X-tendo

CONCRETE IMPLEMENTATION OF NEW ENERGY PERFORMANCE CERTIFICATES FEATURES: TESTINGS AND RESULTS IN NINE COUNTRIES- COMFORT

MARCH 2022

THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT NO 845958.

Project Acronym	X-tendo
Project Name	eXTENDing the energy performance assessment and certification schemes via a mOdular approach
Project Coordinator	Lukas Kranzl Technische Universität Wien (TU Wien) Gusshausstraße 25-29/370-3, A-1040 Vienna E. Lukas.Kranzl@tuwien.ac.at
Project Duration	2019 - 2022
Website	www-x-tendo.eu

Deliverable No.	D5.2
Dissemination Level	Public
Work Package	WP5- Testing and implementation guidelines
Lead beneficiary	e-think energy research
Contributing beneficiary(ies)	TU Wien, VITO, BPIE, ADENE, CRES, TREA, AAECR, DEA, EASt, NAPE, ENEA
Author(s)	Hummel Marcus (e-think), Campbell David (EST), Weatherall David (EST), Green Caroline (EST)
Co-author(s)	Schmidinger David (e-think)
Reviewed by	Jerzy Kwiatkowski (NAPE) Editing: Roberta D'Angiolella
Date	15.3.2022
File Name	X-tendo_Deliverable 5.2

Legal Notice

TABLE OF CONTENT

LIST OF ABBREVIATIONS

ADENE	Portuguese Energy Agency, Department of Buildings
AAECR	Romanian Association of Energy Auditors for Buildings
CDD	Cooling Degree Days
CRES	Centre for Renewable Energy Sources and Saving
DEA	Danish Energy Agency
DH	District Heating
EASt	Energy Agency of Styria
ENEA	Italian National Agency for New Technologies, Energy and Sustainable Economic Development
EST	Energy Saving Trust
HDD	Heating Degree Days
IEQ	Indoor environmental quality
MFH	Multi-family house
NAPE	National Energy Conservation Agency
SFH	Single family house
TREA	Tartu Regional Energy Agency

1 INTRODUCTION

The focus of the Horizon 2020 project X-tendo is the further development of energy performance certificate (EPCs) schemes in EU Member States. This should be done in two dimensions: on the one hand additional indicators are developed that add further relevance to EPCs. On the other hand, EPC handling should be improved to make it easier, more reliable and interconnected with other building related data. 5 features in each of the two dimensions are elaborated throughout the project. This includes the analysis of the theoretical background, the development of materials and methods, the testing of the features in concrete implementation projects, as well as the dissemination on developed ideas and materials.

The goal of the testing of the developed feature materials is to understand the practical viability and the challenges in the practical implementation of the developed ideas and materials in selected countries of the EU. Depending on the feature different types of tests and test projects have been performed. In-building tests apply the feature materials on concrete buildings, user tests consist of understanding the user perception related to the developed materials and ideas, system tests intend to understand the application of feature ideas and materials in related systems like EPC database systems.

The overall approach of testing and further developing feature materials is shown in Figure 1 and consists of the following steps:

- In the first phase of the project the feature leads (FL) developed beta versions of feature materials, hereby taking into account needs and feedback from Implementing Partners (IPs). An overview of FLs and involved IPs per feature can be seen in Table 1. These materials consist of different parts depending on the feature. In most cases these consist of guidelines, spreadsheets or program code in defined languages like sql or python.
- The beta versions of the feature materials have then been provided to the IPs to test their application in their national / regional settings. The IPs have performed different types of tests with or in the context of the developed materials. In some cases, especially for in-building tests of certain features, the tests also involved EPC assessors.
- After finishing the test projects, the IPs reported about their testing results in two different ways: on the one hand they filled previously developed questionnaires (see the annex for exemplary questionnaires). On the other hand, they wrote test result reports providing more details about the context and results of the test projects.
- The filled-out questionnaires as well as the testing results reports have been used as a basis to derive conclusions for the final reshape of the feature materials. They also serve as an input to guiding the implementation of the features in the different countries / regions.

