X-tendo

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

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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.

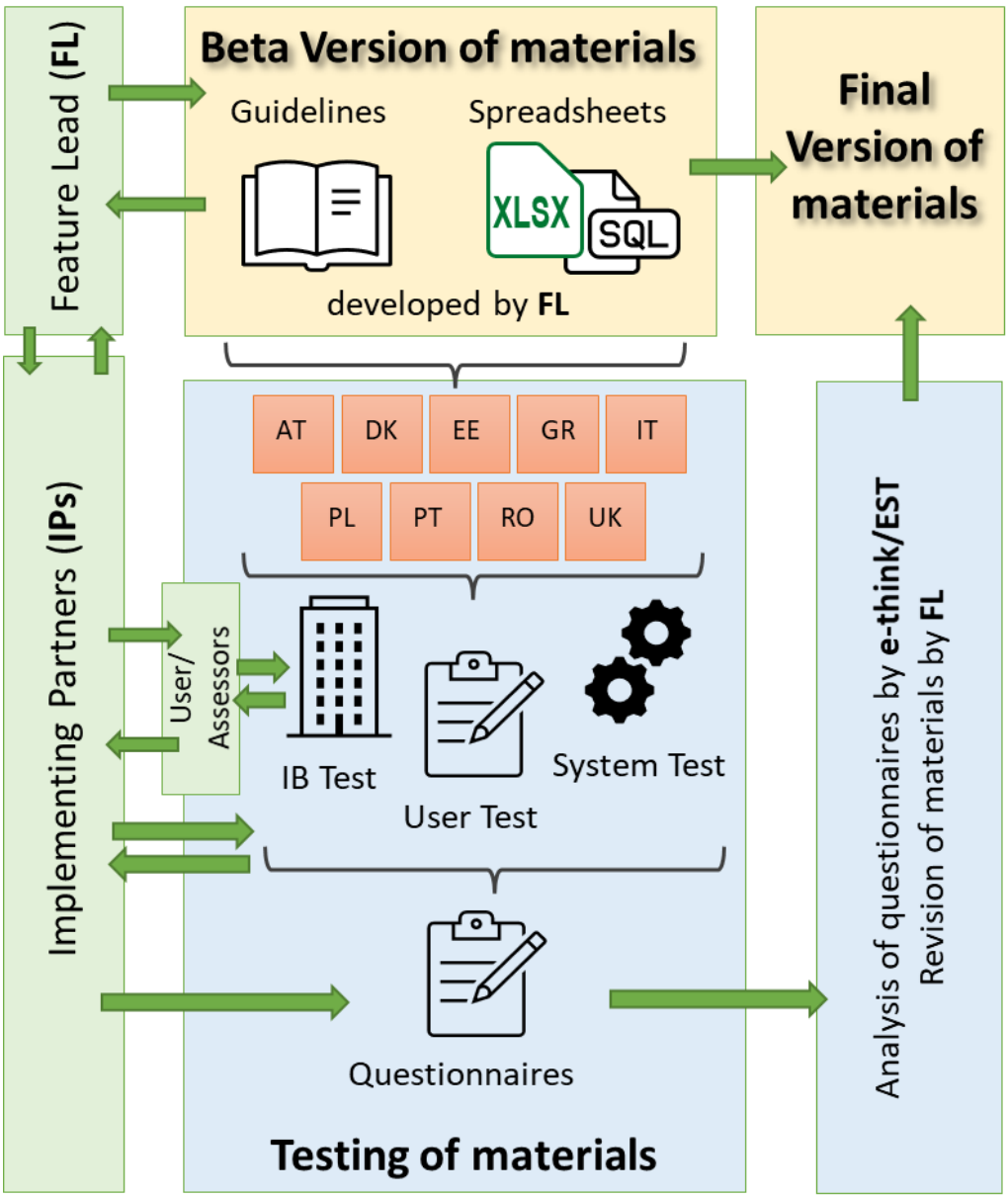

Figure 1: Approach for testing feature materials in the X-tendo project

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 7: BUILDING LOGBOOK

2.1 Introduction

Building logbooks are repositories for detailed building information, including energy performance data but can also include administrative data, material inventory, smart building aspects, history of maintenance and renovations etc. They act as a single point of input, access and visualisation of all the information associated with a building unit throughout its lifecycle. Over the lifespan of buildings, data is routinely gathered (manually and automatically) and can be made available for various stakeholders when they need it. However, despite its many benefits, only a couple of regions have building logbooks with multiple databases integrated and several functionalities (The Woningpas in Flanders, Belgium is probably the leading example). Much of the data currently collected goes unused as it gets discarded or forgotten or is not compatible with other stakeholders' systems and needs. The lack of an overarching structure shared across the built environment leads to information asymmetry, lack of transparency and higher risk for investment and renovation decisions.

Logbooks can enable better decision-making on the individual building level, including management of technical and functional aspects, safety, conservation of economic value, certification, and improved energy and environmental performance. Organised and shared data reduces uncertainty but also the time and cost needed for collecting missing information. In this sense, building logbooks can reinforce the successful implementation of all other X-tendo features.

Availability of granular performance and maintenance data in addition to the EPC could provide a more robust and reliable indication of energy performance and reduce data gaps about the building performance. Logbooks can enhance the overview of the entire building stock at all levels, allow public authorities to better tailor various measures, set benchmarks and strategies, as well as monitor progress towards climate goals (including through the national long-term renovation strategies).

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

The logbooks feature was tested in Estonia (TREA), Greece (CRES) and Portugal (ADENE). The countries had different starting points and logbook needs, which resulted in three different test scenarios. The ambition for the implementing countries was to take steps towards the full-fledged logbook concept.

Estonia performed a system test. Greece and Portugal performed system and user tests.

Table 2 – Description of F7 tests – building logbooks

Estonia (TREA)			Greece (CRES)			Portugal (ADENE)		
