the results are to be considered for the definition of the U-CERT EPB Assessment. They are the following:

The 5 core EPB standards, explicitly mentioned in Annex 1 of the amended EPBD [8]:

- EN ISO 52000-1, Energy performance of buildings — Overarching EPB assessment – Part 1: General framework and procedures (2017)
- EN ISO 52003-1, EPB – Indicators, requirements, ratings, and certificates – Part 1: General aspects and application to the overall energy performance (2017)
- EN ISO 52010-1, EPB – External climatic conditions – Part 1: Conversion of climatic data for energy calculations (2017)
- EN ISO 52016-1, EPB – Energy needs for heating and cooling, internal temperatures, and sensible and latent heat loads – Part 1: Calculation procedures (2017)
- EN ISO 52018-1, EPB – Indicators for partial EPB requirements related to thermal energy balance and fabric features – Part 1: Overview of options (2017)

Also, the following:

- EN 16798-1, Energy performance of buildings — Ventilation of 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 16798–7, Energy performance of buildings – Ventilation for buildings – Part 7: Calculation methods for the determination of air flow rates in buildings including infiltration (Module M5–5)
- EN 16798–5–1, Energy performance of buildings – Ventilation for buildings – Part 5–1: Calculation methods for energy requirements of ventilation and air conditioning systems (Modules M5–6, M5–8, M6–5, M6–8, M7–5, M7–8) – Method 1: Distribution and generation

- EN 15316-4-2, Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies – Part 4–2: Space heating generation systems, heat pump systems, (Module M3–8-2, M8–8-2).
- Draft ISO/FDIS 520232-1:2021, Energy performance of buildings — Energy requirements and efficiencies of heating, cooling and DHW distribution systems — Part 1: Calculation procedures

The EN 15378-3, Energy performance of buildings –Heating and DHW systems in buildings – Part 3: Measured energy performance, (Module M3–10 and M8–10) is also present in Deliverable 3.1, nonetheless it is not related to a calculated EP assessment.

Moreover, U-CERT also considered enriching EPB Assessments and Certification Schemes with complementary-to-energy assessments and indicators, such as Smart Readiness Indicator (SRI) and Indoor Environmental Quality (IEQ).

## U-CERT Calculated EPB Assessment

As exposed in Deliverable 3.2 [10], the calculated EPB Assessment under standard conditions and standard weather data is often referred to as asset performance, and it is the most widely used for regulatory applications. It can be referred to the building as a whole and to specific parts. The indicators should be the result of performing building EP assessments following U-CERT guidelines recommendations. Note that it is possible to calculate EPB assessments not intending to represent an asset performance. In that case there are certain choices made in Deliverable 3.1 that ought to be changed (e.g., use conditions, weather data, etc.) with a view of representing a tailored assessment rather than a standardized or asset assessment.

The U-CERT Calculated EPB Assessment covers the energy performance dimension, the Smart Readiness Indicator, and Indoor Environmental Quality, as defined in Table 3.

Table 3. Indicators related to U-CERT's Calculated EPB Assessment and Certification Scheme [10]

| Category | Indicators | U-CERT EPB Assessment and Certification Scheme | | Recognized as complementary to any EPB Assessment |
|---|---|---|---|---|
| | | Included | Left as voluntary | |
| Energy Performance | Overall EP indicators | X | - | - |
| | Partial EP indicators | X | - | - |
| Smart Readiness | SRI | X | - | - |
| IEQ | ALDREN Thermal score | X | - | - |
| | ALDREN TAIL | - | X | - |
| | Triple-A reno Combined Label | - | - | X |
| Cost | Cost | - | - | - |

In the scope of Task 4.1, all indicators contained in U-CERT's Calculated EPB Assessment and Certification schemes will be tested in as many case studies as possible. Note that, as exposed in Introduction, not all case studies will be eligible for all U-CERT testing.

U-CERT
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## Energy performance

Energy performance is the core of EPB Assessments, both U-CERT's and nationals'. One of the crucial aspects in U-CERT's testing phase is to assess how close or different EPB Assessment calculation methodologies are.

### U-CERT vs National

The uneven information on each context's EPB Assessment generated a dual comparison procedure for each case study context according to National Annexes availability (see Table 2).

1. **Simplified comparison**, without the need of National Annexes.
2. **Detailed comparison**, requiring the National Annexes.

These two procedures are explained in further detail in the subsequent sections, and for both a set of supporting tools will be used.

Furthermore, the case studies' EPCs collected during Task 2.1 will be compared against U-CERT EPC with a view of establishing an analysis. This will be the basis for Deliverable 4.2.

#### *Simplified comparison*

The idea behind the **simplified comparison** is to use a set of supporting spreadsheets to assess the impact of certain national choices linked to EPB Standard EN ISO 52000-1 [1].

The spreadsheets used allow to assess the impact of choices made by U-CERT (see Deliverable 3.1 [9]) on Table A/B.16 (*Weighting factors (based on gross or net calorific value)*), Table A/B.17 ($k_{exp}$ *factor*), Table A/B. 24 (*Perimeter choice*), Table A/B.27 (*Basis for the energy performance of buildings*). Thus, the needed information to perform this **simplified comparison** is just the national choice on **weighting factors**, **$k_{exp}$ factor**, **perimeter choice**, and **basis for the energy performance of buildings**. This information can be obtained through the general questionnaire on EN ISO 52000-1, so every case study country can perform the simplified comparison. Needless to say, that the information on the national choices would also be present in the National Annexes.

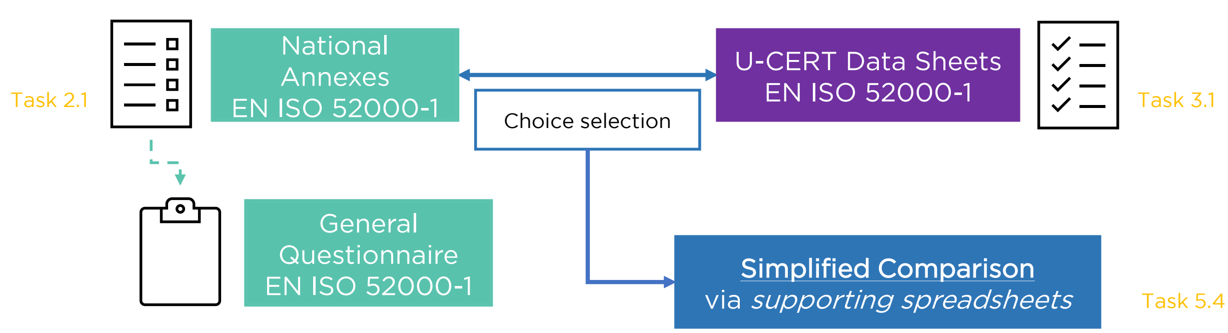


Figure 3. National vs U-CERT EPB Assessment EN ISO 52000-1 choices. Simplified Comparison

The logic behind these spreadsheets is to consider a default building (i.e., a single-family house) with an intermediate climate (e.g., Northern Italy), where Heating, Cooling and Domestic Hot Water uses are considered. An **hourly calculation procedure** is used for two days of the year: a winter and a summer one, to simulate the two extreme conditions. A total of 5 spreadsheets are used, covering different combination of building services and technical systems:

Covering space heating and domestic hot water:

- Gas Boiler + Thermal Solar:
  - *Case_Simpl_EN_ISO_52000-1_01_boil_PVno_TSyes*:
- Gas Boiler + Thermal Solar + Photovoltaic:
  - *Case_Simpl_EN_ISO_52000-1_02_boil_PVyes_TSyes*:
- Heat Pump + Thermal Solar:
  - *Case_Simpl_EN_ISO_52000-1_03_hp_PVno_TSyes*:
- Heat Pump + Thermal Solar + Photovoltaic:
  - *Case_Simpl_EN_ISO_52000-1_04_hp_PVyes_TSyes*:

Covering space heating and cooling:

- Heat Pump + Photovoltaic:
  - *Case_Simpl_EN_ISO_52000-1_05_hp_PVyes_TSno_Heat&Cool*:

As a result, the simplified comparison allows to obtain tentative results of the impact certain national choices have when compared with U-CERT's, according to Deliverable 3.1. Also, it allows to compare cross-country choices.

The results of this comparison will be included in Deliverable 4.3 [11].

### *Detailed comparison*

The idea behind the **detailed comparison** is to rely on a dynamic simulation tool to check the impact of some EPB Standard choices which require hourly calculations. To properly define the simulation models, having access to National Annexes is required.

The procedure is to model the building with an official EPB Assessment calculation software abiding by each country's National Annexes and start modifying the national choices from certain EPB Standards to reflect U-CERT's according to Deliverable 3.1. Next, the impact of the choices made in the tables labelled as *important* in Deliverable 3.1 will be assessed one by one.

There are no requirements as far as which calculations tools to use, however **they should be flexible enough to allow to modify national choices**. In the scope of U-CERT, a methodology has been developed relying on the tools provided by Cype Ingenieros S.A[3]. It is a software company based in Spain and developer of official EPB Assessment software in many European countries (i.e., Spain, Italy, France, Portugal, Bulgaria, etc.).

The basic geometry of the building will be created using IFC Builder™, and then attached to the different simulation cases thanks to the Open BIM environment. Thus, relying on Cypetherm HE Plus™ and Cypetherm CE™ for the calculation of the national EPB Assessment and Certification for Spain and Italy, respectively. Next, the needed modifications, according to the main EPB Standards' choices, will be made. Some will be directly applied to the "national" models, relying on the official software previously mentioned. Others, however, won't be possible to assess with such tools due to the official software being too rigid, so Cypetherm EPlus™ will be used. Furthermore, for very specific choices, it may be required to manually modify the calculation file to be

[3] More information at: http://www.cype.com/en/

assessed through the calculation engine itself; in this case, Energy Plus™. The complete methodology is illustrated in Figure 4.

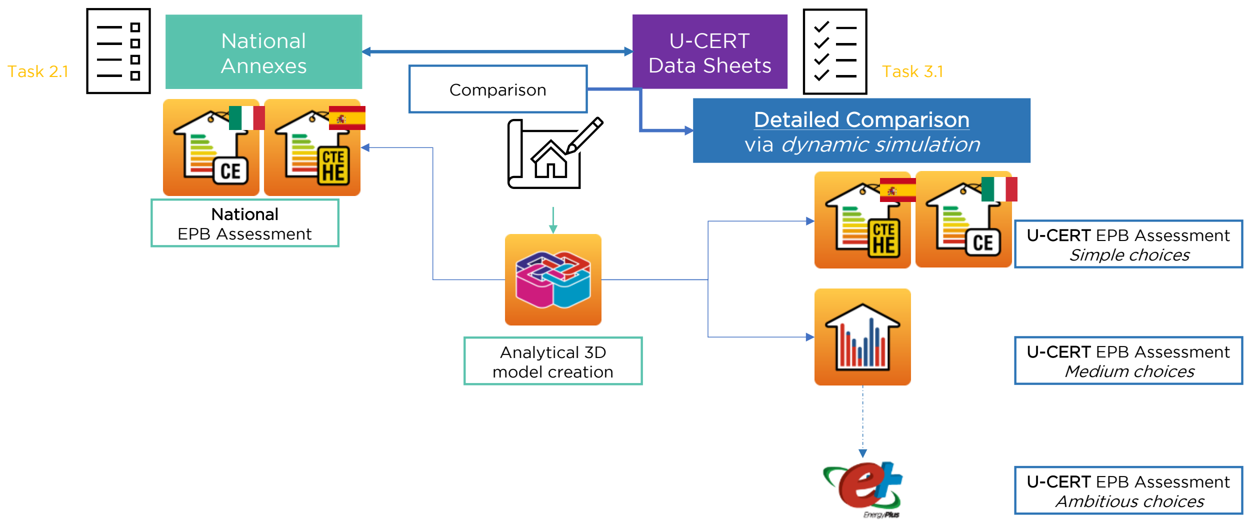


Figure 4. National vs U-CERT EPB Assessment. Detailed Comparison

Apart from the modifications in the simulation files related to the choices made in the most important EPB Standards, it will also be possible to perform tailored simulations. These simulations will serve to calculate the energy performance of buildings under actual conditions and with actual occupants (i.e., different use conditions, diverse weather data files, etc.). This specific case should be the base for the comparison with actual metered data. The detailed models will also be leveraged to calculate mock-ups of U-CERT EPB indicators, as designed in Deliverable 3.2.

With a view of increasing comparability between methodologies, for both contexts (i.e., Spain and Italy) the same two buildings will be used. A residential single-family house, and an office.

The geometries are common and have been modelled from the CAD blueprints using the IFC Builder ™ software. The resulting 3D BIM models can be found open access in the following links:

- Single-family house;
- Office.