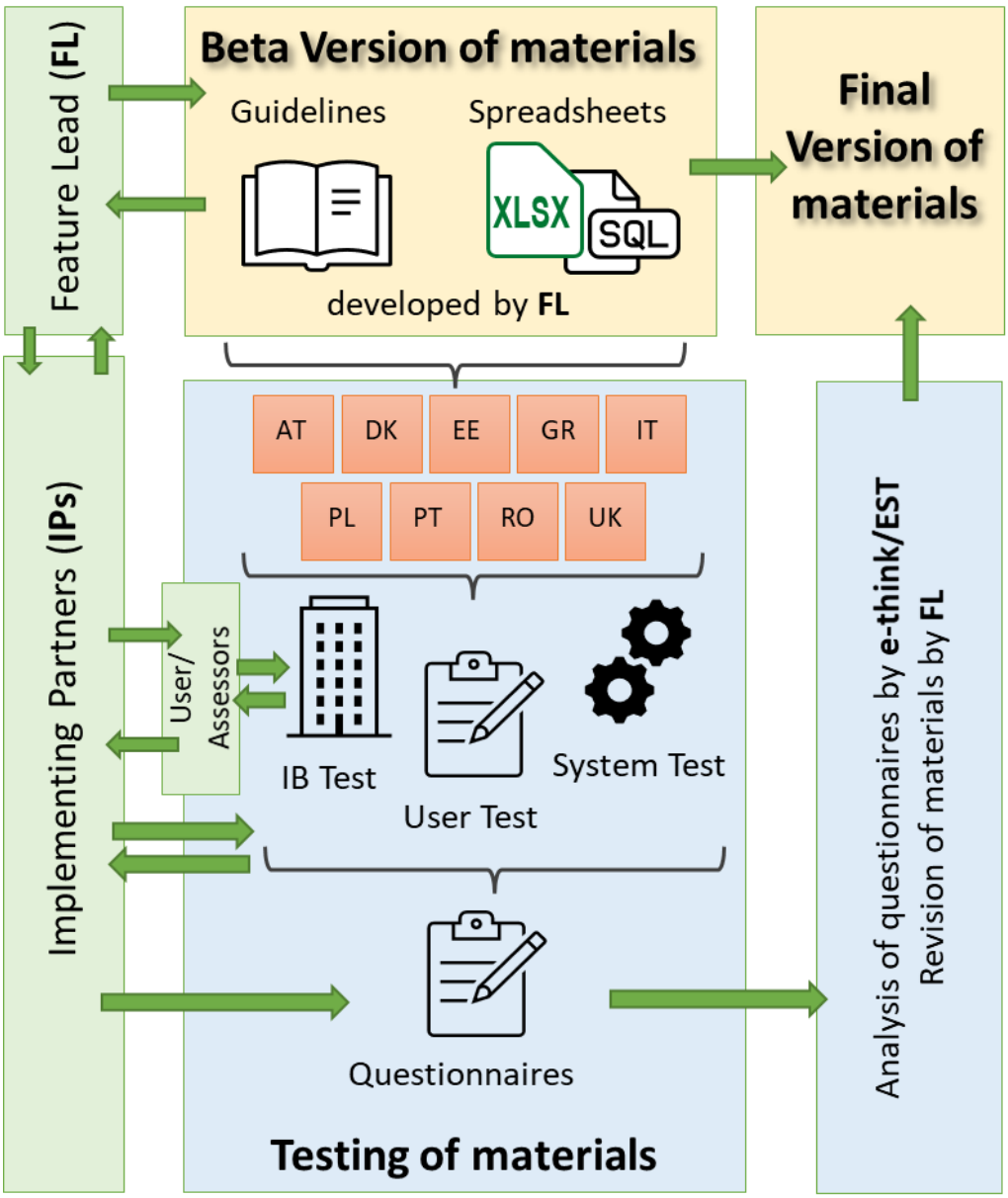

Figure 1: Approach for testing feature materials in the X-tendo project

The following Table 1 gives an overview of the types of tests that have been performed for the different features in the different implementing countries. More details of the characteristics of each test project are described in the feature chapters.

