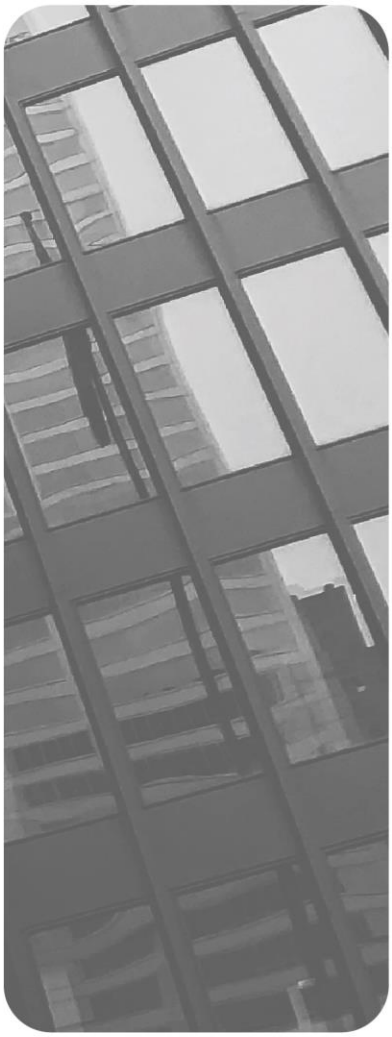


D4.1 Detailed common calculation and measurement protocols of U-CERT EPC-s for the cases

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

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	EPB Center, 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

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

Index

List of Figures

List of Tables

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 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 by testing the U-CERT EPC approach, in selected cases is Work Package (WP) 4's main contribution to U-CERT. 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 Operational Rating; the U-CERT converged set of National Datasheets for the set of EPB standards making the U-CERT's Asset Rating; the Smart Readiness Indicator[i] (SRI); the user-friendliness of the EPC's; the possibility to assess the impact of innovative products and technologies and non-technical measures to total performances in holistic EPCs.

The general fitting of WP4 within the Work Packages (WP) of the U-CERT project is the following.

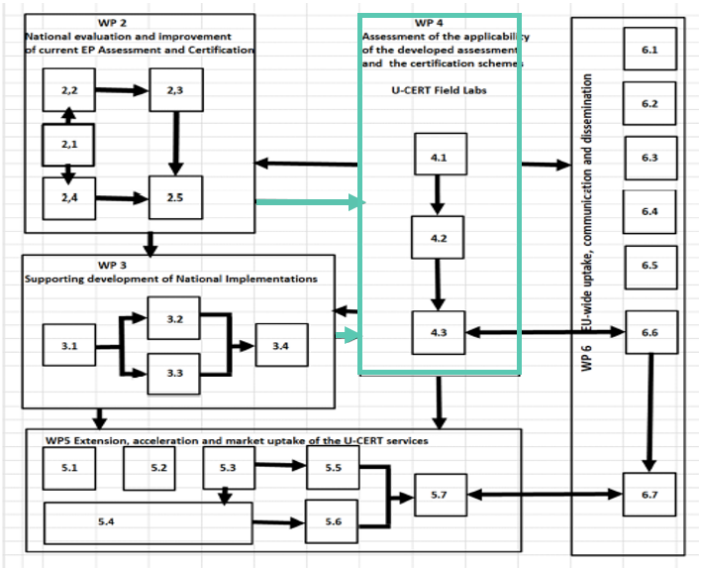


Figure 1. Synergies between Work Packages within U-CERT. Source: U-CERT's Grant Agreement

[i] More on the Smart Readiness Indicator in https://smartreadinessindicator.eu/

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 the 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. Valuable 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 Asset Rating; and in Task 3.2, the whole calculation methodology of all the U-CERT EPC features (Asset and Operational Rating, SRI, IEQ, partial indicators, energy cost, actual measured data, etc.) will be designed. Furthermore, the U-CERT EPC 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, fed by **Task 4.1: Development of common calculation and measurement protocols to evaluate the applicability and user friendliness of the EPCs**. In the following pages, the common calculation and measurement protocol, object of Task 4.1, will be referred to as "the protocol".

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

Case Studies description

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

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[i]
2b		Hagaporten III	Sweden	Offices	2008	N/A	2019	33.265[i]
3		J7B office building	Estonia	Offices	2018	N/A	2018	2.170[ii]
4		University	Hungary	Educational building	1877	2014	2018	2.243[iii]

[i] Heated area, excluding heated garage.
[ii] Net surface.
[iii] Undetermined.

5a		Quart 33	Spain	Multi-family building	2009	N/A	2013	3.098[iv]
5b		UMH Rectorate	Spain	Office	2008	2018	2017	8.520[iv]
6a		Computer and Information Science, University of Ljubljana	Slovenia	Educational building	2014	N/A	2014	24.985[v]
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[vi]
8		Building 22, Campus Leonardo, Polimi	Italy	Educational building	1999	-	-	2.972[iii]
9		Two-family house	Bulgaria	Two-family building	2002	2010	2020	320

[iv] Living spaces area.
[v] 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.
[vi] Useful area.