An exemplary view is shown in Figure 5 and Figure 6.

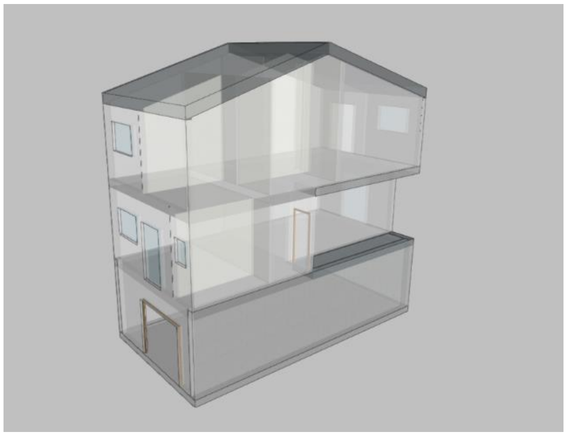

Figure 5. Residential building. Detailed comparison.

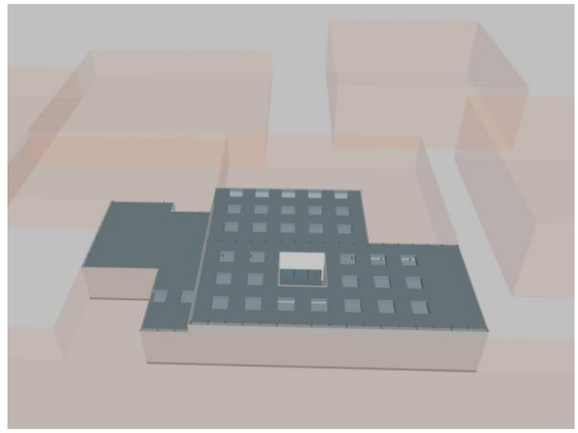

Figure 6. Non-residential building. Detailed comparison.

The residential building is a fictitious **detached single-family house** and is one of the geometries used for the BES TEST. The non-residential building is an actual **office building**, in which IVE's headquarters are based – it is U-CERT's Case Study 5c-. It constitutes a renovation of an existing building.

For the procedure followed for the comparison between Spain's National Annexes and U-CERT's refer to this document's Annex B, and to for the Italian case to Annex C.

## Smart Readiness

The Smart Readiness, as exposed in Deliverable 3.2, refers to the capability of buildings or building units to adapt their operation to the needs of the occupant, also optimizing energy efficiency and overall performance, and to adapt their operation in reaction to signals from the grid. It is U-CERT proposal to include some elements of the SRI, as defined by [12], into EPB Assessments.

For the assessment of the SRI in U-CERT Case Studies, the guidelines stated in the outcomes of the second technical study [12] will be followed. Case Studies would be able to follow the simplified (method A) or detailed (method B) assessment procedure, depending on the quality of the available data and the building typology by relying on the calculation spreadsheets generated for the public testing of the SRI [13]. Thus, with regards to the SRI every case study will be used as testbed.

Many of the elements comprising the calculation method (e.g., services, functionality, weightings, impact scores, etc.) are still tentative, and can be subject to further changes in the process of policy development and implementation in various local contexts. U-CERT team is overall committed to support the SRI implementation, updating and evolution processes throughout U-CERT's implementation play an active role in the "SRI platform" and exchange with all the concerned stakeholders, especially during the SRI national testing exercises 2021-2022.

## Indoor Environmental Quality

As written in Deliverable 3.2, several methodologies for the inclusion of the IEQ dimension in calculated EPB Assessments will be tested: namely, the ALDREN Thermal score, the ALDREN TAIL and the Triple A-reno combined labelling scheme.

The guidelines established in [14] will be followed for the ALDREN Thermal Score, and [15] will be followed for the ALDREN TAIL testing. Regarding the Triple-A reno Combined Labelling scheme, the digital tool is self explanatory[4].

The Triple-A reno Combined Labelling scheme will only be applicable to residential buildings, and ALDREN TAIL to non-residential buildings[5]. ALDREN TAIL, in its calculated fashion is restricted to the analysis of the thermal environment via dry-bulb temperature; to the Indoor Air Quality (IAQ) via CO2 concentration and air relative humidity; to the visual environment via the daylight factor and illuminance. For all, it requires to have hourly simulated values spanning a complete year. With regards to ALDREN's Thermal Score, hourly temperature values calculated under standard use conditions and standard weather data are needed.

With regards to IEQ case study testing, the following applies to each case study demonstration.

Table 4. IEQ case study testing. U-CERT Calculated EPB Assessment

| Case Study | IEQ demonstration | | |
|---|---|---|---|
| | ALDREN Thermal Score | ALDREN TAIL (simulated) | Triple-A reno Combined Labelling |
| 1 | Voluntary | Voluntary | Not applicable |
| 2a | Voluntary | Voluntary | Not applicable |
| 2b | Voluntary | Voluntary | Not applicable |
| 3 | Voluntary | Voluntary | Not applicable |
| 4 | Voluntary | Voluntary | Not applicable |
| 4b | Voluntary | Voluntary | Not applicable |
| 5a | Voluntary | Voluntary | Yes |
| 5b | Voluntary | Voluntary | Not applicable |
| 5c | Voluntary | Voluntary | Not applicable |
| 6a | Voluntary | Voluntary | Yes |
| 6b | Voluntary | Voluntary | Yes |
| 7 | Voluntary | Voluntary | Yes |
| 8 | Voluntary | Voluntary | Not applicable |
| 9 | Voluntary | Voluntary | Yes |
| 10a | Voluntary | Voluntary | Not applicable |
| 10b | Voluntary | Voluntary | Yes |
| 11a | Voluntary | Voluntary | Not applicable |
| 11b | Voluntary | Voluntary | Yes |

[4] For access to Triple-A reno Combined Performance Label digital tool, refer to: https://engine.triplea-reno.eu/label

[5] Despite it, the testing is going to be made open to other building typologies, aware that the EPC Recast project is working on adapting ALDREN TAIL to the residential typology.

Since the ALDREN Thermal Score was released on November 2021 and requires a detailed simulation of case studies not initially foreseen at proposal stage, just like ALDREN TAIL (simulated), it is left as voluntary to case studies.

## U-CERT Measured EPB Assessment

As mentioned in Deliverable 3.2, although measurement based EPB Assessments are gaining interest, they are not as widespread as calculated EPB Assessments. Moreover, the EN 15378-3 *Energy performance of buildings – Heating and DHW systems in buildings. Part 3: Measured energy performance*, covering the modules M3-10 and M8-10 is the only EPB Standard dealing with measured energy performance in buildings [16].

Therefore, unlike for the energy performance of Calculated EPB Assessments, a comparison between U-CERT's and each CS country's Measured EPB Assessment lacks value and will not be performed.

## Energy performance

Unlike for the U-CERT Calculated EPB Assessment, given the low implementation of measurement-based EPB Assessments, the comparison between national and U-CERT measured EPB Assessments is not relevant. Thus, for the involvement of case studies, U-CERT will leverage a collaboration agreement signed with the CEN-CE project[6] for the use of the supporting spreadsheet of the standard EN 15378-3. However, equal testing in all case studies can't be expected given the uneven metered data availability.

Table 5. Energy vectors data overview in U-CERT case studies

| Case Study | Energy vector per use | | | |
|---|---|---|---|---|
| | Heating | DHW | Cooling | Ventilation |
| 1 | Electricity | Natural gas | Electricity | Electricity |
| 2a | District heating | District heating | Electricity and Deep Green Cooling | Electricity |
| 2b | District heating | District heating | District cooling | Electricity |
| 3 | Electricity | Electricity | Electricity | Electricity |
| 4 | Natural gas | Electricity | Electricity | No |
| 4b | Natural gas | Electricity | Electricity | No |
| 5a | No | Electricity | No | No |
| 5b | Electricity | Electricity | Electricity | Electricity |
| 5c | Electricity | No | Electricity | Electricity |
| 6a | Natural gas | Natural gas | Electricity | Electricity |
| 6b | District heating | District heating | Electricity | Electricity |
| 7 | District heating and Natural gas | District heating and Natural gas | Electricity | No |
| 8 | Natural gas | Electricity | Electricity | Electricity |
| 9 | Biomass and Electricity | Electricity | No | No |
| 10a | Natural gas | Electricity | Electricity | Electricity |
| 10b | Electricity | Electricity | No | Electricity |
| 11a | District heating | Electricity | Electricity | Electricity |
| 11b | Electricity | Electricity | No | Electricity |

[6] More information at: https://www.cen-ce.eu/

Additional considerations apply to the inclusion of auxiliary energy or to the inclusion of cold-water volume regarding the DHW consumption, for instance.
Also, when dealing with metered fuels, the conversion to delivered energy should explicit the calorific value used. In the case of solid fuels, the quality, density, and humidity should also be determined.

- **Time interval**. If detailed metering is in place, the time resolution and the time span of the measured data needs to be characterized and synchronicity between them should be ensured. For instance, in the case of stored fuels, the time of the supply usually does not correlate with the time of the deliverance or consumption.
Moreover, there are services which are very seasonal, like space cooling and, mostly, space heating. This time-dependency should be accounted for in the measurements, and if several measurements are used, then it should be ensured that they are of the same length, and that the specific measurement is made at a time with low use of the energy carrier that is being measured, to reduce uncertainties, [4].
- **EPB and non-EPB uses**. It is also important to identify whether the measurements cover only EPB uses or also non-EPB uses or services out of the scope of the EPB Assessment. If in the measured energy there are some services out of the scope of the EPB Assessment, they should be subtracted. The methodology to perform such subtraction and separation between the services should be considered.

Specifically, for the services covered by the EPB Standard on measured EP Assessment, the following detail on measured energy data applies to the case studies.

Table 6. Measured energy data overview in U-CERT case studies

| Case Study | Detail on measured energy data availability | |
|---|---|---|
| | Heating | DHW |
| 1 | Monitoring data | Monitoring data & Dedicated invoices |
| 2a | Monitoring data | Monitoring data |
| 2b | Monitoring data | Monitoring data |
| 3 | Monitoring data | Monitoring data |
| 4 | Dedicated invoices | No |
| 4b | Monitoring data | Monitoring data |
| 5a | No | No |
| 5b | Monitoring data | No |
| 5c | No | No |
| 6a | Monitoring data | Monitoring data |
| 6b | Monitoring data | Monitoring data |
| 7 | Not possible to be retrieved | Not possible to be retrieved |
| 8 | Not possible to be retrieved | Not possible to be retrieved |
| 9 | New monitoring data | New monitoring data |
| 10a | Dedicated invoices | No |
| 10b | Overall invoice | Overall invoice |
| 11a | Not possible to be retrieved | Not possible to be retrieved |
| 11b | Not possible to be retrieved | Not possible to be retrieved |

Most case studies are in position of rolling-out a full assessment, either based on monitoring data or on invoices. Case study 5a and 5c is not able to assess because there is not data available. Case studies 7, 11a and 11b, although have metering in place, it is not possible to be retrieved, due to privacy issues. Case study 9 has recently changed the technical building system in place, shifting from biomass boiler to electric heat pump. Therefore, relevant historic measured data is not yet available.

Case Studies in a position of testing CEN-CE's spreadsheet on EN 15378-3 should abide by the following protocol.

### Protocol

There are certain measurement intervals, where the information is gathered, which compose in turn the measurement period. Specific considerations on the comparison between calculated and measured EP assessment can be found in section 8, especially in 8.7, in EN ISO 52000-2 [17].

It is important to ensure that the measured data and the assessed object are consistent. Of utmost importance is the determination of the reference area for the EP indicators. For instance, *"a space category that is formally allocated as inhabitable space should [...] be assumed to be an inhabitable area, [...] if this space is in practice regularly occupied (and its energy consumption is measured)"* as stated in EN ISO 52000-2 section 6.2.2.2 [5].

As additional EPB Standards are developed regarding measured EP Assessments, the workflow defined in Annex D in EN ISO 52000-1 [1] will become applicable.

According to EN 15378-3 [16], the needed input data when assessing the EP of the heating and DHW service in buildings is the following, per measurement interval.

- **Date of measurement**. Information about start and end or length of the interval.
- **Energy consumption**, during the interval, which may come from:
  - **Meter readings**, recording initial and final readings;
  - **Maintenance reports**;
  - **BACS**, **BMS** or similar;
  - **Invoices**, based on actual consumption not estimations.

  The auxiliary energy consumed for the heating and DHW service should also be considered.

  For hourly metering, there is a need to apply a coefficient of proportionality depending on the fuel used.

- **DHW consumption** recording by means of dedicated meter reading, often volumetric. If there is not one, then use EN 12831-3 [18] for estimation is needed if heating and DHW are measured together.