Table 1 – Overview of testing activities by feature and implementing country / partner

		1. Smart readiness	2. Comfort	3. Outdoor air pollution	4. Real energy consumption	5. District energy	6. EPC database	7. Building logbook	8. Enhanced recommendations	9. Financing options	10. One stop shops
		Feature lead partner									
Country	Implementing Partners	VITO	BPIE	NAPE	VITO	e-think	TU Wien	BPIE	TU Wien	ADENE	ADENE
AT	EASt	IB	IB		IB				Expert		
DK	DEA					Expert	S		IB	U/S	U/S*
EE	TREA	IB Expert			IB			U/S			
GR	CRES	IB Expert	IB Expert				S	U/S			
IT	ENEA				IB	IB	S				
PL	NAPE			IB U Expert		IB			IB S	Expert	
PT	ADENE		IB					U/S Expert		U/S	U/S* Expert
RO	AAECR	IB	IB		IB Expert	IB				U/S	U/S*
UK	EST				**		Expert		IB		S
	No of partners testing	4	4	1	4	3	3	3	3	3	1 stand-alone test*

*Feature 10 tests in DK/PT/RO are delivered alongside testing of feature 9 **Note UK test under feature 10 also relevant here

This report provides the summary of the outcomes of the testing activities for each of the 10 features in one or several implementing countries. This is mainly based on the analysis of the evaluation questionnaires filled out by the implementing partners, but also on the content of the testing results reports where these have already been available at the time of writing the document. The questionnaires hereby consist of general questions along the testing steps, questions on testing time and related costs, an evaluation against defined cross-cutting criteria (Quality and Reliability, User-friendliness, Economic feasibility, and Consistency with ISO/CEN standards) and final thoughts. The questionnaires slightly differ for the different types of test projects (in-building, system, user tests) and for the different features (composition of detailed questions for the cross-cutting criteria). Exemplary evaluation questionnaires for each of the three types of test projects can be found in the Annex of this report.

With this the report should provide a summary of the outcomes of the testing activities on the different features in the different countries, provide conclusions for further development of the developed ideas and materials towards the end of the project and beyond, explain the practicability and challenges in the implementation of the features in practice, and give guidance for organising similar test projects in the future.

The report first provides an introduction to the topic of the feature, the developed methodologies and materials and the performed testing activities. This is followed by the description of the testing results structured by the types of test projects. This includes a description of overall results, estimated time and costs and the different cross-cutting criteria. Finally, conclusions out of the testing activities are presented.

2 FEATURE 2: COMFORT

2.1 Introduction

Indoor activities, outside noise, pollution, landscape and building characteristics have a significant impact on the indoor environmental quality (IEQ). The residential sector is of exceptional importance as people spend approximately 60-90% of their day in their homes. Infants, young children, elderly and bedridden people spend an even greater proportion of their day in dwellings and are more exposed to the adverse health effects of poor IEQ. Educational buildings are also crucial as children spend a substantial amount of their day at school. Several studies conducted in school environments have shown that the indoor air quality in many classrooms is very unhealthy. IEQ is also highly relevant for office buildings. Apart from the large amount of time that employees spend indoors, various studies have shown that the IEQ has a significant impact on their work performance, productivity and wellbeing.

In course of X-tendo a methodology to calculate the indoor comfort level of a building has been developed. The idea is that it is simple enough to integrate the procedure into the EPC assessment. The method can be applied to both new and existing buildings. If the building is in use and occupied, an operational rating is available (CORP), while for new or unoccupied buildings, a provisional asset rating is available (CARP).

More information about the feature can be found in the introductory report or on the X-tendo website.

The comfort feature (both CORP and CARP) was tested in Austria (EASt), Greece (CRES), Portugal (ADENE) and Romania (AAECR). All tests were in-building tests, the following table shows the buildings / apartments it was tested on.