System test name	System test type	Description	System test name	System test type	Description	System test name	System test type	Description
EM Energiamonitor	Viability of new feature	Assessment of renovation cost based on expected result and logbook entries	F7.ST.01 Logbook software prototype	Software design and prototype development	Design of a Logbook Messaging Protocol that will describe the process will exchange data with the EPC database; Development of a prototype of a logbook software system.	F7.ST.01 Data integration;	Automatic EPC data integration into casA+;	Automatic EPC data integration into the building logbook;
						F7.ST.02 Functionalities development;	Development of the buildings components dashboard;	Buildings components dashboard where the user can access all the information available for his/her building;
						F7.ST.03 Functionalities development	Energy and water consumption data integration	Energy and water consumption data integration into the building logbook.
			User test name	User test type	Description	User test name	User test type	Description
			F7.UT.01 Logbook Features;	Identification of design elements of a logbook via Stakeholders consultations;	Discuss with stakeholders the proposed design elements of logbook features and get feedback.;	F7.UT.01	Logbook functionalities	Questionnaire on the user experience focusing in the 2 functionalities developed
			F7.UT.02 Logbook Interoperability	Stakeholders meetings	Demonstrate the system developed in 5.3-System Test and discuss with stakeholders how the link and the design of a standard web-service providing interoperability between a building logbook and an EPC registry could work.			

2.2 Results of the testing activities

Overall results of system tests

Portugal (ADENE)

In Portugal, the goal of system testing was to develop and implement two new functionalities, buildings dashboard and consumption monitoring, and to link these with the EPC database where possible. The buildings dashboard provides the building owner with access to all the logbook data for their building. Consumption monitoring integrates energy and water consumption data from the EPC database into the logbook.

ADENE described the implementation of these functions as 'very easy'. There were minimal challenges for ADENE in implementing the new feature, as the major developments for interoperability with the EPC platform had already been implemented.

The main advantages of the logbook features were to hold information related to a building in one location, and to allow the homeowner to add and modify information for their property.

Most of the cost involved subcontracting the technical team to develop and implement the logbook features in casA+, the existing one-stop shop (OSS). ADENE advised that the best way to minimise the costs is to plan and manage the technical development carefully, ideally

involving the technical design team for the OSS platform. This minimises effort and reduces costly mistakes and rework.