  In absence of dedicated metering for heating and DHW, additional **service separation** may be needed to eliminate the influence the use of the same energy vector for other uses out of the scope of the assessment (e.g., kitchen, etc.).

- **Average external dry-bulb temperature**, during the interval, which may come from:
  - **Dedicated on-site hourly measurement**, avoiding direct air current and solar radiation influence, and measured at a representative elevation;
  - **Nearby weather station hourly or daily reading**;

    - **Standard weather data file for the location**[7].

  An arithmetic mean or weighted average should be applied for each hourly value.

- **Average indoor dry-bulb temperature**, during the interval, which may come from:
    - **Dedicated on-site sensor hourly measurement**, avoiding direct solar radiation influence, and at the center of the room at 1,5m elevation.
        - For residential buildings, one sensor per representative unit with different use is required.
        - For non-residential buildings, there is a requirement of one sensor per each 100 m2 floor surface with different use. Also, *"if the volume of non-heated areas is accounted in the assessment, their indoor temperature should be measured"* [16].

      If there are several sensors, a volumetric weighted average should be used on the data of each zone.

    - **Thermostatic setpoint**;
    - **Declared value by the occupants**, although it is not advisable due to possible bias;
    - **Standard indoor temperature based on building declared use**.
- Degree of **use of the building**. During the measurement intervals there must not be change in the operational time, indoor temperature thermostatic setpoint nor in the heated area.
- Identify whether the measurement belongs to:
    - **Heating season**, with the heating system on.
    - **Non-heating season**, with the heating system off.
    - In between both.

[7] From the JRC TMY Generator. Available at: http://re.jrc.ec.europa.eu/pvgis5/tmy.html.

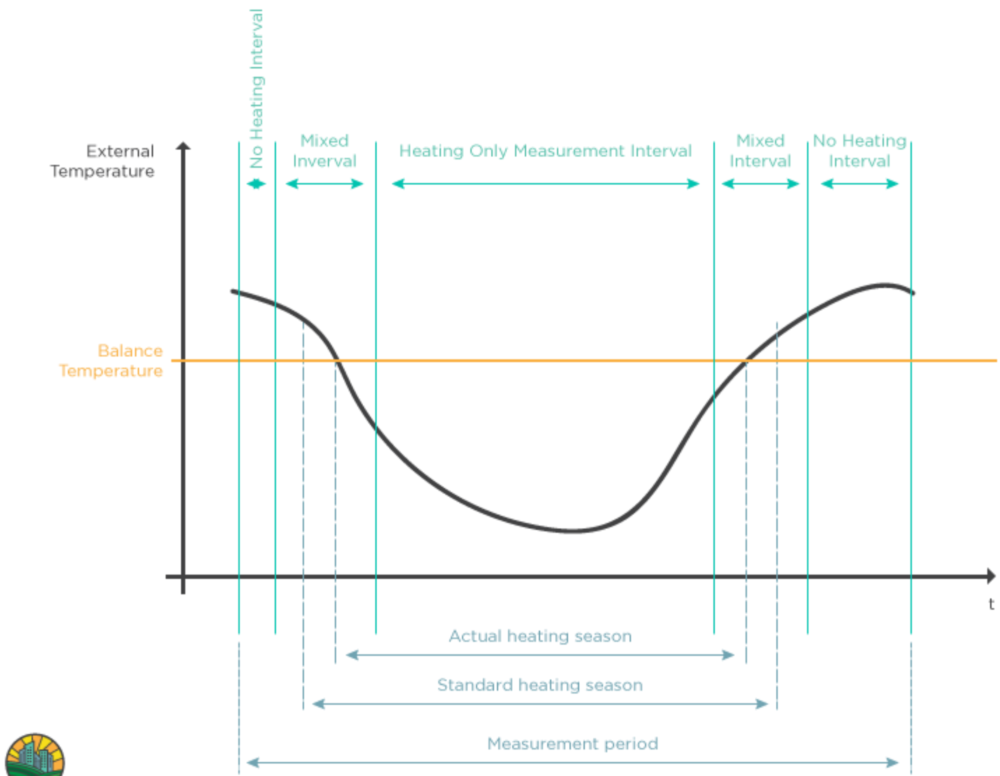


Figure 7. Example of measurement intervals and seasons. Information from [4].

There are specific considerations depending on the type of energy vector:

- Biomass. The energy consumption determination should consider the possibility of variable moist content, and conversion from mass to volume, using declared density and calorific value by the supplier.
- LPG. Similar considerations.
- Natural gas. In the case of volumetric meters, there is a need to apply a coefficient of volumetric correction based on actual absolute temperature and pressure at the measurement point. Noting that the information from invoices usually is already referred to standardized conditions and in energy units [kWh].

The standard states two different methods regarding the assessment of the measurements.

- Seasonal data interpolation. To use this method, it is advisable having data for at least three years. Where initial and final readings should take place within the season. For instance, some weeks after the beginning of the season for the start, and some weeks before the end of the season for the final measurement. This is to ensure the measurement interval ensures the integrity of the variable intended to be measured, as it is shown in Figure 7.
- Energy signature method. Several measurements should be made, all the same length and long enough to be able to account for the thermal inertia of the building. An integer number of weeks is recommended, and it is important that the measurements reflect the most representative

conditions, for instance, cool days without much radiation during the wintertime for heating.

It is advised, nonetheless, that the first two years after the finishing of the construction of the building are discarded.

The following should specially be considered [4].

- Weather data. When using external climatic data sources, not only geographical closeness should be considered, but also elevation.
- Internal temperature. It is the most uncertain value, since it can be conditioned by thermostatic setpoints, or be user biased.

It states the following regarding the methodology of linear regression to extrapolate the delivered energy measured to normalized conditions.

- Seasonal interpolation method.
  1. Obtain, for a given measurement interval, the delivered energy, and the accumulated temperature difference, which can be represented by the heating degree days.
  2. Apply, if so, a correction factor according to the normalized indoor temperature, to account for additional factors governing the heating needs other than the temperature difference between indoors and outdoors (internal heat gains, radiation, etc.).
  3. Define the parameters of the linear regression equation, which relate the degree days with the delivered energy.
  4. Extrapolate to the normalized number of degree days.
  5. Apply, if so, a correction factor to normalize user behavior.
- Energy signature method.
  1. Obtain, for a given measurement interval, the delivered energy, and the accumulated temperature difference, which can be represented by the heating degree days. For each interval, convert them to average power and average external temperature, respectively.
  2. Define the parameters of the linear regression equation, which relate the average external temperature with the delivered power for the measurement's intervals within the heating season.
  3. Do the same for the ones fully out of the heating season.
  4. Determine the intersection of the two functions. That point defined the actual balance conditions.
  5. Assume a default temperature difference because of gains.
  6. Shift the linear regression to the internal temperature using the default temperature difference.
  7. With it, calculate the delivered power for the average seasonal external temperature, and multiply it by the heating season duration, [6].

The process to obtain U-CERT Operational Assessment should consider the delivered energy per each EPB service and per energy carrier.

- The measured energy for the given service is corrected to reflect the equivalent standardized conditions. There will be different corrections depending on the service to be assessed.
  - Space heating. It is considered that the difference between internal and external temperature is the main driving variable. The following actual context information to the measurement is needed [4].

- Knowledge of the average internal temperature.
- Knowledge of the average external temperature.

- **DHW**. The following context information to the measurement is needed [4].
  - Knowledge of the volume produced.

Important to consider here the scope and time required to obtain the measured data from the building and context information to perform U-CERT Operational Assessment. For instance, in [7] there's an estimation of the times required for each inspection phase for level 1 inspection of a heating and DHW installation.

It is important to take into consideration the following statement from EN 15378-4:2017. *"An operational rating attempt on a system that was not designed or upgraded to support operational rating will seldom meet the quality requirements for the validity of the standardized operational rating"* [4].

The base tool for the U-CERT Operational Assessment will be the EN 15378-3 spreadsheet developed in the framework of the CEN-CE project. U-CERT and CEN-CE project have reached a formal collaboration agreement on this end.

The U-CERT Operational Assessment testing in the case studies will be performed using the EN 15378-3 spreadsheet developed in the framework of the CEN-CE project. Such tool has been adapted to consider the energy vectors present in U-CERT case studies (see Table 7), both for the energy signature and for the seasonal data interpolation method.

To capture the specifics surrounding the quantity and quality of the measured data from the U-CERT case studies, a detailed questionnaire was prepared[8]. The following information was obtained:

- **Detail**. Whether the available energy data is at energy carrier level, measured in a general meter; per service, obtained from detailed metering or a combination of them; per generator, with metered data from different services, etc.

## Indoor Environmental Quality

The same considerations as for the U-CERT Calculated EPB Assessment analogous section apply. In the case of the measurement based EPB Assessment, the feasibility of the testing of measured IEQ is subject to the availability of metered data required for the ALDREN TAIL.

Table 7. Measured IEQ data overview in U-CERT case studies

| Case Study | Measured IEQ parameters | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ | VOC | PM | $T_{db,}$ indoor | $T_{db,}$ outdoor | $T_{op,}$ indoor | RH | Illuminance | Sound Press. |
| 1 | No | No | No | Yes | Yes | No | No | No | No |
| 2a | No | No | No | Yes | Yes | No | Yes | No | No |
| 2b | No | No | No | Yes | Yes | No | Yes | No | No |
| 3 | Yes | No | No | Yes | Yes | No | No | Yes | No |
| 4 | No | No | No | No | No | No | No | No | No |
| 4b | Yes | No | No | Yes | Yes | Yes | Yes | No | No |

[8] Refer to WS4 on U-CERT's 3rd Consortium Meeting Minutes for further details.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 5a | No | No | No | No | No | No | No | No | No |
| 5b | Yes | No | No | No | No | No | No | No | No |
| 5c | No | No | No | No | No | No | No | No | No |
| 6a | Yes | Yes | No | Yes | Yes | No | Yes | No | No |
| 6b | Yes | Yes | No | Yes | Yes | Yes | Yes | No | No |
| 7 | No | No | No | Yes | No | No | No | No | No |
| 8 | No | No | No | Yes | Yes | No | Yes | No | No |
| 9 | No | No | No | No | No | No | No | No | No |
| 10a | No | No | No | No | No | No | No | No | No |
| 10b | Yes | No | No | Yes | No | No | Yes | No | No |
| 11a | Yes | Yes | No | Yes | Yes | Yes | No | No | No |
| 11b | Yes | Yes | No | Yes | Yes | Yes | No | No | No |

In terms of IEQ measured data availability, case studies 4, 5a, 5c and 9 are not in position of providing any historic measured data; the rest will to some extent.

Case Studies in a position of testing ALDREN TAIL's spreadsheet on should abide by the following protocol.

### Protocol

There are certain measurement intervals, where the information is gathered, which compose

The ALDREN TAIL index, mentioned in U-CERT's Deliverable 2.4 [19], abides by the most relevant EPB Standard on the matter, the EN 16798-1, while also contemplating indicators from many building certification schemes and Level(s). The **ALDREN TAIL indicator and methodology** constitute the bases of the inclusion of as measured IEQ assessment in the U-CERT EPC scheme. However, given that the scope of ALDREN's project was non-residential buildings, namely hotels and offices, small changes are implemented with a view to account for the residential typology. Refer to section 4 in ALDREN's Deliverable 2.4 [15] for further details.

It is important that only the areas dominated by people's comfort are included in the assessment. More specifically,

- For residential buildings, one sensor per representative unit with different use is required, but for the illuminance sport measurements.
- For non-residential buildings, the requirements from [15] apply having a maximum of 10 sampling locations, covering at least the 10% of the office floor area in office buildings, and guest room floor area in hotel buildings. Similar considerations for other typologies apply.

Needless to say, that, the different elements within the whole U-CERT EPC scheme may not be applicable to all buildings in all situations. Some points from section 6.2.4 in EN ISO 52000-2, are worth reproducing here:

- *"For new buildings, the measured energy indicator is not available.*
- *For existing buildings which are rented or sold, the way the building is managed could change and the measured energy indicator could change as a result.*
- *In existing public buildings where there is no change in ownership, the measured energy indicator can be a measure of the quality of the management and can be used to motivate building operators and users.*

- *For managers of buildings, a measured energy indicator can be easily obtained from data often stored in their information systems*
- *Measured energy indicator and standard calculated energy indicator do not necessarily include the same energy uses*[9]*"* [8].