Table 2 – In-building test objects for F2 – comfort indicator

Austria (EASt)			Greece (CRES)			Portugal (ADENE)			Romania (AAECR)		
building category	const. year	type	building category	const. year	type	building category	const. year	type	building category	const. year	type
SFH detached	1992	B	MFH detached	1976	A	SFH	2010	B	SFH	2016	B
SFH detached	2013	B	MFH detached	1976	A	MFH	1990 2006*	A	MFH	1974	A
SFH detached	1991	B	Office	1986 1992*	A	Office	1994	B	Office	2015	A
SFH detached	2021	B	Office	2001	A	School	1994	B	Kinder-garten	1969 2016*	B
MFH	2019	A									
MFH	1950	A									
MFH	2020	A									
MFH	2019	A									
School	2011	B									
Office	No data	A									

A … apartment or unit in building B … whole building * … year of renovation

The steps for the in-building tests of this feature were generally the same in all countries:

1. Administration / data collection – including gathering of building data, distribution of tasks and establish a testing strategy
2. Measurements – carrying out the measurements in the buildings
3. Surveys – conduct the foreseen surveys amongst the building users
4. Checklists – perform inspections and observations in on-site visits
5. Rating calculation – calculate the comfort indicators using the provided spreadsheets

Particularities in the implementation of these different testing steps in the different tests are described in the following.

Austria (EASt)

In Austria 10 buildings were assessed with the provided assessment tools (CORP and CARP). Measurements were conducted in all buildings for at least one month in the summer period and one month in the winter period. The measurements, checklists as well as survey results were used in the provided assessment tools to calculate the different comfort indicators: thermal comfort, indoor air quality, visual comfort and acoustic comfort.

Greece (CRES)

In Greece tests have been conducted in four buildings: two office buildings and two apartments. On-site visits and walk through audits were carried out combined with the testing of F1 (SRI). Data regarding the buildings and their systems were gathered and a

survey was carried out. Measuring equipment was used to record indoor temperature, relative humidity, CO_2 concentration as well as ambient temperature. Light measurements took also place at corresponding rooms. All collected information was used in the provided spreadsheets to calculate the comfort ratings.

Portugal (ADENE)

ADENE tested and calculated the comfort indicators in 4 different types of buildings: a SFH, a MFH, an office and a school. Measurements of outdoor temperature, indoor temperature, CO_2 concentration and relative humidity were performed for two weeks between July / September 2021 (1st campaign) and December 2021 / January 2022 (2nd campaign). Due to COVID-19 restrictions in place at the time of testing, access to the buildings was limited. Therefore, checklists and surveys were filled with the users / owners through web-calls. Then the provided spreadsheets for calculating CARP and CORP were used with the collected data to quantify thermal comfort, indoor air quality, visual comfort and acoustic comfort as well as the overall comfort rating.

Romania (AAECR)

AAECR performed the testing of the comfort indicators in 4 different types of buildings: a SFH, a MFH, an office and a kindergarten/school. Measurements were performed for one week in March 2021 and one week in July/August 2021 for outdoor temperature, indoor temperature, indoor CO_2 concentration and relative humidity. During in-situ visits, architectural plans, checklists and surveys were filled with building characteristics and users' perception. Then the CARP and CORP tools were used with collected data and additional calculations to quantify thermal comfort, indoor air quality, visual comfort and acoustic comfort, leading to the overall comfort rating.

2.2 Results of the testing activities

Overall result of in-building tests

The implementing partners (IPs) rate the overall difficulty to implement the feature between “somewhat easy” (CRES, EASt), “neither easy nor difficult” (AAECR) and “somewhat difficult” (ADENE). To explain the feature to the assessors most IPs rated “neither easy nor difficult” (AAECR, ADENE, EASt), CRES rated it “easy”.

All IPs were able to perform all steps in the testing process in all buildings. At the same time challenges in the implementation of the testing activities have been identified.

The main challenges reported are related to the measurement of performance data in the buildings / apartments. On the one hand the measuring equipment must be available. Many assessors currently might not have the needed sensors. On the other hand, it is necessary to cover at least several days of performance measurement in periods that are representative for the overall comfort related situation. This can be challenging mainly due

to the limited time usually invested or expected for on-site visits and re-visits in course of EPC assessments.

Another challenge reported relates to the implementation of the survey or checklist on user perception. ADENE and EASt found it challenging to explain some sections to the building owners / users. Furthermore, due to COVID-19 restrictions part of the interaction with the building owners / users was only possible via web-calls.