10a		Médiathèque Michel Crépeau	France	Public library	1997	-	2020	9.200[vii]
10b		Individual house	France	Single-family house	1974	N/A	2020	94[vii]
11a		Green Lighthouse	Denmark	Office	2009	N/A	2012	972
11b		Home for Life	Denmark	Single-family house	2009	N/A	2010	191

Table 1. Case Studies description

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.

[vii] Gross floor area.

Definitions

The following document uses certain concepts which may be unfamiliar to the public and also for EPB assessors without deep knowledge of the EPB standards. The key concepts behind U-CERT EPC scheme are the following:

- **Asset Rating**. It is the rating obtained after conducting a calculated EP assessment under standardized conditions. For instance, if following the national/regional EPC scheme methodology or if following the set of EPB standards for the U-CERT EPC calculation defined in U-CERT's Deliverable 3.1. In the document both the terms U-CERT Asset Rating and U-CERT Calculated EP Assessment are used. However, it is preferred to refer to the U-CERT Calculated EP Assessment, as it covers the whole calculation process not only the result of the rating.
- **Tailored Rating**. It is the rating obtained after conducting a calculated EP assessment under certain customized conditions. For instance, reflecting in the calculation the actual use of the building and/or using a non-standard weather data file.
- **Operational Rating**. It is the rating obtained after conducting a measured EP assessment followed by a normalization procedure on building use and weather. In the document the terms U-CERT Operational Rating, and U-CERT Measured EP Assessment and U-CERT Operational Assessment are used. However, it is preferred to refer to Assessment rather than Rating, as it covers the whole methodological process, not only the result of the rating.

For deeper knowledge of the terms and definitions, refer to EN ISO 52000-1 section 3 [3].

Common calculation and measurement protocol

U-CERT's aim is to develop a user-centred EPC scheme, and for this several assessments and indicators are used or leveraged. The rationale behind it is detailed next:

1. The starting point in U-CERT is the **National Asset Rating**, which commonly is based only in calculations and covers, generally, only energy indicators and partial energy performance. By means of the *U-CERT Comparison and calculation toolkit for National Annexes,* it should be possible to put in contrast national methodology with the set of EPB standards, assessing the impact of the national choices made, and obtaining help in filling the National Annexes.

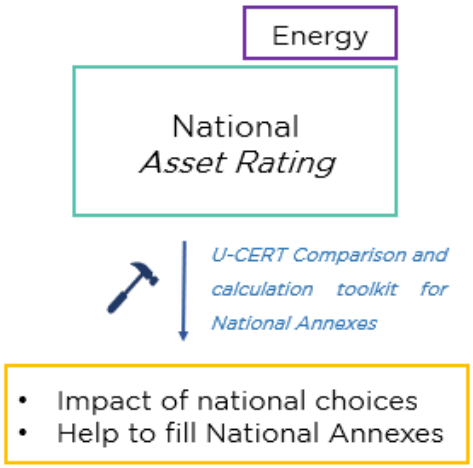


Figure 2. National Asset Rating within U-CERT

2. Next, one of the aims of U-CERT is including metered data in the EPC schemes. Thus, the **U-CERT as measured assessment**, obtained directly from the building covering, ideally, IEQ, energy and cost indicators. This rating, using the *U-CERT Building Operational Rating Solution*, should evolve to the **U-CERT Operational Assessment**, which would cover normalized indicators mainly of energy and leveraging the SRI.

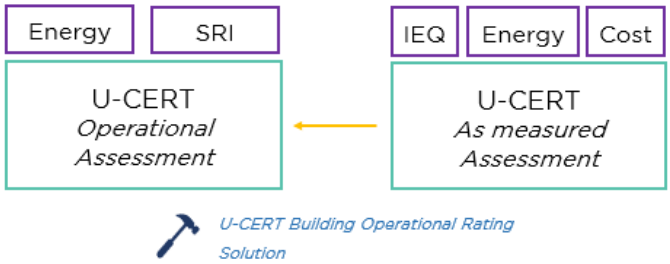


Figure 3. U-CERT as measured and Operational Assessment

3. The comparison and benchmarking between the U-CERT, measurement-based, assessments and the national EPC ratings would yield information regarding **gap bridging** and **innovative products and solutions assessment**. This endeavour will be covered by Task 4.3.

All those items would feed the evidence-based recommendations for reliable EPC rating.

In order to test the different elements envisioned by U-CERT, several synergies with previous and existing innovative projects, endeavours, and tools are to be leveraged.

The **protocol therefore is devoted to clarifying the needed input data, and specific considerations**, from any building upon which the U-CERT EPC is to be assessed, paying close attention to the case studies specificities.

Additional indicators may be included after Task 3.2 completion.

Collection of data for current EPCs

The first step in the protocol is the collection of existing EPCs, calculated 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 [4], but also the **EPC report** or form. This document contains detailed information regarding the building as such and its technical building systems, along with energy performance improvement recommendations for existing buildings [1]. Lastly, if possible, the filled **National Annexes**, detailing the calculation methodology in terms of the applicable EPB standards is also meaningful.