Thus, and as also pointed out by U-CERT's Deliverable 2.4 [19], there is a need to clearly differentiate in the assessment between **existing buildings** and **new or majorly renovated buildings**. For particular considerations of IEQ Assessment, using the ALDREN TAIL index, in existing buildings refer to Annex 4 in ALDREN's Deliverable 2.4 [15]. Also, and as the **catalogue on EPC profiles** showed in U-CERT's Deliverable 5.3 [20], the U-CERT certification schemed should not only adapt to different building typologies, but also to *"user types and their purpose of use"*. This document should be read with those concepts in mind.

Refer to Annex 4 in ALDREN's Deliverable 2.4 for further details on the assessment of the different indicators on **existing buildings** depending on whether there are calculations or measurements. In the framework of the use of ALDREN within U-CERT, only the TAIL Index based on measurements will be used.

As general remark, measurements should be made in **unoccupied spaces**, aiming to reflect the closest average behavior of the building. Thus, measurements close to ventilation ducts or other air currents; heating or cooling sources; direct solar radiation, and the like should be avoided.

The ALDREN TAIL index has been designed in a way that full correspondence with EN 16798 is reached. *"The worst quality corresponding to Category IV receives color green, the next worst quality receives color orange corresponding to Category II, the first best quality level corresponding to Category II receives color yellow and the best quality level corresponding to Category I is depicted by color green"* [15].

Regarding the IEQ Assessment relying on **dedicated measurement campaigns**, the assessment process comprises four phases, as established in [15]:

- Preparation;
- Measurements on Day 1;
- Measurements on Day 8;
- Measurements on Day 30.

Thus, the measurement period spans for a total of 30 days. However, when having **onsite ongoing measurements,** the process can be repeated periodically.

In order to assess the comparison on the IEQ status of a building before and after the renovation, the procedure should be repeated *"at two seasons [...] (and) if only one season can be studied, it must be the same season before and after renovation"* [15].

The ALDREN TAIL index covers the following parameters:

- Thermal environment.
    - Dry-bulb temperature.

[9] Additional considerations regarding the comparison between calculated and measured EP can be found in section 8 in EN ISO 52000-2 [5].

- Acoustic environment.
  - Noise level.
- Indoor air quality.
  - $CO_2$ concentration;
  - Ventilation rate;
  - Air relative humidity;
  - Visible mold;
  - Benzene;
  - Formaldehyde;
  - Radon;
  - PM2.5.
- Lighting visual environment.
  - Illuminance.

Note that the assessment is not limited by the fact of not having all the parameters. It can be partially assessed, and still be meaningful.

## U-CERT EPC

The U-CERT EPC was developed in Deliverable 3.2. Case Studies' national EPCs will be compared to U-CERT EPC. The result of such comparison will be presented in Deliverable 4.2, and the results of the analysis in Deliverable 4.3.

## Summary

As a summary, each case study will be required to perform the following testing activities with regards to assessing U-CERT's EPB Assessment and Certification scheme.

Table 8. Summary of Case Study testing

| Case Study | U-CERT Calculated EPB Assessment | | | | | | U-CERT Measured EPB Assessment | |
|---|---|---|---|---|---|---|---|---|
| | EP | | SRI | IEQ | | | EP | IEQ |
| | Simplified | Detailed | | ALDREN Thermal Score | ALDREN TAIL | TAR Combined Label | CEN-CE | ALDREN TAIL |
| 1 | N/A | N/A | Yes | Voluntary | Voluntary | No | Yes | No |
| 2a | N/A | N/A | Yes | Voluntary | Voluntary | No | Yes | Yes |
| 2b | N/A | N/A | Yes | Voluntary | Voluntary | No | Yes | Yes |
| 3 | N/A | N/A | Yes | Voluntary | Voluntary | No | Yes | No |
| 4 | N/A | N/A | Yes | Voluntary | Voluntary | No | Yes | No |
| 4b | N/A | N/A | Yes | Voluntary | Voluntary | No | Yes | Yes |
| 5a | N/A | N/A | Yes | Voluntary | Voluntary | Yes | No | No |
| 5b | N/A | N/A | Yes | Voluntary | Voluntary | No | Yes | No |
| 5c | N/A | N/A | Yes | Voluntary | Voluntary | No | No | No |
| 6a | N/A | N/A | Yes | Voluntary | Voluntary | Yes | Yes | Yes |
| 6b | N/A | N/A | Yes | Voluntary | Voluntary | Yes | Yes | Yes |
| 7 | N/A | N/A | Yes | Voluntary | Voluntary | Yes | No | No |
| 8 | N/A | N/A | Yes | Voluntary | Voluntary | No | Yes | Yes |
| 9 | N/A | N/A | Yes | Voluntary | Voluntary | Yes | Yes | No |
| 10a | N/A | N/A | Yes | Voluntary | Voluntary | No | No | No |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10b | N/A | N/A | Yes | Voluntary | Voluntary | Yes | Yes | Yes |
| 11a | N/A | N/A | Yes | Voluntary | Voluntary | No | No | No |
| 11b | N/A | N/A | Yes | Voluntary | Voluntary | Yes | No | No |

Note that the assessment of U-CERT's Calculated energy performance will be performed, in both simplified and detailed ways, using reference buildings rather than actual case studies.

## U-CERT digital solutions

In the scope of Task 5.4, a set of digital tools will be developed. There is a subset of which should be tested by case studies:

- U-CERT Comparison and calculation toolkit for National Annexes;
- U-CERT Open Data Solution;
- U-CERT Building Operational Rating Solution.

Once the actual tools are available, the testing instructions will be prepared and disseminated among case studies.

## Activities, Teams & Responsibilities

Each case study holder will designate the necessary team to ensure the proper development and the success of the demonstration as established in Table 8.

### Activities

The activities related to the case study buildings data collection may be different from partner to partner, since not every case study building needs to roll-out every step of the protocol. Consequently, a dedicated training season will take place involving all case studies. This will happen during a Working Session in Consortium Meeting 4.

The general activities to be followed by case studies are the following:

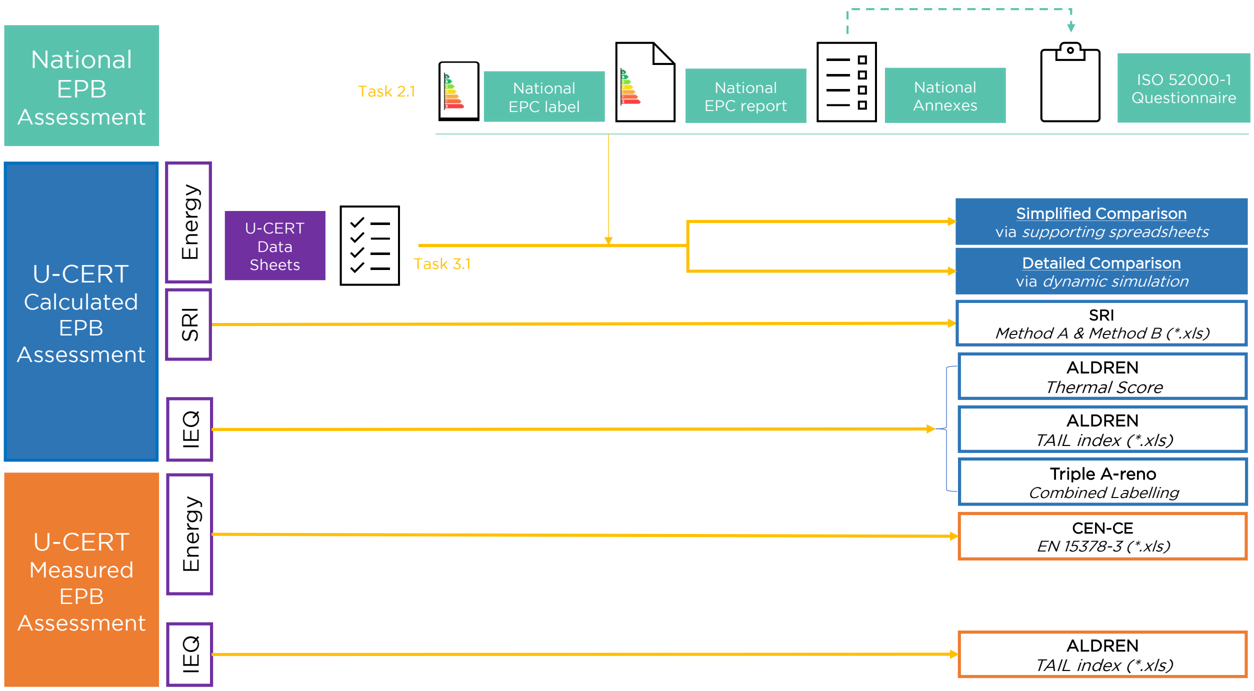


Figure 8. U-CERT Case Study Testing Layout

Case studies were requested in the scope of Task 2.1 to provide all the available information describing each National EPB Assessment methodology. Task 4.1 created the ISO 52000-1 to obtain additional information. The questionnaire can be found in Annex I.

With regards to the demonstration related to U-CERT Calculated and Measured EPB Assessment, all the methodologies and supporting tools will be made available to case studies. Note that the **simplified** and **detailed** comparison will be applied relying on reference buildings, thus, are left out of the scope of case study testing.

### Planning

Case Studies will receive the testing tools; namely, the **questionnaire** and the **calculation spreadsheets** on May 18th, 2021, coinciding with U-CERT's 4th Consortium Meeting. They are expected to complete and send the testing tools back to IVE before June 18th, 2021. Thus, ensuring enough time for the preparation of Deliverable 4.2.

Given ALDREN's thermal Score was published in November 2021, in U-CERT's 5th Consortium Meeting a dedicated presentation will be given with a view of giving case studies the information to perform the demonstration. As stated in Indoor Environmental Quality, such testing activity, as well as ALDREN TAIL's calculated version, will be voluntary.

## Teams & Responsibilities

Each case study holder will designate the necessary team to ensure the proper development and the success of the collection of information, materialized with carrying out the tasks outlines in Activities.

Table 9. Teams & Responsibilities for case study's information management

| Case Study | Partner(s) | Team/person responsible |
|---|---|---|
| 1 | HIA | Eric Willems |
| 2a | KTH | Andrei Vladimir Lițiu |
| 2b | KTH | Andrei Vladimir Lițiu |
| 3 | TalTech | Karl-Villem Võsa |
| 4 | COM | Zoltan Magyar |
| 4b | COM | Zoltan Magyar |
| 5a | IVE | Pablo Carnero Melero |
| 5b | ATECYR | Pedro Vicente Quiles |
| 5c | IVE | Pablo Carnero Melero |
| 6a | IRI-UL | Andreja Burkeljca |
| 6b | IRI-UL | Andreja Burkeljca |
| 7 | AIIR | Cătălin Lungu / Tiberiu Catalina |
| 8 | AiCARR | Luca Alberto Piterà |
| 9 | EnEffect | Stanislav Andreev / Kamen Simeonov |
| 10a | Tipee | Florian Battezzati |
| 10b | Tipee | Florian Battezzati |
| 11a | DTU | Menghao Qin |
| 11b | DTU | Menghao Qin |

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# I. Annex A. ISO 52000-1 questionnaire

The ISO 52000-1 questionnaire is a general transcription of the standard's Annex A and can be found here.

With a view to ensuring access to the information, a complete copy of the questionnaire is provided together with this document.

# II. Annex B. Detailed comparison. Spain

This section contains the protocol for the **detailed comparison** of U-CERT vs Spain's official EPB Assessment and Certification Scheme.

## Introduction

The purpose of this study is to quantify the impact the implementation of the U-CERT methodology on the current Spanish official EPB Assessment. For that, a set of choices from Deliverable 3.1 [9] are going to be implemented *in lieu* of the equivalent official one, as stated in Spain's National Annexes [21].

The selection of the choices to be demonstrated are the following:

- EN ISO 52000-1. Table A/B.16 – Weighting factors[1];
- EN ISO 52000-1. Table A/B.17 – $k_{exp}$ factor;
- EN ISO 52010-1. Table A/B.2 – Weather station and climatic data set;
- EN 16798-1. Table A/B.5 – Temperature ranges for hourly calculation of cooling and heating energy in four categories of indoor environment;
- EN 16798-1. Clause A/B.8 – Occupants schedules for energy calculations;
- EN ISO 52016-1. Table A/B.7 — Choice between calculations with thermally coupled or uncoupled thermal zones.

The selected choices are based on the intention of assessing the impact of modifying the Spanish calculation methodology to getting closer to U-CERT's value proposition. Thus, the choices that, although being labelled as *important* in Deliverable 3.1, have not been included is because they were already aligned with the National Annexes.

Additionally, the energy models used for the detailed comparison will also be used to perform other analysis such as the impact of diverse building use (i.e., occupant behaviour, thermostatic setpoints, etc), and the effect of including non-EPB energy consumption capable of absorbing exported energy (see [17] for further details). In relation to the self-produced and exported energy, different time intervals for the compensation of energy (step B in [1]) will me considered. Furthermore, innovative control strategies for the technical building systems will be tested as well.