Overall, IPs rate the feasibility to include the developed methodology into the standard EPC assessment between "somewhat practical" (AAECR, ADENE, CRES) and "very practical" (EASt).

Estimated time and costs per EPC

As written in the previous chapter performing the necessary measurements in the buildings (step 2 in the testing procedure) was a challenge reported by the IPs. Measurements at least for two periods must be conducted, one in winter, one in summer. Thus, sensors must be installed and deinstalled at least once, but most probably twice to be able to use the sensors the rest of the year for other measurements. For the installation and deinstallation of the sensors in the buildings between 15 minutes (ADENE) and 60 minutes per building (EASt, AAECR) have been reported. For the administration and data collection (step 1) between 15 minutes (EASt) and 4 hours (AAECR) per building were reported. The necessary time for performing the survey (step 3) and the checklists (step 4) for each building vary between 15 minutes (EASt), 30 minutes (ADENE, AEECR) and 40 minutes (CRES). For the rating calculation (step 5) per building between 15 minutes (EASt), 30 minutes (AAECR, ADENE) and 1 hour (CRES) were needed. In total this sums up to between 2 and 6 hours per building. Deviations between the reported numbers on the one hand show that different time allocations have been applied by the different testing organisations. On the other hand, it could also be an indication that there might be potentials to reduce the necessary time for assessing the suggested comfort rating, as the least time per building was needed by EASt, who tested the feature on 10 building, whereas the others on 4 buildings each.

The estimated costs per EPC for performing all the steps in the testing procedure range between 75 EUR (CRES), 85 EUR (AAECR), 100 EUR (ADENE) and 160 EUR (EASt). These costs do not include the equipment costs. By far the largest share of the costs with 50 – 59% of the total costs was reported for carrying out the measurements in the buildings.

Cross cutting criteria

Quality and reliability

All implementing partners agree that the calculation methods are well established and clearly described in the guidelines. However, some of required inputs were not fully clear to the IPs or did not cover all possible options. AAECR reported e.g. that triple glazed windows were not provided as an option in determining the acoustic comfort, EASt reported that natural ventilation calculation was a bit complex, but once performed for one case became

clear. All IPs agree that the results of the indicator calculations are shown transparently. EASt mentions that they missed an overall table with the sections results. The IPs also report that the data in the spreadsheets is in consistent format to increase interoperability. CRES reports that some bugs in the spreadsheet tool were identified.

User-friendliness

The IPs agree that the feature is explained in a straightforward language. AAECR, ADENE and CRES report that a glossary of technical terms is missing. ADENE hereby refers to the tool checklist and the survey. EASt reports that in the glossary provided in the guidelines some wordings were found to be missing. While ADENE didn't miss references to documents, AAECR and CRES suggest to also have references to documents in the spreadsheet tool.

IPs confirm that graphics are used that increase the user's understanding of the feature. ADENE suggest that a similar graphical representation as for the overall comfort indicator could be provided for each single indicator.

IPs also agree that the developed materials are flexible to be used in different building types.

Economic feasibility

The IPs agree that the implementation of this feature would increase the costs of the EPCs (see also the chapter on estimated time and costs). In all implementing countries the feature requires data that is currently not part of the EPC assessment. While AAECR, ADENE and CRES report that the time needed for gathering the missing data is above 1 hour, EASt state that these data can easily be gathered during on-site visits in below 1 hour. No additional on-site visits were needed in Austria as well as in Greece for the case that all information needed for the survey was collected during the first visit / assessor visit.

Measurements have been performed to gather data on temperatures, CO_2 and humidity. ADENE states that these measurements are the main barrier in implementing this feature. EASt mentions that real measurements tend not to be practical to provide the information for the comfort rating.

ADENE and EASt report that required measurement instruments are available below 200 EUR. EASt report that equipment with acceptable accuracy is available for below 150 EUR, ADENE states that equipment can be found for that price but not easily. In contrast, AAECR and CRES report that measurement equipment in their countries could not be found below 200 EUR. However, in Romania and Greece the required equipment was easily found on the market.

Consistency with ISO/CEN standards

In the implementation of the test only ADENE slightly adapted the feature to national standards. In Portugal currently the EPC methodology is adapted to include a thermal comfort indicator. This has been taken into account in the testing.