This endeavor is developed in the project benefiting from the synergies between Task 4.1 and Task 2.1, specifically by means of Deliverable 2.1 Info Layer 1. Of relevance is also section 7 in the sister project QualDeEPC's Deliverable 3.1 [2].

Existing EPCs 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-centered indicators or abide by the EPB Standards.

Lessons learned from case studies

There are many previous, and ongoing, actions and initiatives which have studied the different building energy performance certification schemes within the European Union (EU) and the United Kingdom (UK). Of special relevance are the U-CERT sister projects; specially X-tendo [3] and QualDeEPC [4].

The 11 countries providing case studies allow for different EPB Assessments for the EPC rating method. According to the study performed by the Building Performance Institute Europe (BPIE) in 2014 [5] the partner countries' EPB Assessments have the following characteristics.

Country	EPB Assessment	
	National EPC method	Used in case study
The Netherlands	Calculated	Calculated
Sweden	Calculated and Measured	Measured
Estonia	Calculated and Measured	Calculated
Hungary	Calculated	Calculated
Spain	Calculated	Calculated
Slovenia	Calculated and Measured	Calculated
Romania	Calculated	Calculated
Italy	Calculated	Calculated
Bulgaria	Calculated calibrated	Calculated
France	Calculated and Measured	Measured and Calculated
Denmark	Calculated and Measured	Calculated

Table 2. Methodologies used in partner countries for the evaluation of the EP of buildings. Own elaboration with data from [5]

Although many U-CERT partner countries allow for both types of EPB Assessments, calculated and measured, for the issuing of the EPC, one French case study is the only one providing an EPC purely based on measurements. However, the French national EPC scheme is in the process of being modified, with the EPC based on measurements being put into question with the update of the EP Assessment methodology [6]. The Bulgarian case study provides an EPC based on energy audit calculations, which are

calibrated using actual measured data, according to the national methodology [6]. The Swedish case studies do rely on measurements, but also perform a normalization to a certain degree. Special remark deserves the Swedish regulation, where the EPC ought to be based on metered values if they are available. For the case of new buildings, without availability of measured energy performance, it is allowed to give a calculated EPC, which must be validated by a measured one no later than two years after the end of the construction [7].

Generally, **the countries which allow for calculated and measured EPB Assessments, leave the latter as mandatory for existing buildings fulfilling certain criteria** (large old buildings, public buildings, etc.).

This fact does make sense, since in existing buildings very often the project information is missing and performing calculated EPC Assessments implies making assumptions which may cause high degrees of uncertainty.

Moreover, calculated EPC Assessment itself is not unique in the EU, and each MS has developed its own calculation procedure often based on one or several software. The 11 case study holder countries, according to the QualDeEPC's Deliverable 2.1 [7], have different status of availability of EPC software.

Country	Single official mandatory software	Private software	Certification mechanism for private software
The Netherlands	Yes, only for existing buildings.	Yes	Not clear. The Building Decree designates NEN 7120 as a method for determining the energy performance coefficient.
Sweden	No	Yes	No
Estonia	No	Yes	Generally recognized methods can be used for validation of software (IEA BESTEST among others).
Hungary	No	Yes	No
Spain	No	Yes	Yes
Slovenia	No	Yes	Yes
Romania	No	Yes	Yes, only for collective apartment buildings.
Italy	Yes, only for existing residential buildings	Yes	Yes
Bulgaria	No	Yes	No
France	No	Yes	Yes
Denmark	No	Yes	Yes

Table 3. EPC software availability status in partner countries. Own elaboration with data from [7]

In the case of Spain, 6 different software may be used for issuing the EPC, [8]. All of them theoretically fulfill the same technical requirements on the assessment of the building energy performance [9]. However, the assessment of the same building with the different software has been proven to provide different results [10], and even variation in the EPC rating, with discrepancies of one or even two categories in the rating scale. In the case of Bulgaria, it is possible to perform the EPC assessment with any software, however the Public Administration controls that the calculations are performed abiding by the official methodology and following national guidelines. Moreover, the EPC calculation methodology is based in energy audits, therefore only

registered energy auditors, who are required to own specific measurement equipment, are eligible to issue EPCs.

Therefore, not only the input and output data may be different depending on the type of EPC Assessment, but also within the same type. **The input data for a calculated EPC assessment may consider diverse levels of detail depending on whether the calculation software is the official mandatory or a private one, thus yielding different qualities in the assessment**. Also, some other considerations may affect, such as variations according to different typologies of buildings. These great discrepancies hinder the comparison between EPC assessments both within the same country, and at European level.

In regards to the collection of partner countries **National Annexes**, only the Spanish one has been collected [8].

U-CERT Asset Assessment

U-CERT Asset Assessment is one of the backbone elements of U-CERT next-generation EPCs. It provides an EPB standard-based calculated EP assessment, under standard conditions and with standard occupants. Thus, it is harmonized, while accounting for some flexibility degree (e.g. climatic data), tackling the current inability of cross-country comparison and helping to instill trust in the market [9]. The specifics of its calculation methodology are presented in detail in U-CERT's Deliverable 3.1.