Before getting in the details of the impact of such choices, some brief explanation of Spain's EPB Assessment calculation methodology is required.

## Spain's EPB Assessment

According to Spanish EPB Assessment methodology [22], there are certain parameters which are mandatory and fixed by regulation (e.g., weather data file, occupancy schedules in residential buildings, primary energy weighting factors, etc.), certain parameters which can be modified if the calculation software allows for more precise definition (e.g., infiltration modelling, ground temperature, etc.), and variables which are dependent on the project or design (e.g., thermal characteristics of the envelope, present technical building systems, etc.). It is within these boundary conditions that any official EPB calculation is performed.

[1] The weighting factors to be used are hourly values, defined according to EN 17423 [29], following a practical methodology pending of publication.

In general terms, there are more mandatory and fixed parameters for EPB Assessments in residential buildings than for non-residential buildings.

## EP Rating

The performance scale ranges from Class A to Class G. Currently, there is a dual rating scale, since there are two main EP indicators, the non-renewable primary energy consumption, and the equivalent $CO_2$ emissions.

## Reference values

The legislation establishes different considerations with regards to EP Rating depending on the main use category of buildings. For residential private residential buildings, there is a fixed reference. For other buildings there is a reference building that is generated for each assessment, hence the reference to define the EP rating varies with each assessed building.

### *Residential*

There is a fixed reference defined in terms of the climate severity of the location, and the residential building category (i.e., single-family, or multi-family buildings). Such reference is set for **combined thermal energy needs** (i.e., heating and cooling), **non-renewable primary energy consumption** and **equivalent $CO_2$ emissions**. See Annex IV for more details in [23].

For instance, a single-family dwelling located in València will have the reference values as upper limits to each energy class stated in Table II-1.

Table II-1. Reference values for residential buildings. Spain

| | Energy needs [kWh/m²·year] | | Non-renewable primary energy consumption [kWh/m²·year] | | | | $CO_2$ emissions [kg$CO_2$/m²·y] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Heating | Cooling | Heating | Cooling | DHW | **Total** | Heating | Cooling | DHW | **Total** |
| A | 9.7 | 10.0 | 14.1 | 10.2 | 7.7 | 23.8 | 3.1 | 2.5 | 1.9 | 5.5 |
| B | 18.4 | 14.3 | 26.7 | 14.6 | 9.0 | 45.1 | 5.9 | 3.6 | 2.2 | 10.4 |
| C | 31.1 | 20.4 | 45.1 | 20.8 | 10.9 | 76.2 | 10.0 | 5.1 | 2.6 | 17.5 |
| D | 49.9 | 29.7 | 72.3 | 30.3 | 13.7 | 122.1 | 16.0 | 7.4 | 3.3 | 28.1 |
| E | 83.6 | 36.7 | 165.4 | 37.4 | 26.8 | 229.6 | 39.3 | 9.2 | 6.5 | 54.9 |
| F | 102.8 | 45.1 | 203.5 | 46.0 | 29.2 | 268.6 | 48.3 | 11.3 | 7.6 | 64.3 |

Thus, a building with a non-renewable primary energy consumption of 122.0 kWh/(m²·y) would be rated D according to Table II-1. An additional scale is provided for energy needs, although it is only informative as energy needs are not main EP indicator.

### *Non-residential*

For the non-residential buildings, the reference is set based on the theoretical consumption that the equivalent *reference* building would have. The guidelines to define the reference building can be found in section 8 in [22]. The rating is established based on the ratio between the main EP indicator of the object building and the equivalent result for the reference building. For further details refer to section 2.5 in [23].

The reference building is a digital copy of the object building, from which geometry, orientation, occupancy schedules, etc., are imported. However, some other features are fixed, such as the technical characteristics of the thermal envelope.

## Study building definition

As exposed in Detailed comparison, there are two geometries that are the basis for the comparative EPB Assessment.

The process has been common for both buildings, as depicted in Figure 4.

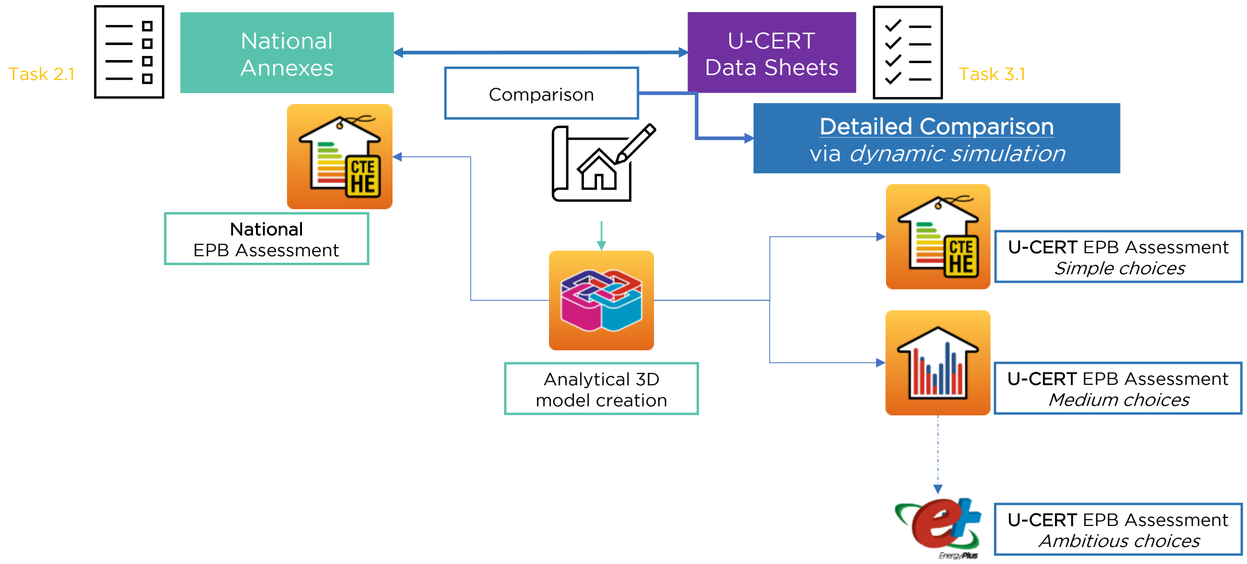


Figure II-1. Spain vs U-CERT EPB Assessment. Detailed Comparison.

As shown in Figure II-1, Cypetherm HE Plus™ is an eligible software to perform official EPB Assessments and issue EPCs in Spain. Relying on such tool, it is possible to obtain the EPB Assessment of any of the object buildings, fully abiding by Spain's National Annexes. Moreover, for the office building, the equivalent reference building is automatically generated in the back end, hence allowing to issue the EPC. Therefore, implementing U-CERT choices directly in Cypetherm HE Plus ™ is the preferred option since it is possible to leverage the seamless process of official EPB Assessments. However, as mentioned in Spain's EPB Assessment, the official EPB Assessment holds some limitations, and it is rather a "rigid" procedure. Not only because there are some parameters fixed by the regulation, but also because the output indicators are fixed and can't be modified.

A tool providing greater flexibility in the setting of customized EPB Assessments is Cypetherm EPlus ™, given that it is an agnostic energy performance software, not bound to any legislative restriction. This tool is also compatible with the Open BIM Environment and enables to rely on the same 3D BIM Analytical model as Cypetherm HE Plus ™. Thus, relying on Cypetherm EPlus ™ allows to perform modifications on the model from Cypetherm HE Plus™ (i.e., modify certain EPB Standard parameters to reflect U-CERT's choices), and assessing the impact. However, it still holds the limitations that the output indicators are fixed and can't be modified. Moreover, for the case of the office building, the reference building required by the Spanish legislation to issue the EPC rating is not automatically generated. This is a major barrier for the detailed comparison with the office building, but not for the single-family dwelling, as the Spanish regulation considers a fixed reference for residential buildings.

The last and most flexible option is Energy Plus ™. During the process of performing energy simulations with both Cypetherm HEPlus ™ and Cypetherm EPlus ™ auxiliary files of the object and reference (if applicable) buildings are generated. Such files can be dealt with Energy Plus ™ directly, allowing to freely modify any parameters, and define as many outputs variables as desired.

The choices listed in Introduction will be tested as exposed in Detailed comparison, where the applicability of the different software options is listed.

Table II-2. Software used for each U-CERT choice. Spain

| Choice | | Software | | |
|---|---|---|---|---|
| Standard | Table/Clause | Cypetherm HE Plus | Cypetherm EPlus | Energy Plus |
| EN ISO 52000-1 | A/B.16 | - | - | X |
| EN ISO 52000-1 | A/B.17 | - | - | X |
| EN ISO 52010-1 | A/B.2 | X | - | - |
| EN 16798-1 | A/B.5 | X[a] | X[a] | - |
| EN 16798-1 | A/B.8 | X[a] | X[a] | - |
| EN ISO 52016-1 | A/B.7 | X | - | - |

[a] Just for the case of the office, given that such parameters are not fixed. For the single-family house, Cypetherm EPlus ™ will be used.

In the subsequent sections each case; namely, the single-family and the office building, will be defined.

## Single family house

For the fictitious residential building, depicted in Figure 5, no shading from external elements has been considered. It is composed by two above-ground floors, an underground garage, and a gable roof. Its useful area is a total of 95 m².

The thermal envelope of the building is depicted in Table II-3 and Table II-4.

Table II-3. Opaque thermal envelope definition. Single family house. Spain

| Name | Type | Thickness [cm] | Area [m²] | Thermal transmittance [W/(m²·K)] | Colour outside layer |
|---|---|---|---|---|---|
| Ground Floor | Floor | 25.00 | 50.07 | 0.10 | Medium |
| Layers | Material | Thickness [cm] | Density [kg/m³] | Conductivity [W/(m·K)] | Specific heat [J/(kg·K)] |
| Layer 1 | Ceramic tile | 1.50 | 2000.00 | 1.000 | 800.00 |
| Layer 2 | Cement mortar | 1.50 | 1900.00 | 1.300 | 1000.00 |
| Layer 3 | Insulation | 2.00 | 40.00 | 0.011 | 1000.00 |
| Layer 4 | Reinforced concrete slab | 20.00 | 2500.00 | 2.500 | 1000.00 |
| Name | Type | Thickness [cm] | Area [m²] | Thermal transmittance [W/(m²·K)] | Colour outside layer |
| Underground Wall | Wall | 25.00 | 68.36 | 0.77 | N/A |
| Layers | Material | Thickness [cm] | Density [kg/m³] | Conductivity [W/(m·K)] | Specific heat [J/(kg·K)] |
| Layer 1 | Concrete slab with | 25.00 | 1900.00 | 1.350 | 1000.00 |

| | | | | | |
|---|---|---|---|---|---|
| | aggregates 1800 < d < 2000 | | | | |
| **Name** | **Type** | **Thickness [cm]** | **Area [m²]** | **Thermal transmittance [W/(m2·K)]** | **Colour outside layer** |
| Exterior Wall | Wall | 20.50 | 171.58 | 0.82 | Medium |
| **Layers** | **Material** | **Thickness [cm]** | **Density [kg/m³]** | **Conductivity [W/(m·K)]** | **Specific heat [J/(kg·K)]** |
| Layer 1 | Cement mortar | 1.50 | 1900.00 | 1.300 | 1000.00 |
| Layer 2 | Perforated brick | 11.50 | 900.00 | 0.500 | 1000.00 |
| Layer 3 | Insulation | 2.00 | 40.00 | 0.011 | 1000.00 |
| Layer 4 | Hollow brick | 4.00 | 920.00 | 0.400 | 1000.00 |
| Layer 5 | Gypsum plaster | 1.50 | 1100.00 | 0.570 | 1000.00 |
| **Name** | **Type** | **Thickness [cm]** | **Area [m²]** | **Thermal transmittance [W/(m2·K)]** | **Colour outside layer** |
| Interior slab cantilever | Exterior slab (ground) | 28.50 | 4.94 | 0.52 | Medium |
| **Layers** | **Material** | **Thickness [cm]** | **Density [kg/m³]** | **Conductivity [W/(m·K)]** | **Specific heat [J/(kg·K)]** |
| Layer 1 | Ceramic tile | 1.50 | 2000.00 | 1.000 | 800.00 |
| Layer 2 | Cement mortar | 2.00 | 1900.00 | 1.300 | 1000.00 |
| Layer 3 | Insulation | 5.00 | 40.00 | 0.030 | 1000.00 |
| Layer 4 | Ceramic slab | 20.00 | 1660.00 | 1.670 | 1000.00 |
| **Name** | **Type** | **Thickness [cm]** | **Area [m²]** | **Thermal transmittance [W/(m2·K)]** | **Colour outside layer** |
| Exterior garage slab | Exterior slab (roof) | 28.50 | 4.59 | 0.46 | Medium |
| **Layers** | **Material** | **Thickness [cm]** | **Density [kg/m³]** | **Conductivity [W/(m·K)]** | **Specific heat [J/(kg·K)]** |
| Layer 1 | Ceramic tile | 1.50 | 2000.00 | 1.000 | 800.00 |
| Layer 2 | Cement mortar | 2.00 | 1900.00 | 1.300 | 1000.00 |
| Layer 3 | WS ceramic interlayer | 25.00 | 1660.00 | 1.670 | 1000.00 |
| **Name** | **Type** | **Thickness [cm]** | **Area [m²]** | **Thermal transmittance [W/(m2·K)]** | **Colour outside layer** |
| Rooves | Roof | 37.00 | 52.59 | 0.46 | Intermedium |
| **Layers** | **Material** | **Thickness [cm]** | **Density [kg/m³]** | **Conductivity [W/(m·K)]** | **Specific heat [J/(kg·K)]** |
| Layer 1 | Ceramic tile | 1.50 | 2000.00 | 1.000 | 800.00 |
| Layer 2 | Cement mortar | 1.50 | 1900.00 | 1.300 | 1000.00 |
| Layer 3 | Insulation | 2.00 | 40.00 | 0.011 | 1000.00 |

| | | | | | |
|---|---|---|---|---|---|
| Layer 4 | Concrete with light aggregates | 7.00 | 1600.00 | 1.150 | 1000.00 |
| Layer 5 | Ceramic slab | 25.00 | 1660.00 | 1.670 | 1000.00 |