2.3 Conclusions and discussion

The method to derive a comfort indicator developed in X-tendo was tested in 4 implementing countries: Austria, Greece, Portugal and Romania. The overall implementation of the feature was perceived between "somewhat difficult" and "somewhat easy" by the different implementing partners (IPs).

The developed tool and guidelines were felt easy to use and relevant to the user when assessing the energy performance of a building. The tool is perceived as well established from the IPs. Still, a glossary of terms as well as references to documents could be provided in the tool itself to increase user-friendliness. Also, the tool is currently not adapted for the use with Apple computers.

The main challenges in the implementation of the feature into national EPC schemes in the test countries were related to the performance of on-site measurements. Hereby two main aspects have been reported: 1) the additional effort for installing and de-installing of equipment as well as the related costs for equipment and staff costs, and 2) the representativity of the measurement period for the average comfort in the building. ADENE, CRES and EASt report that especially the first aspect would be a relevant barrier to the implementation of the procedure into national EPC schemes. ADENE therefore suggest to only use the CARP methodology, not the CORP methodology.

3 ANNEX

3.1 Questionnaires

Table 3: Exemplary questionnaire for in-building tests

General questions and testing steps		
	Provide a short summary of the test you are carrying out. Please describe in your words.	
	Overall, how easy or difficult was the feature to implement? Please select an option.	
	How easy or difficult was it to explain the feature to the assessor and/or other stakeholders involved in delivering the test? Please select an option.	
	List all of the planned steps for implementing the feature. Please list performed tasks in each step	
	Were you able to perform each step? Please select an option for each step	
	[Only answer this question for options you selected "No" or "In part" in previous question] Why were you not able to perform or complete these steps? Please describe in your words.	
	[Only answer this question if you were able to perform the step and you faced any challenges] Did you face any challenges in steps that you were able to complete (for those you answered "Yes")? Please describe in your words.	
	Overall, how feasible is it to include the feature as part of a standard EPC assessment? Please select an option.	
	Explain your answer to the above question. Please describe in your words.	
Testing time & costs		
	How much time (in minutes) did it take to perform each step	
	What are the approximate costs incurred in each step? Please specify the positions as well as an approximate estimate. (Costs per EPC)	
Cross Cutting Criteria		
	Quality and Reliability	
		Are the calculation methods clearly described?
		Is the required input data clearly asked?
		Is the user provided fundamental technical knowledge needed to understand the details of the feature?
		Is training of experts/assessors needed for the feature?
		Are the results shown transparently?
		Does the user have access to formulas/application interface?
		Does the user have access to weightages for the calculation of results?
		Are measures foreseen to ensure that data collected is verified (e.g. completeness, accuracy timelines etc.)?
		Is training of experts/assessors needed for the feature?
	User-friendliness	
		Are the technical terms used provided in a glossary?
		Are the references to documents provided?
		Is the stepwise description for feature assessment provided?
		Are the results presented in graphical way?
		Did you consider the impact of graphical results on the user?

		Does the evaluation of the feature consider flexibility to adapt the methodology to different building types?
		Are the multiple-benefits (health, energy, cost saving etc.) of the feature studied?
	Economic feasibility	
		Does this feature increase EPC costs?
		Does the methodology require additional data to the one already included in current EPC derivation?
		If additional data is required, does it take longer than 1 hour to gather them?
		Is an additional on-site visit or measurement needed?
	Consistency with ISO/CEN standards	
		Have any national regulations been used in the methodology of this feature? If yes, which one?
		Is the data used for the feature already covered by the current EPC?
Final thoughts		
	Do you have any suggestions for improving this feature? For example, the description, recommendations, modules, or calculation methodology. Please describe in your words. Do you have any other comments? Please describe in your words.	