The initial course of action of the project was to rely on the collection of MS National Annexes under Task 3.1, to come to a converged set of national data sheets for the set of EPB Standards. This converged set of national data sheets would in turn constitute the basis for the calculation methodology of the U-CERT Asset Assessment. 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 has delayed the methodology development of Task 3.1. As stated in section 1 of Deliverable 3.1, 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 Asset Rating.

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 Asset Assessment. They are the following:

The 5 core EPB standards, explicitly mentioned in Annex 1 of the amended EPBD [10]:

- 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).

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.

In Deliverable 3.1 several supplementary documents have been developed:

- **Supplementary 1. Proposal for the U-CERT converged set of National Datasheets for the main EPB standards.**
- **Supplementary 2. Proposed categorization of Annex A choices**, depending on the nature of the options.
- **Supplementary 3. Template for U-CERT converged set of National Datasheets for measured energy performance.**
- **Supplementary 4. Overview of EPB standards' spreadsheets and usability to quantify the impact of a specific "Annex A" choice**.
- **Supplementary 5. Tentative indication of the input data needed for using the U-CERT EPB calculation method**.

Case Studies will be asked to provide Asset Assessment-like information. Ideally, this information should be obtained after performing a calculation abiding by the choices proposed by U-CERT. However, since developing a new simulation software based on the particular choices made in Deliverable 3.1 is out of the scope of the U-CERT project, case studies will be allowed to provide such information using existing national EPC as a source.

Case Studies are welcome to analyze the proposed U-CERT converged set of National Datasheets for the main EPB Standards, using Deliverable 3.1 Supplementary document 1. As the *U-CERT Comparison and calculation toolkit for National Annexes* is developed, in the scope of Task 5.4, Case Studies may be further involved.

U-CERT Measured Assessment

Despite the advantages of the standardized calculated assessments, yielding asset ratings, they do not directly reflect the actual performance of the building. Thus, the creation of the U-CERT Operational Assessment, which provides an EPB standard-based measured EP assessment, under normalized conditions and with normalized occupant behavior. The U-CERT Operational Assessment also leverages the SRI.

Figure 4. U-CERT Measured Assessments

The process, illustrated in ¡Error! No se encuentra el origen de la referencia., allows to go from *as measured* U-CERT Assessment, user and weather influenced, to full U-CERT Operational Assessment, obtaining weather and user normalized energy rating. All this while providing additional meaningful indicators in the fields of cost, IEQ and leveraging the SRI.

As measured assessment

The As Measured Assessment covers energy, cost and IEQ indicators collected by means of measurement intervals, composing the measurement period. They are all gathered under actual use and weather conditions.

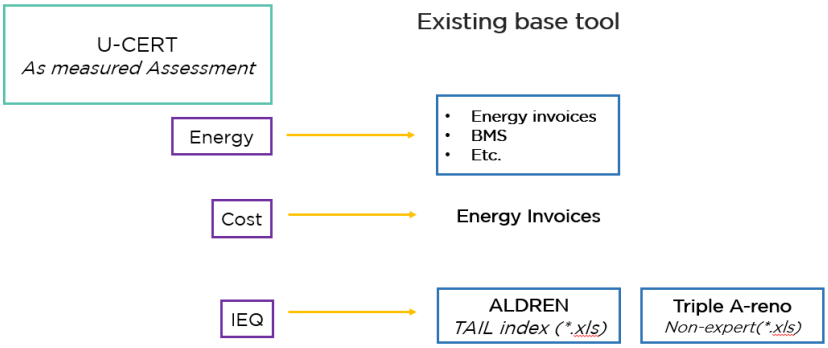


Figure 5. U-CERT As Measured Assessment. Tool scale-up

The *as measured* indicators provide meaning to the current user of the building, since they convey the information about how is the building itself and its technical systems actually used.

For the case study testing, U-CERT will roll-out the methodologies from previous WPs, while also leveraging tools developed by other innovation projects. They will be references next.

Energy

The *as measured* energy indicator intends to capture the final energy consumption per energy vector of a certain building, under the actual use and weather conditions.

For the energy indicators in the U-CERT As Measured Assessment, existing metered data will be used.

With a view to ensuring that what is intended to be assessed coincides with what is being measured, for each energy vector consumption retrieved per measurement interval the following must be identified:

- Generators, devices and systems served by it;
- Services satisfied by that equipment (EPB and non EPB);
- Whether those services belong to the whole building or to some parts of it.

Many sources of information are eligible to provide the *as measured* final energy consumption, namely:

- **Meter readings**, recording initial and final readings;
- **Maintenance reports**;
- **BACS**, **BMS** or similar;
- **Invoices**, based on actual consumption not estimations.

The auxiliary energy consumed should also be considered, and if an indicator is to be given per service, some **separation procedures** from the overall measurement may be needed, especially in the case of invoices, which generally cover the overall energy consumed in the billing period per energy vector.