Table II-4. Glazed thermal envelope definition. Single family house. Spain

| | | | |
|---|---|---|---|
| | Name | Thermal transmittance [W/(m²·K)] | Opening Control |
| | Window 1 | 5.70 | Manual |
| Glass | Solar factor | Thermal transmittance [W/(m2·K)] | |
| | 0.86 | 5.70 | |
| Frame | Frame fraction [%] | Thermal transmittance [W/(m2·K)] | Colour |
| | 10 | 5.70 | Light |
| Shading | Technology | Control | |
| | No | N/A | |
| | Name | Thermal transmittance [W/(m²·K)] | Opening Control |
| | Window 3 | 3.30 | Manual |
| Glass | Solar factor | Thermal transmittance [W/(m2·K)] | |
| | 0.74 | 3.30 | |
| Frame | Frame fraction [%] | Thermal transmittance [W/(m2·K)] | Colour |
| | 10 | 3.30 | Light |
| Shading | Technology | Control | |
| | No | N/A | |

The technical building systems considered are shown in ¡Error! No se encuentra el origen de la referencia. and Table II-6.

Table II-5. Heating technical system definition. Single family house. Spain

| Heating | | | | |
|---|---|---|---|---|
| Generation | Technology | Energy carrier | Nominal power [kW] | Nominal efficiency [%] |
| | Conventional boiler | Gas | 24.00 | 80% |
| Storage | Capacity [m³] | | Control | |
| | No | | N/A | |
| Distribution | Circuit type | Losses [%] | Circulation device | Control |
| | Two pipes | 5% | Pump | On-Off |
| Emission | Technology | | Control | |
| | Radiators | | Central | |

Table II-6. DHW technical system definition. Single family house. Spain

| DHW | | | | |
|---|---|---|---|---|
| Generation | Technology | Energy carrier | Nominal power [kW] | Nominal efficiency [%] |

| | | | | |
|---|---|---|---|---|
| | Conventional boiler | Gas | 24.00 | 80% |
| Storage | Capacity [m³] | | Control | |
| | No | | N/A | |
| Distribution | Circuit type | Losses [%] | Circulation device | Control |
| | One pipe | 5% | No | N/A |

The heating and DHW technical system share the same generator. No cooling technical system exists in the dwelling.

No electricity production is considered in the base case, however, to assess the impact of certain choices related to post-processing elements, on-site electricity production of 5.4 kWp coplanar PV panels will be included.

The building use (i.e., internal loads, occupation, etc.), domestic hot water use profile, and the thermostatic setpoints have been assumed as fixed by the regulation [24]. The are depicted in Table II-7, Table II-8 and Table II-9, respectively. These values are common for every residential building EPB Assessment.

Table II-7. Building use. Single family house. Spain

| Building use [W/m²] | | Hours | | | | | |
|---|---|---|---|---|---|---|---|
| Mode | Days | 0:00-6:59 | 7:00-14:59 | 15:00-17:59 | 18:00-18:59 | 19:00-22:59 | 23:00-23:59 |
| Sensible occupation | Weekdays | 2.15 | 0.54 | 1.08 | 1.08 | 1.08 | 2.15 |
| | Weekend | 2.15 | 2.15 | 2.15 | 2.15 | 2.15 | 2.15 |
| Latent occupation | Weekdays | 1.36 | 0.34 | 0.68 | 0.68 | 0.68 | 1.36 |
| | Weekend | 1.36 | 1.36 | 1.36 | 1.36 | 1.36 | 1.36 |
| Lights | All days | 0.44 | 1.32 | 1.32 | 2.20 | 4.40 | 2.20 |
| Equipment | All days | 0.44 | 1.32 | 1.32 | 2.20 | 4.40 | 2.20 |

Table II-8. Building use. Single family house. Spain

| DHW daily use profile [%] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 1 | 0 | 0 | 0 | 0 | 1 | 3 | 10 | 7 | 7 | 6 | 6 |
| 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 5 | 5 | 4 | 3 | 4 | 4 | 5 | 7 | 6 | 6 | 5 | 5 |

Table II-9. Thermostatic setpoints. Single family house. Spain

| Setpoint | | Hours | | | |
|---|---|---|---|---|---|
| Mode | Month | 0:00-6:59 | 7:00-14:59 | 15:00-22:59 | 23:00-23:59 |
| Cooling | January – May | - | - | - | - |
| | June – September | 27 | - | 25 | 27 |
| | October – December | - | - | - | - |
| Heating | January – May | 17 | 20 | 20 | 17 |
| | June – September | - | - | - | - |
| | October – December | 17 | 20 | 20 | 17 |

The daily DHW demand considered is of 112 litres/day at 60°C.

The open access energy model from Cypetherm HE Plus ™ can be found here.

## Office building

The office building, depicted in Figure 6, is a recent refurbishment of a building located in a larger complex. Actual shading from nearby and adjacent buildings has been considered. It is composed by one floor spanning a total useful floor area of 482.41 m$^2$.

The characteristics of the thermal envelope, as well as the parameters of the technical building systems have been extracted from the office refurbishment project. The data relating to the use of the building, such as occupancy patterns, lighting, thermostats, ventilation, thermal loads for internal equipment, etc., have been established in detail, according to the actual use of each of the rooms that make up the building.

The thermal envelope of the building is depicted in Table II-10 and Table II-11.

Table II-10. Opaque thermal envelope definition. Office. Spain

| Name | Type | Thickness [cm] | Area [m$^2$] | Thermal transmittance [W/(m$^2$·K)] | Colour outside layer |
|---|---|---|---|---|---|
| Slab | Floor | 136.00 | 540.03 | 0.02 | |
| Layers | Material | Thickness [cm] | Density [kg/m$^3$] | Conductivity [W/(m·K)] | Specific heat [J/(kg·K)] |
| Layer 1 | Ceramic tile | 2.00 | 2000.00 | 1.000 | 800.00 |
| Layer 2 | Concrete with light aggregates 1600 < d < 1800 | 5.00 | 1700.00 | 1.150 | 1000.00 |
| Layer 3 | Sand and gravel [1700 < d < 2200] | 15.00 | 1950.00 | 2.000 | 1045.00 |
| Layer 4 | Air gap 1m | 100.00 | 1.00 | 0.025 | 1008.00 |
| Layer 5 | OWS Concrete interlayer | 25.00 | 1330.00 | 1.316 | 1000.00 |
| Name | Type | Thickness [cm] | Area [m$^2$] | Thermal transmittance [W/(m$^2$·K)] | Colour outside layer |
| Enclosure 3 | Wall | 12.00 | 53.39 | 0.61 | Intermedium |
| Layers | Material | Thickness [cm] | Density [kg/m$^3$] | Conductivity [W/(m·K)] | Specific heat [J/(kg·K)] |
| Layer 1 | Gypsum plasterboard [PYL] 750 < d < 900 | 2.00 | 825.00 | 0.250 | 1000.00 |
| Layer 2 | EPS Expanded polystyrene [ 0.037 W/[mK]] | 5.00 | 30.00 | 0.037 | 1000.00 |
| Layer 3 | CBH with dense aggregates 50 mm | 5.00 | 2090.00 | 1.000 | 1000.00 |

| Name | Type | Thickness [cm] | Area [m²] | Thermal transmittance [W/(m²·K)] | Colour outside layer |
|---|---|---|---|---|---|
| Enclosure 1 | Party wall | 22.00 | 146.28 | 1.67 | |
| Layers | Material | Thickness [cm] | Density [kg/m³] | Conductivity [W/(m·K)] | Specific heat [J/(kg·K)] |
| Layer 1 | CHB with dense aggregates 110 mm | 11.00 | 1300.00 | 0.647 | 1000.00 |
| Layer 2 | CHB with dense aggregates 110 mm | 11.00 | 1300.00 | 0.647 | 1000.00 |
| Name | Type | Thickness [cm] | Area [m²] | Thermal transmittance [W/(m²·K)] | Colour outside layer |
| Enclosure 4 | Party wall | 11.00 | 232.81 | 2.33 | |
| Layers | Material | Thickness [cm] | Density [kg/m³] | Conductivity [W/(m·K)] | Specific heat [J/(kg·K)] |
| Layer 1 | CHB with dense aggregates 110 mm | 11.00 | 1300.00 | 0.647 | 1000.00 |
| Name | Type | Thickness [cm] | Area [m²] | Thermal transmittance [W/(m²·K)] | Colour outside layer |
| Enclosure 2 | Party wall | 11.50 | 132.91 | 1.92 | |
| Layers | Material | Thickness [cm] | Density [kg/m³] | Conductivity [W/(m·K)] | Specific heat [J/(kg·K)] |
| Layer 1 | Gypsum plaster d < 1000 | 2.00 | 850.00 | 0.400 | 1000.00 |
| Layer 2 | Double HB wall [60 mm < W < 90 mm] | 7.50 | 930.00 | 0.469 | 1000.00 |
| Layer 3 | Gypsum plaster d < 1000 | 2.00 | 850.00 | 0.400 | 1000.00 |
| Name | Type | Thickness [cm] | Area [m²] | Thermal transmittance [W/(m²·K)] | Colour outside layer |
| Suspended ceiling | Roof | 10.00 | 540.03 | 0.44 | |
| Layers | Material | Thickness [cm] | Density [kg/m³] | Conductivity [W/(m·K)] | Specific heat [J/(kg·K)] |
| Layer 1 | Mineral wool [0.04 W/[mK]] | 8.00 | 40.00 | 0.040 | 1000.00 |
| Layer 2 | Gypsum plasterboard | 2.00 | 825.00 | 0.250 | 1000.00 |

| | | | | | |
|---|---|---|---|---|---|
| | [PYL] 750 < d < 900 | | | | |

Table II-11. Glazed thermal envelope definition. Office. Spain

| | Name | Thermal transmittance [W/(m²·K)] | Opening Control |
|---|---|---|---|
| | Terrace Window | 3.16 | Manual |
| Glass | Solar factor | Thermal transmittance [W/(m2·K)] | |
| | 0.75 | 2.80 | |
| Frame | Frame fraction [%] | Thermal transmittance [W/(m2·K)] | Colour |
| | 0.3 | 4.00 | Dark |
| Shading | Technology | Control | |
| | External blind | Manual | |
| | Name | Thermal transmittance [W/(m²·K)] | Opening Control |
| | Courtyard glazing | 2.80 | Fixed |
| Glass | Solar factor | Thermal transmittance [W/(m2·K)] | |
| | 0.75 | 2.80 | |
| Frame | Frame fraction [%] | Thermal transmittance [W/(m2·K)] | Colour |
| | 0.1 | 2.80 | Light |
| Shading | Technology | Control | |
| | No | N/A | |
| | Name | Thermal transmittance [W/(m²·K)] | Opening Control |
| | Window WS 1 | 3.16 | Manual |
| Glass | Solar factor | Thermal transmittance [W/(m2·K)] | |
| | 0.75 | 2.80 | |
| Frame | Frame fraction [%] | Thermal transmittance [W/(m2·K)] | Colour |
| | 0.3 | 4.00 | Dark |
| Shading | Technology | Control | |
| | No | N/A | |

The technical building systems considered are shown in ¡Error! No se encuentra el origen de la referencia., Table II-13 and Table II-14.