Table 4: Exemplary questionnaire for system test

Questions	
	Provide a short summary of the test you are carrying out. Please describe in your words.
	Overall, how easy or difficult was the feature to implement? Please select an option.
	List all of the key changes you planned to make to the existing 'back-end' EPC systems to enable the feature. Include all changes, whether they were successfully implemented or not. Please put a small description (5 words or less) for each change in a cell.
	Were you able to perform each planned change? Please select an option for each change.
	[Only answer this question for options you selected "No" or "In part" in previous question] Why were you not able to perform or complete these steps? Please describe in your words.
	What are the major challenges in implementing the new feature? Please describe in your words.
	What are the main advantages of the feature? Please describe in your words.
	Explain the major areas of monetary cost in implementing the new feature. Please describe in your words.
	What can be done to minimise the monetary cost in each area? Please describe in your words.
Cross Cutting Criteria	
	Quality and Reliability
	Are the calculation methods clearly described?
	Is the required input data clearly asked?
	Are the results shown transparently?
	Does the user have access to formulas/application interface?
	Does the user have access to weightages for the calculation of final results?
	Are the specific requirements to carry out the assessment outlined for assessors?
	Is training of experts/assessors needed for the feature?
	Are the qualification requirements clearly outlined for experts/assessors?
	User-friendliness
	Is the stepwise description for feature assessment provided?
	Are reporting templates used?
	Is the calculation/process description provided in guidelines?
	Does the tool have stepwise description of the assessment?
	Economic feasibility
	Does the implementing need additional infrastructure in the form of servers, programs, ...? If so, are these costs higher than €1000 to purchase, according to a rough estimation?
	Are there high skills (for example: IT and programming knowledge) required to implement and handle the feature?
	Consistency with ISO/CEN standards
	Have any national regulations been used in the methodology of this feature? If yes, which one?
	Is the data used for the feature already covered by the current EPC?
Final thoughts	
	Do you have any suggestions for improving this feature? For example, the description, recommendations, modules, or calculation methodology. Please describe in your words.
	Do you have any other comments? Please describe in your words.

Table 5: Exemplary questionnaire for user tests

Questions	
	Provide a short summary of the test you are carrying out. Please describe in your words.
	List all of the planned steps for delivering the test. Please put a small description (5 words or less) for each step in a cell.
	Were you able to perform each planned step? Please select an option for each step.
	[Only answer this question for options you selected "No" or "In part" in previous question] Why were you not able to perform or complete these steps? Please describe in your words.
	[Only answer this question if you were able to perform the step and you faced any challenges] Did you face any challenges in steps that you were able to complete (for those you answered "Yes")? Please describe in your words.
	How well did the users understand the feature? Please select an option. (Only answer if a question regarding perception was in the questionnaire)
	What did the test tell you about how much users find the feature useful? Please select an option.
	What did the test tell you about how much users liked or disliked the feature? Please select an option.
	What did the test tell you about how users would use the information provided in the new feature? Please describe in your words.
	List the headline quantified results from your test, for example, the percentage of users who found the feature useful. Please describe in your words. (Please provide at least the top 3 findings)
	Did users make any suggestions for changing the feature? Please describe in your words.
New questions	
	Please describe the participation in the survey (number of participants, potentially split to different target groups; share of returned questionnaires)
	Please describe the objective of the survey
	Please describe the main questions asked
	Please describe the main findings of the survey
	Please provide us with quantitative results in the form of additional xls file as much as possible (e.g. anonymised filled questions or aggregated results of the survey questionnaires)
Testing time	
	How much time (in minutes) did it take to perform each step
Final thoughts	
	Do you have any suggestions for improving this feature? For example, the description, recommendations, modules, or calculation methodology. Please describe in your words.
	Do you have any other comments? Please describe in your words.

X-tendo

eXTENDing the energy performance assessment and certification schemes via a mOdular approach

TU WIEN TECHNISCHE UNIVERSITÄT WIEN Vienna | Austria

AAECR Asociația Auditorilor Energetici pentru Clădiri din România

adene Agência para a Energia

BPIE

КАПЕ CRES

Danish Energy Agency

ENEA

ENERGIE AGENTUR Steiermark

energy saving trust

ethink ENERGY RESEARCH

NAPE NATIONAL ENERGY CONSERVATION AGENCY

Tartu Regiooni Energiaagentuur Tartu Regional Energy Agency

vito Energy Ville

www.x-tendo.eu

#Xtendoproject

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 845958.