For hourly metering, there is a need to apply a coefficient of proportionality depending on the fuel used [11].

All the measurements in each interval should be summed to reflect a certain period of the assessment, typically, a year.

Cost

The *as measured* cost indicator targets to capture the expenditure per energy vector of a certain building, considering the actual use and weather conditions.

To capture the energy cost, the most reliable source of information are the **invoices** provided by the utility company per energy vector.

IEQ

The *as measured* IEQ indicator seeks to represent the actual state of the building in terms of comfort and IEQ, under actual use and weather conditions.

Regarding the actual building state in terms of comfort and IEQ evaluation, the ideal situation is to be able to rely on existing measurements. For that, the ALDREN TAIL Index is going to be leveraged through a collaboration agreement between project representatives.

The ALDREN TAIL index, mentioned in U-CERT's Deliverable 2.4, 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 [12] 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 [12] 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*[i]*"* [11].

Thus, and as also pointed out by U-CERT's Deliverable 2.4 [13], 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 [12]. Also, and as the **catalogue on EPC profiles** showed in U-CERT's Deliverable 5.3 [14], 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*

[i] Additional considerations regarding the comparison between calculated and measured EP can be found in section 8 in EN ISO 52000-2 [12].

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" [12].

Regarding the IEQ Assessment relying on **dedicated measurement campaigns**, the assessment process comprises four phases, as established in [12]:

- 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"* [12].

The ALDREN TAIL index covers the following parameters:

- Thermal environment.
  - Dry-bulb temperature.
- 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.

With a view to also assess existing buildings, often lacking any specific metering device, some qualitative self-assessing elements are going to be included. For this purpose, the Combined Labelling Tool developed for the Triple A-reno [15] will be leveraged. They would cover a **qualitative assessment** with a view of providing low-level diagnosis to existing buildings without metered data, which often are the ones with lowest IEQ and in greatest need of building renovation.

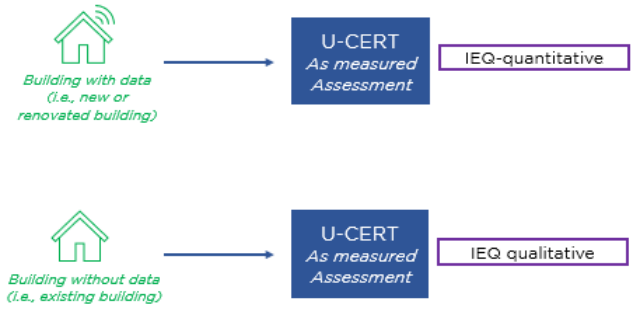


Figure 6. Measured IEQ Assessments within U-CERT.

This is of relevance given the data availability regarding IEQ parameters exists 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
5a	No	No	No	No	No	No	No	No	No
5b	Yes	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

Table 4. Measured IEQ data overview in U-CERT case studies

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

U-CERT Operational Assessment

Unlike the case of the U-CERT Asset Assessment, there is not a set of standards regulating the particulars behind measured EP assessments. There is only one dealing with heating and DHW services. 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. There are general guidelines in it which can serve as the basis for the U-CERT Operational Assessment, given they condition the approach taken by any measured EPB Assessment.

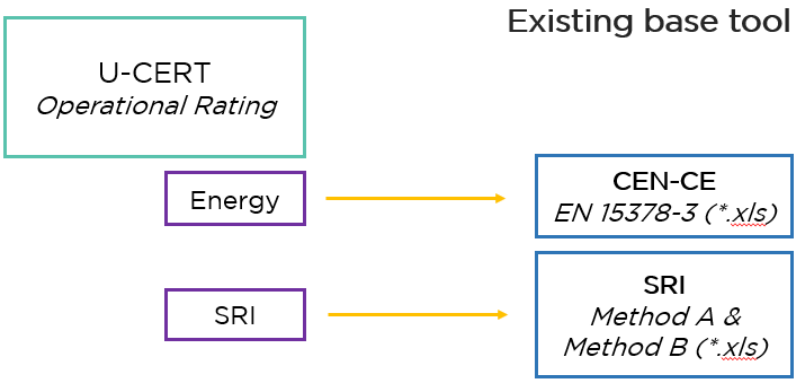


Figure 7. U-CERT Operational Assessment. Tool scale-up

Accounting for the energy consumption for the services of heating and DHW is a valuable starting point, since they represent the greatest end-use intensity in the residential sector with 68% and 13% respectively, according to the European Commission statistics.

Energy

The U-CERT Operational Assessment, being the result of a measured EP assessment for heating and DHW, follows different principles than the U-CERT calculated Assessment. 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 a 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 [12].

As additional EPB Standards are developed regarding measured EP Assessments, the workflow defined in Annex D in EN ISO 52000-1 [18] will become applicable.

According to EN 15378-3 [11], 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 [19] 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**[ii].

  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"* [11].

    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.