Table II-12. Heating technical system definition. Office. Spain

| Heating | | | | |
|---|---|---|---|---|
| Generation | Technology | Energy carrier | Nominal power [kW] | Nominal efficiency [%] |
| | VRF 1 / VRF 2 | Electricity | 25 / 25 | 545% / 545% |
| Storage | Capacity [m³] | | Control | |
| | No | | N/A | |
| Distribution | Circuit type | Losses [%] | Circulation device | Control |
| | Coolant | - | Compressor | - |

| Emission | Technology | Control |
|---|---|---|
| | Cassette | Zone thermostat |

Table II-13. Cooling technical system definition. Office. Spain

| Cooling | | | | |
|---|---|---|---|---|
| Generation | Technology | Energy carrier | Nominal power [kW] | Nominal efficiency [%] |
| | VRF 1 / VRF 2 | Electricity | 22.4 / 22.4 | 528% / 528% |
| Storage | Capacity [m³] | | Control | |
| | No | | N/A | |
| Distribution | Circuit type | Losses [%] | Circulation device | Control |
| | Coolant | - | Compressor | - |
| Emission | Technology | | Control | |
| | Cassette | | Zone thermostat | |

Table II-14. DHW technical system definition. Office. Spain

| DHW | | | | |
|---|---|---|---|---|
| Generation | Technology | Energy carrier | Nominal power [kW] | Nominal efficiency [%] |
| | Electric heater | Electricity | 1.20 | 100% |
| Storage | Capacity [m³] | | Control | |
| | 0.08 | | No | |
| Distribution | Circuit type | Losses [%] | Circulation device | Control |
| | One pipe | 5% | No | N/A |

The heating and cooling technical system share the same generator and terminal units (Mitsubishi PUHY-P200YNW-A).

No electricity production is considered in the base case, however, to assess the impact of certain choices related to post-processing elements, on-site electricity production of 54.45 kWp 37° tilted PV panels will be included.

The modelled building use is depicted in Table II-15, showcasing the main office space. Unlike for the case of the single-family building, Spanish regulation states that the use conditions for non-residential buildings are *project data*. Thus, they can be defined with complete freedom by the EPB assessor.

Table II-15. Main office space use. Office. Spain

| % Respect to Peak | | Hours | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Mode | Peak | 0:00-7:59 | 8:00-8:59 | 9:00-10:59 | 11:00-11:59 | 12:00-13:59 | 14:00-15:59 | 16:00-16:59 | 17:00-23:59 |
| Occupation | 32 people | - | 60 | 100 | 70 | 100 | 30 | - | - |
| Ventilation | 320l/s | - | 100 | 100 | 100 | 100 | 100 | - | - |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Lights | 1364 W | - | 100 | 100 | 100 | 100 | 100 | 100 | - |
| Equipment | 3298 W | - | 60 | 100 | 70 | 100 | 30 | - | - |

The ratio between sensible and latent occupation thermal load varies depending on the degree of activity of each zone. Nevertheless, the sensible ratio of the main office space use is 61% The same happens with the ratio between radiant and sensible occupation thermal load, in this case, the radiant ratio of the main office space use is 60%.

The modelled thermostatic setpoints is depicted in Table II-16.

Table II-16. Thermostatic setpoints. Office. Spain

| Setpoint | | Hours | | |
|---|---|---|---|---|
| Mode | Month | 0:00-7:59 | 8:00-15:59 | 16:00-23:59 |
| Cooling | January – April | - | - | - |
| | May – October | - | 25 | - |
| | November – December | - | - | - |
| Heating | January – April | - | 21 | - |
| | May – October | - | - | - |
| | November – December | - | 21 | - |

The open access energy model from Cypetherm HE Plus ™ can be found here.

# III. Annex C. Detailed comparison. Italy

This section contains the protocol for the **detailed comparison** of U-CERT vs Italy's official EPB Assessment and Certification Scheme.

## Introduction

The purpose of this study is to quantify the impact of the implementation of the U-CERT methodology on the current Italian official EPB Assessment. For that, a set of choices from Deliverable 3.1 [9] are going to be implemented *in lieu* of the equivalent official one, as stated in Italy's National Annexes [25].

The selection of the choices to be demonstrated are the following:

- EN ISO 52000-1. Table A/B.16 – Weighting factors[1];
- EN ISO 52000-1. Table A/B.17 – $k_{exp}$ factor;
- EN ISO 52010-1. Table A/B.2 – Weather station and climatic data set;
- EN 16798-1. Table A/B.5 – Temperature ranges for hourly calculation of cooling and heating energy in four categories of indoor environment;
- EN 16798-1. Clause A/B.8 – Occupants schedules for energy calculations;
- EN ISO 52016-1 Table A/B.2 – Choice between hourly or monthly calculation method;
- EN ISO 52016-1. Table A/B.7 — Choice between calculations with thermally coupled or uncoupled thermal zones.

The selected choices are based on the intention of assessing the impact of modifying the Italian calculation methodology to getting closer to U-CERT's value proposition. Thus, the choices that, although being labelled as *important* in Deliverable 3.1, have not been included in because they were already aligned with the National Annexes.

Differently from the comparison between Spanish and U-CERT methodologies, described in Annex B, an additional choice has been added for the Italian case (*EN ISO 52016-1 Table A/B.2 – Choice between hourly or monthly calculation method*). This is because Italian legislation does not oblige to use hourly calculation procedure, as suggested by U-CERT, but allows to use a monthly calculation procedure. Therefore, it has been decided to also assess the difference between using hourly or monthly methodologies.

Additionally, the energy models used for the detailed comparison will also be used to perform other analysis such as the impact of diverse building use (i.e., occupant behaviour, thermostatic setpoints, etc), and the effect of including non-EPB energy consumption capable of absorbing exported energy (see [17] for further details). In relation to the exported energy, different time intervals for the compensation of exported energy (step B in [1]) will be considered. Furthermore, innovative control strategies for the technical building systems will be tested as well.

Before getting in the details of the impact of such choices, some brief explanation of Italy's EPB Assessment calculation methodology is required.

[1] The weighting factors to be used are hourly values, defined according to EN 17423 [29], following a practical methodology pending of publication.

## Italy's EPB Assessment

According to Italian EPB Assessment methodology [25], there are certain parameters which are mandatory and fixed by regulation (i.e., weather data file, occupancy schedules in residential and non-residential buildings, primary energy weighting factors, etc.) and variables which are dependent on the project or design (i.e., thermal characteristics of the envelope, present technical building systems, etc.). It is within these boundary conditions that any official EPB calculation is performed.

To get the Energy Performance Certification of a building, two types of assessments can be carried out: *Design Rating* or *Asset Rating*. For them, the following input data must be considered:

Table III-1. Types of official EPB Assessments. Italy

| Type of Assessment | | Input data | | |
|---|---|---|---|---|
| | | Uses | Weather | Building |
| A1 | Design Rating | Standard | Standard | Design |
| A2 | Asset Rating | Standard | Standard | Actual |

## EP Rating

The performance scale ranges from Class A4 to Class G. Currently there is a single rating scale, since there is one main EP indicator, the non-renewable primary energy consumption.

## Reference values

The legislation establishes that the EP Rating is defined, for both residential and non-residential buildings, starting from the non-renewable EP indicator ($EP_{gl,nren,rif,standard(2019/21)}$) of the Reference building. This value is set as the limit between classes A1 and B. The other ranges needed to define the other rating classes are obtained through reduction/increase multiplication factors, as stated in Table III-2.

Table III-2. Building's rating scale based on non-renewable EP indicator $EP_{gl,nren}$. Italy

| | | |
|---|---|---|
| | Class A4 | ≤ 0.40 $EP_{gl,nren,rif,standard(2019/21)}$ |
| 0.40 $EP_{gl,nren,rif,standard(2019/21)}$ < | Class A3 | ≤ 0.60 $EP_{gl,nren,rif,standard(2019/21)}$ |
| 0.60 $EP_{gl,nren,rif,standard(2019/21)}$ < | Class A2 | ≤ 0.80 $EP_{gl,nren,rif,standard(2019/21)}$ |
| 0.80 $EP_{gl,nren,rif,standard(2019/21)}$ < | Class A1 | ≤ 1.00 $EP_{gl,nren,rif,standard(2019/21)}$ |
| 1.00 $EP_{gl,nren,rif,standard(2019/21)}$ < | Class B | ≤ 1.20 $EP_{gl,nren,rif,standard(2019/21)}$ |
| 1.20 $EP_{gl,nren,rif,standard(2019/21)}$ < | Class C | ≤ 1.50 $EP_{gl,nren,rif,standard(2019/21)}$ |
| 1.50 $EP_{gl,nren,rif,standard(2019/21)}$ < | Class D | ≤ 2.00 $EP_{gl,nren,rif,standard(2019/21)}$ |
| 2.00 $EP_{gl,nren,rif,standard(2019/21)}$ < | Class E | ≤ 2.60 $EP_{gl,nren,rif,standard(2019/21)}$ |
| 2.60 $EP_{gl,nren,rif,standard(2019/21)}$ < | Class F | ≤ 3.50 $EP_{gl,nren,rif,standard(2019/21)}$ |
| | Class G | > 3.50 $EP_{gl,nren,rif,standard(2019/21)}$ |

The reference building is a digital copy of the object building, from which geometry, orientation, geographical location, intended use, occupancy schedules and boundary conditions are imported. However, some other features are fixed, such as building elements (i.e., thermal envelope) and technical systems. Hence, the Reference Building is therefore a building having fixed values for thermal envelope elements and for standardized technical systems. The guidelines to define the reference building can be found in Decree 26/06/2015 [26] and its Annexes[2].

For instance, thermal transmittance values of opaque vertical elements, facing outwards, climate-free environments or against ground, of the reference building thermal envelope must be equal to the following values, as stated in Table III-3, depending on the climatic zones where the assessed building is located.

Table III-3. Thermal transmittance reference values for opaque vertical elements, facing outwards, climate-free environments or against ground.

| Climatic Zone | U [W/m²·K] | |
|---|---|---|
| | 2015 | 2019/2020 |
| A & B | 0.45 | 0.43 |
| C | 0.38 | 0.34 |
| D | 0.34 | 0.29 |
| E | 0.30 | 0.26 |
| F | 0.28 | 0.24 |

## Study building definition

As exposed in Detailed comparison, there are two geometries that are the basis for the comparative EPB Assessment.

The process has been common for both buildings, as depicted in Figure III-1.

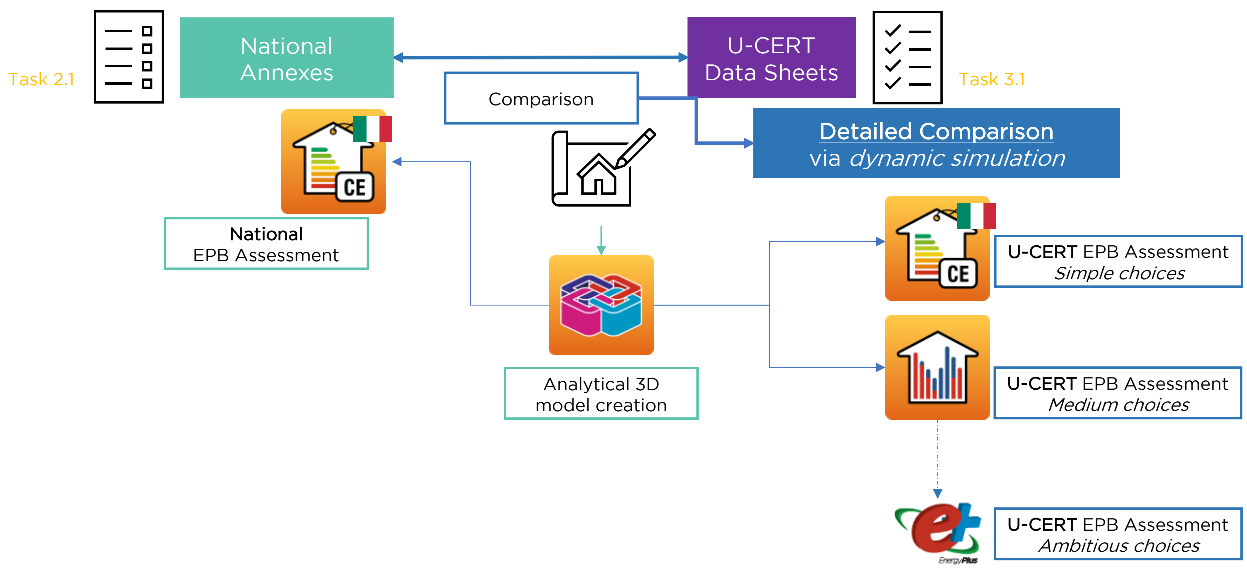


Figure III-1. Italy vs U-CERT EPB Assessment. Detailed Comparison.