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

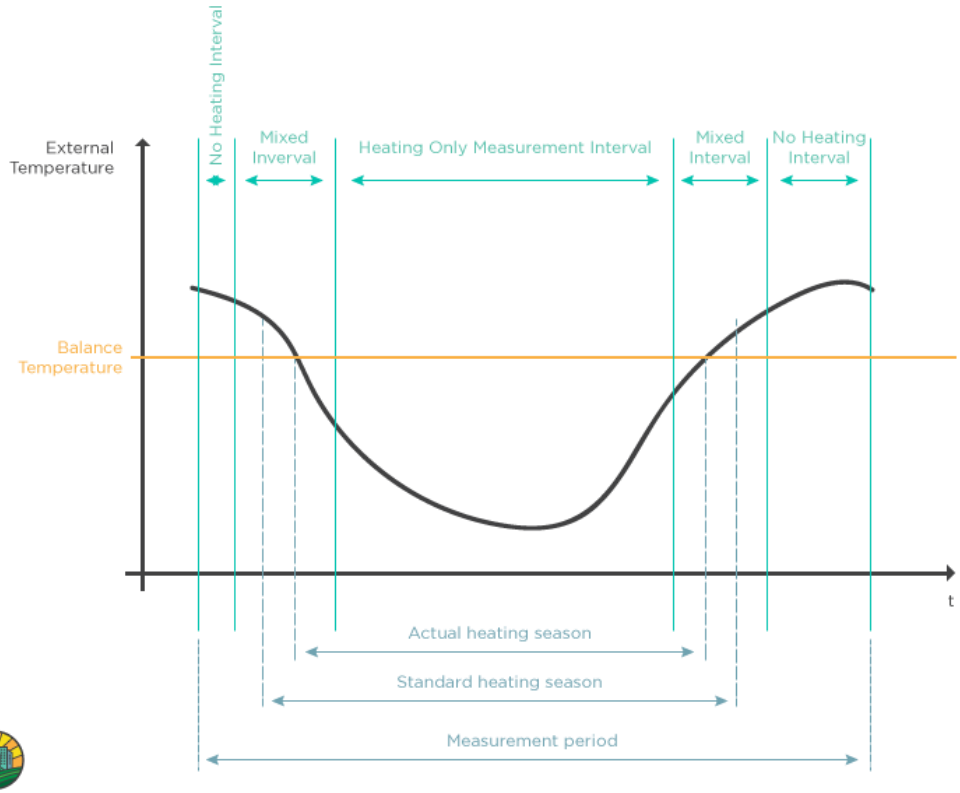


Figure 8. Example of measurement intervals and seasons. Information from [13].

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 8.
- **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 [13].

- 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, in order 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, [14].

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 [13].
  - Knowledge of the average internal temperature.
  - Knowledge of the average external temperature.
- **DHW**. The following context information to the measurement is needed [13].
  - 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 [15] 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"* [13].

The base tool for the U-CERT Operational Assessment will be the EN 15378-3 spreadsheet developed in the framework of the CEN-CE[iii] 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 4), both for the energy signature and for the seasonal data interpolation method.

In order to capture the specifics surrounding the quantity and quality of the measured data from the U-CERT case studies, a detailed questionnaire was prepared[iv]. 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.

[iii] More on CEN-CE project in https://www.cen-ce.eu/.
[iv] Refer to WS4 on U-CERT's 3rd Consortium Meeting Minutes for further details.

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
5a	No	Electricity	No	No
5b	Electricity	Electricity	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

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

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, [13].
- **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.

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
5a	No	No
5b	Monitoring data	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

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

Most case studies are in position of rolling-out a full assessment, either based on monitoring data or on invoices. Case study 5a 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.

The existence of continuous monitoring linked to Building Management System (BMS) not only eases the collection of data, but also serves as the infrastructure for a future **continuous real-time assessment**.

SRI

For the assessment of the SRI in the Case Studies, the guidelines stated in [16] 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.

In the framework of Task 4.1, the SRI public beta testing is performed on all U-CERT case studies, by means of the specific guidelines and documentation developed by the SRI study team at EU level. U-CERT team is overall committed to support the SRI implementation, updating and evolution processes throughout U-CERT's implementation and play an active role in the "SRI platform" and exchange with all the concerned stakeholders, especially during the SRI national testing exercises 2021-2022.

The results from the public beta testing of the tools available yielded the following results:

Case Study	SRI Impact Scores [%]							
	Energy Savings on site	Flexibility for the grid and storage	Comfort	Convenience	Wellbeing and health	Maintenance & fault prediction	Info. to occupants	Total
1	49	12	52	39	100	33	27	**36**
2a	63	38	64	54	50	38	54	**54**
2b	62	38	63	54	50	38	54	**54**
3	74	15	75	53	48	50	54	**57**
4	51	12	64	31	0	39	23	**37**
5a	2	0	11	3	0	0	0	**1**
5b	41	20	48	44	47	41	53	**40**
6a	76	14	79	67	85	54	46	**61**
6b	61	7	64	54	78	41	49	**49**
7	36	0	31	28	67	31	38	**27**
8	26	7	36	33	37	27	17	**24**
9	45	5	37	31	77	32	38	**30**
10a								
10b								
11a	73	23	80	64	100	56	69	**63**
11b	60	7	73	56	65	35	53	**47**

Table 7. SRI impact scores of U-CERT Case Studies

Case Study	SRI Domain Scores [%]								
	Heating	DHW	Cooling	Controlled ventilation	Lighting	Dynamic envelope	Renewable gen. & Storage	EV charging	Monitoring & Control
1	43	34	34	0	60	0	0	0	27
2a	61	73	61	59	88	38	0	26	38
2b	61	73	61	57	88	38	0	26	38
3	76	54	83	51	40	0	23	0	36
4	56	17	51	0	0	0	18	0	30
5a	0	0	0	0	20	0	0	0	0
5b	40	0	33	29	90	0	0	0	40
6a	54	67	81	84	69	55	0	26	48
6b	48	39	71	80	20	0	22	0	38
7	33	44	0	0	24	0	0	0	20
8	22	0	24	19	40	0	0	0	32
9	42	47	0	0	0	0	0	0	20
10a									
10b									
11a	64	41	51	100	88	81	173	-19	48
11b	58	45	0	52	65	81	44	0	35

Table 8. SRI domain scores of U-CERT Case Studies

Activities, 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 the provision of information and use of the selected tools from previous innovative projects and initiatives.

Activities

The activities related to the case study buildings data collection may be different from partner to partner, since not every pilot 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:

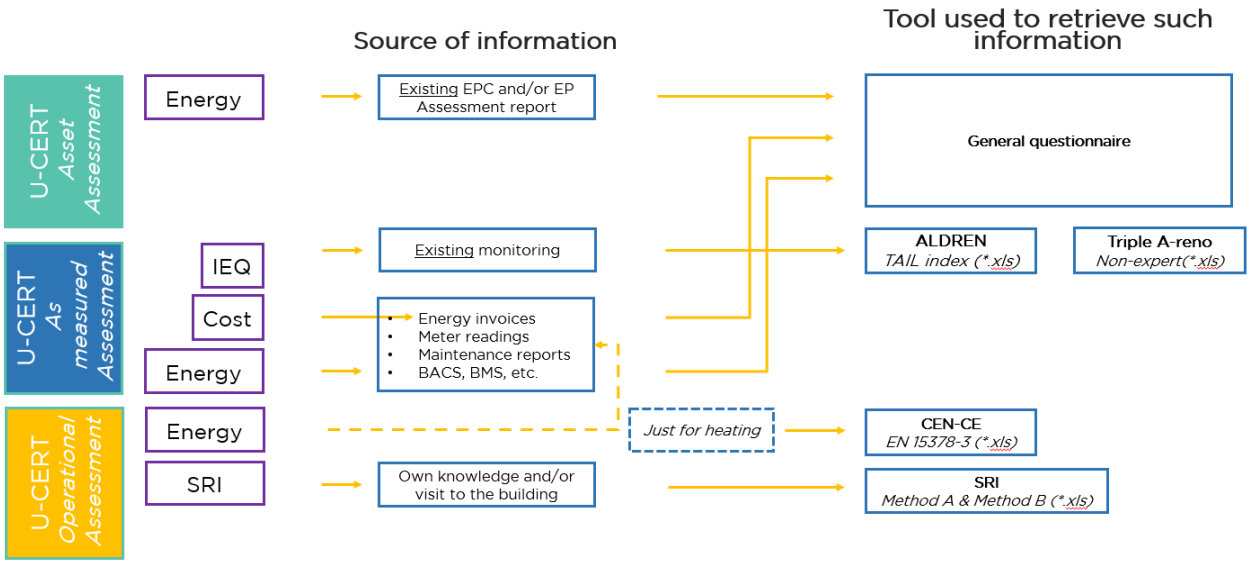


Figure 9. U-CERT Case Study Testing Layout

As exposed in U-CERT Asset Assessment, since the translation of the EPB standard choices from Deliverable 3.1 into a calculation tool is not envisioned in the scope of the project, the information linked to U-CERT Asset Assessment would actually come from existing national EPCs. This information will be gathered via a **general questionnaire**.

Regarding the U-CERT As Measured Assessment, the testing is highly conditioned to the availability of measurements. The inclusion of cost and energy indicators is expected to be uneven among case studies on account of Table 6. This data will be retrieved via the aforementioned **general questionnaire**. Furthermore, the possibility to test the U-CERT Operational Assessment is also subject to measured data availability on heating and DHW services. That specific item of the U-CERT scheme will be assessed through the **EN 15378-3 spreadsheet** developed by the CEN-CE project. For the IEQ dimension the type of assessment is conditional to measurements available, as shown in Figure 6. Thus, the assessment tool to be used in case studies will be the **ALDREN TAIL calculation spreadsheet** for case studies with data availability; and the **Triple A-reno non-expert spreadsheet** for the rest. Refer to Table 4 for an overview on the measured IEQ data availability in case studies.