As shown in Figure III-1, Cypetherm C.E. ™ is an eligible software to perform official EPB Assessments and issue EPCs in Italy. Relying on such tool, it is possible to obtain the EPB Assessment of any of the object buildings, fully abiding by Italy's National Annexes. Moreover, for both residential and non-residential buildings, the equivalent reference building is automatically generated in the back end, hence allowing to issue the EPC. Therefore, implementing U-CERT choices directly in Cypetherm C.E. ™ is the preferred option since it is possible to leverage the seamless process of official EPB

[2] This Decree is composed of three different Decrees: one for the Energy Certification; one for the minimum Energy Performance of buildings and one that defines the characteristics of the technical report to be filled in.

Assessments. However, as mentioned in Italy's EPB Assessment, the official EPB Assessment holds some limitations, and it is rather a "rigid" procedure. Not only because there are some parameters fixed by the regulation, but also because the output indicators are fixed and can't be modified. Moreover, Cypetherm C.E. ™ allows to develop only a monthly calculation procedure.

A tool providing greater flexibility in the setting of customized EPB Assessments is Cypetherm EPlus ™, given that it is an agnostic energy performance software, not bound to any legislative restriction and which allows to develop hourly calculation procedure. This tool is also compatible with the Open BIM Environment and enables to rely on the same 3D BIM Analytical model as Cypetherm C.E. ™. Thus, relying on Cypetherm EPlus ™ allows to perform modifications on the model from Cypetherm C.E. ™ (i.e., modify certain EPB Standard parameters to reflect U-CERT's choices), and assessing the impact. However, it still holds the limitations that the output indicators are fixed and can't be modified. Moreover, for the residential case and for the office building, the reference building required by the Italian legislation to issue the EPC rating is not automatically generated. As mentioned in Annex B, this is a major barrier for the detailed comparison for both buildings.

The last and most flexible option is Energy Plus ™. During the process of performing energy simulations with both Cypetherm C.E. ™ and Cypetherm EPlus ™ auxiliary files of the object and reference (if applicable) buildings are generated. Such files can be dealt with Energy Plus ™ directly, allowing to freely modify any parameters, and define as many outputs variables as desired.

If it was not possible to overcome the main barrier, mentioned above, about the manual creation of the reference building, a solution could be to use a different software, EDILCLIMA ™, which is, as well as CYPETHERM C.E. ™, an eligible software to perform official EPB Assessments and issue EPCs in Italy and that allows to perform, for residential and non-residential buildings, both an hourly calculation procedure and a monthly calculation procedure, always obtaining the corresponding reference building. In this case the structure of the analysis, instead of being as described in Figure III-2, will be as follows:

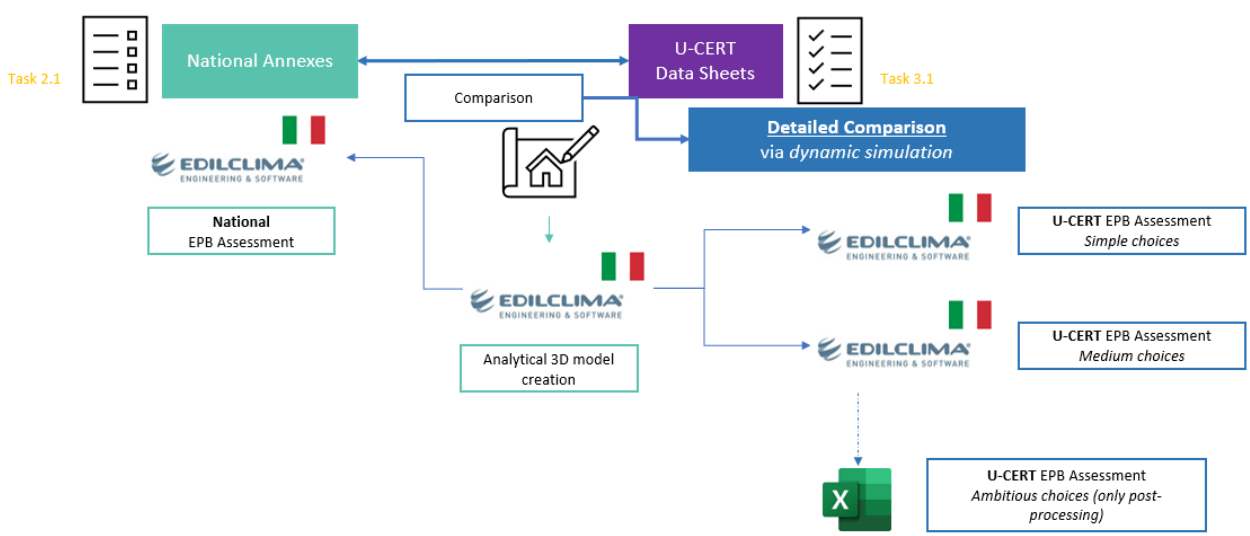


Figure III-2. Italy vs U-CERT EPB Assessment. Detailed Comparison (using EDILCLIMA ™).

The choices listed in Introduction will be tested as exposed in Table III-4, where the applicability of the different software options is listed.

Table III-4. Software used for each U-CERT choice. Italy

| Choice | | Software | | |
|---|---|---|---|---|
| Standard | Table/Clause | Cypetherm C.E. | Cypetherm EPlus | Energy Plus |
| EN ISO 52000-1 | A/B.16 | | | X |
| EN ISO 52000-1 | A/B.17 | | | X |
| EN ISO 52010-1 | A/B.2 | | X | |
| EN 16798-1 | A/B.5 | | X | |
| EN 16798-1 | A/B.8 | | X | |
| EN ISO 52016-1 | A/B.2 | X[a] | X[a] | |
| EN ISO 52016-1 | A/B.7 | | X | |

[a]This choice, which concerns the use of monthly or hourly procedures, is assessed using Cypetherm C.E., following the monthly method and then Cypetherm EPlus, for the hourly one. Then, to assess all other choices Cypetherm EPlus is used. Hence, the hourly method is taken as the basis for the development of the study.

In the subsequent sections each case, namely, the single-family house and the office building, will be defined.

## Single family house

For the fictitious residential building, depicted in Figure 5, no shading from external elements has been considered. It is composed by two above-ground floors, an underground garage, and a gable roof. Its useful area is a total of 95 m$^2$.

The thermal envelope of the building is depicted in Table II-3 and Table II-4.

The technical building systems considered are shown in Table II-5 and Table II-6. The heating and DHW technical system share the same generator. No cooling technical system exists in the dwelling.

No electricity production is considered.

The building use (i.e., internal loads, occupation, etc.), domestic hot water use profile, and the thermostatic setpoints have been assumed as fixed by the regulation [25]. These values are common for every residential building EPB Assessment and are defined from the following rules:

### *Sensible and Latent internal loads*

As stated in chapter 13.1 of UNI TS 11300-1 [27], for residential buildings with useful floor area ($A_f$) less than 120 m$^2$, the overall value of *sensible internal loads* ($\Phi_{int}$), expressed in W, is obtained from the following formula:

$$\Phi_{int} = 7.987\ A_f - 0.0353\ A_f^2$$

Thus, to obtain the *sensible internal loads*, in W/m$^2$, must be divided by the useful floor area ($A_f$).

While, as stated in chapter 13.2 of UNI TS 11300-1 [27], the overall value of *latent internal loads*, per unit of useful floor area, is given by the following formula:

$$\frac{(G_{wv,Oc} + G_{wv,A})}{A_f}$$

For residential buildings, $(G_{wv,Oc} + G_{wv,A})$ is equal to $250\ g/h$.

*Internal temperature and relative humidity*

For residential buildings, thermostatic setpoint during the heating season is set equal to $20$ ℃ and relative humidity is equal to $50\%$.

The standard heating season starts on November 15th and ends on March 31st. This duration is provided by the legislation according to the *Climatic Zone* in which the building is located (in this case *C*).

While, during the cooling season, always for residential buildings, thermostatic setpoint is set equal to $26$ ℃ and relative humidity must be always equal to $50\%$.

The first and last day of the standard cooling season are computed following *method b* described in chapter 7.4.1.2 of UNI EN ISO 13790:2008.

*Domestic Hot Water*

As stated in chapter 7 of UNI TS 11300-2 [28], for residential buildings the daily demand for DHW at delivery temperature, expressed in litres/day, is given by:

$$V_w = a * S_u + b$$

Where:

$a = 1.067$ for $50 < S_u \leq 200$;

$b = 36.67$ for $50 < S_u \leq 200$;

$S_u$ is the useful floor area, expressed in $m^2$.

Water temperature in the domestic hot water distribution network shall be considered as follows:

Table III-5. Water temperature in the domestic hot water distribution network

| | |
|---|---|
| Reference temperature at the delivery | **40** ℃ |
| Distribution network to users | **48** ℃ |
| Final distribution network | **48** ℃ |

Moreover, for residential buildings, the percentage load $p_{w,h}$ for hour *h* in relation to daily need, is given by the following formula:

$$p_{w,h} = \frac{\Phi_{W,d,in,h}}{Q_{w,d,in,day}} * 100$$

Where:

$\Phi_{W,d,in,h}$ is the mean hourly load [kW];

$Q_{w,d,in,day}$ is the mean daily need computed following UNI TS 11300-2 [28] [kWh].

As stated in UNI TS 11300-4 [27], $p_{w,h}$ value is obtained by the following table:

Table III-6. Domestic hot water needs – Hourly profile

| hour | $p_{w,h} = \frac{\Phi_{W,d,in,h}}{Q_{w,d,in,day}} * 100$ |
|---|---|
| 1 | 2.5% |
| 2 | 2.8% |
| 3 | 2.8% |
| 4 | 0.0% |
| 5 | 0.0% |
| 6 | 0.0% |
| 7 | 13.9% |
| 8 | 13.9% |
| 9 | 13.9% |
| 10 | 2.8% |
| 11 | 2.8% |
| 12 | 2.8% |
| 13 | 2.8% |
| 14 | 0.7% |
| 15 | 0.7% |
| 16 | 0.7% |
| 17 | 0.7% |
| 18 | 13.9% |
| 19 | 13.9% |
| 20 | 2.8% |
| 21 | 2.8% |
| 22 | 2.8% |
| 23 | 0.0% |
| 24 | 0.0% |

## Office building

The office building, depicted in Figure 6, is a recent refurbishment of a building located in a larger complex. Actual shading from nearby and adjacent buildings has been considered. It is composed by one floor spanning a total useful floor area of 482.41 m$^2$.

The characteristics of the thermal envelope, as well as the parameters of the technical building systems have been extracted from the office refurbishment project. The data relating to the use of the building, such as occupancy patterns, lighting, thermostats, ventilation, thermal loads for internal equipment, etc., have been established according to the standard values established by the legislation.

The thermal envelope of the building is depicted in Table II-10**¡Error! No se encuentra el origen de la referencia.** and Table II-11.

The technical building systems considered are shown in Table II-12, Table II-13, and Table II-14.

The heating and cooling technical system share the same generator and terminal units (Mitsubishi PUHY-P200YNW-A).

No electricity production is considered.

Such as for the case of the single-family house, Italian regulation [25] states that the use conditions for non-residential buildings are *standard data*. Thus, they cannot be defined with complete freedom by the EPB assessor.

*Sensible and Latent internal loads*

As stated in Table E.3 of Annex E in UNI TS 11300-1 [27], for non-residential buildings the overall value of *sensible internal loads*, expressed in $W/m^2$, is equal to *6*.

While the overall value of *latent internal loads* is always equal to *6* $[10^{-3} g/(h*m^2)]$.

*Internal temperature and relative humidity*

For non-residential buildings, thermostatic setpoint during heating season is set equal to 20 ℃ and relative humidity is equal to 50%.

The standard heating season starts on November 15th and ends on March 31st. This duration is provided by the legislation according to the *Climatic Zone* in which the building is located (in this case *C*).

While, during cooling season, always for non-residential buildings, thermostatic setpoint is set equal to 26 ℃ and relative humidity must be always equal to 50%.

The first and last day of the cooling season are computed following method b described in chapter 7.4.1.2 of UNI EN ISO 13790:2008.

U-CERT
User-Centred Energy Performance Assessment and Certification

## OUR TEAM

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreement number 839937. The European Union is not liable for any use that may be made of the information contained in this document, which is merely representing the authors' view.