Lastly, the SRI is to be assessed using the **official calculation spreadsheets** available, although future updates are to be expected when a new contractor is commissioned by DG ENER to support the testing/implementing phase.

The questionnaire can be found here.

Each specific spreadsheet will be sent to case studies, who should follow the guidelines embedded in the template.

Additional monitoring campaigns are not foreseen. The project will make use of the measurements already in place according to ¡Error! No se encuentra el origen de la referencia. and Table 4.

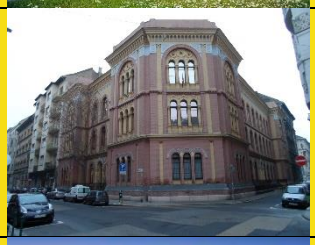
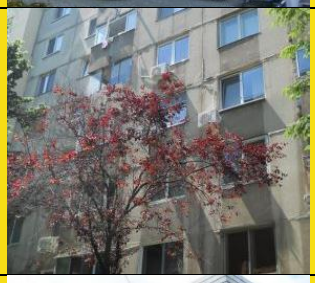
Planning

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.

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.

Case Study	Image	Name	Partner(s)	Team/person responsible
1		Larisa Nursing Home	HIA	Eric Willems
2a		Entré Lindhagen Hus C	KTH	Andrei Vladimir Liţiu
2b		Hagaporten 3	KTH	Andrei Vladimir Liţiu

3		J7B office building	**TalTech**	Karl-Villem Võsa
4		University	**COM**	Zoltan Magyar
5a		Quart 33	**IVE**	Pablo Carnero Melero
5b		UMH Rectorate	**ATECYR**	Pedro Vicente Quiles
6a		Computer and Information Science, University of Ljubljana	**IRI-UL**	Andreja Burkeljca
6b		Faculty of Economics, University of Ljubljana	**IRI-UL**	Andreja Burkeljca
7		Apartment Building 21	**AIIR**	Cătălin Lungu / Tiberiu Catalina
8		Building 22, Campus Leonardo, Polimi	**AiCARR**	Luca Alberto Piterà

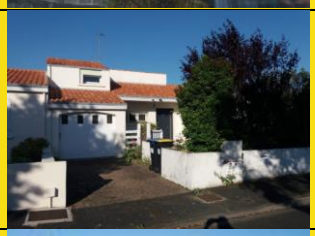
9		Two-family house	**EnEffect**	Stanislav Andreev / Kamen Simeonov
10a		Médiathèque Michel Crépeau	**Tipee**	Florian Battezzati
10b		Individual house	**Tipee**	Florian Battezzati
11a		Green Lighthouse	**DTU**	Menghao Qin
11b		Home for Life	**DTU**	Menghao Qin

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

References

[1] European Parliament and Council of the European Union, *Directive (EU) 2018/844,* Brussels, 2018.

[2] CEN, *ISO 52000-1:2019,* 2019.

[3] Buildings Performance Institute Europe (BPIE), "ENERGY PERFORMANCE CERTIFICATES ACROSS THE EU," BPIE, 2014.

[4] Wuppertal Institut, "D2.1 Report on local EPC situation and cross-country comparison matrix," 2020.

[5] Ministerio para la Transición Ecológica y Reto Demográfico, "Energía y desarrollo sostenible," Secretaría de Estado de Energía, [Online]. Available: https://energia.gob.es/desarrollo/EficienciaEnergetica/CertificacionEnergetica/DocumentosReconocidos/Paginas/documentosreconocidos.aspx. [Accessed 21 04 2020].

[6] Ministerio para la Transición Ecológica, *Condiciones técnicas de los procedimientos para la evaluación de la eficiencia energética en edificios,* Madrid, 2019.

[7] P. C. Melero, "Análisis y Estudio de la Simulación Energética de Edificios Residenciales con Programas Reconocidos," València, 2018.

[8] Ministre de l'ecologie, du developpement durable, des transports et du logement, *Arrête du 8 février 2012,* 2012.

[9] Minister of Economic Affairs and Communications, *Format and procedure of issuance of energy performance certificates,* 2014.

[10] CEN, "CEN/TR 15378-4:2017," 2017.

[11] CEN, *EN 15378-3:2017,* 2017.

[12] CEN, "CEN/TR 15378-1:2017," 2017.

[13] European Comission, "Recomendation (UE) 2016/1318," 2016.

[14] CEN, "ISO/TR 52000-2:2017," Brussels, 2017.

[15] CEN, "ISO/TR 52003:2-2017," CEN, Brussels, 2017.

[16] European Parliament and Council of the European Union, *Directive 2010/31/EU, on the energy performance of buildings,* Brussels, 2010.

[17] CEN, "ISO/TR 52000-1:2017," 2017.

[18] Minister of Economic Affairs and Communications, *Methodology for calculating the energy performance of buildings,* 2013.

[19] Instituto Valenciano de la Edificación (IVE), "D5.1 TripleA-reno Monitoring Protocol," 2019.

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.