Clearly defining the data flow, data structure and data access for different stakeholders is important. Obtaining owner consent for sharing data under specific conditions is necessary. Where data was not already available via the webservice, it may be necessary to request additional data to be uploaded by building owners.

The duration of the testing lasted approximately from January 2021 until September 2021.

Greece (CRES)

In Greece, a logbook messaging protocol was designed to describe the data exchange with the EPC database; and a prototype of an online logbook management system was developed.

The key deliverables were the design of the logbook messaging protocol, and modification of the existing web service to accommodate the logbook, both of which were achieved. A Logbook Messaging Protocol was designed for the agreed architecture described in section 4.1.3 of the report "*Tools/IT-components and related documentation of the proposed calculation and data handling procedures to be tested in WP5*" (D.4.5 of the X-tendo project). The corresponding web service (logbook-ws) and the data provider application, needed for communication with the Greek EPC registry (buildingcert.gr) were both implemented. CRES described the implementation of these functions as 'neither easy nor difficult'.

The technical and practical viability of the proposed logbook design was assessed, taking into consideration the time, cost implications, integration with existing systems, access to data and data privacy issues.

The major challenges were in design of the protocol and the software to make them compatible with external applications of logbook data providers (e.g. Land Registry, Tax Dept., etc.).

The main advantages of the features were integration of building information into a central system owned and, with the potential to be directly operated by, the building owners themselves.

The timeframe for the logbook system and user testing activities lasted from July 2021 until December 2021.

The major costs were in the software design and development, and the collaborative work of the various stakeholders. These costs can be minimised using simple and widely adopted IT technologies.

Dissemination activities are needed in relation to building logbooks, as most of the stakeholders do not have a clear understanding of the logbook concept and its usefulness.

Estonia (TREA)

In Estonia, the aim of system testing was to calculate the cost of proposed future renovation works, based on physical parameters and the condition of a building, derived from building logbook entries on one hand, and a statistical analysis of detailed cost of renovation derived from a database of renovation tender bids.

Consumption data for a building, physical and technical parameters, and previous renovations, including the state of technical systems and components of a building envelope, are stored in a building logbook section of Energiamonitor application. In addition, there is a database of renovation of multi apartment residential buildings, Kredex, which includes renovation cost. The testing planned to demonstrate that the historical information in these data sources could be applied to proposed renovation plans and current costs to predict the cost of a desired renovation. Additionally, where financing is limited, testing planned to demonstrate that it is possible to identify which renovation works can be performed within the limit of available financing.

In Estonia renovation of multi apartment residential buildings is subsidised. The executive agency for the renovation is the Kredex Fund. KredEx also financially supervises the renovation process and carries responsibility for technical supervision. According to the rules of subsidised renovation all contracts must follow a tendering process provided by KredEx.

Due to rigid structuring of bids, it is possible to track the cost of specific parts of renovation works in relation to certain features of a building such as number of apartments, number of floors, living area, heated area, type of heating system etc. or combination of such features.

The key activities of testing utilised the existing logbook data and calculated the estimated cost of renovations. TREA described the implementation of these functions as 'neither easy nor difficult'.

The method was to select multi apartment residential buildings about to undergo renovation. Expected cost based on logbook data (current consumption, physical characteristics of building and technical systems) was calculated. The cost of renovation measures per square meter living area dependent on size of building was calculated. In cases of limited financing, the level of renovation possible within the available financing was calculated. Cost of renovation and price data was anonymised upon retrieval from databases. Costs for proposed renovation work were obtained through the official tendering process.

During testing a desktop application concept was established. The intention was to compare the calculated costs with the actual costs from the planned renovations, once complete, then to adjust the calculation scheme and the Energiamonitor application, where necessary. Due to unforeseen circumstances a key risk ('no buildings are about to be renovated') was realised. The concept was planned to be verified against real renovation projects but

unfortunately, there was no renovation grant available during testing phase and consequently no renovations of multi apartment buildings (at least not linked to the subsidies handled by the KredEx fund). However, occasional questioning of apartment associations has proved this kind of indicative renovation cost calculation application to be useful for aligning renovation plans with available financing.

There were two key risks identified. The first key risk was in identifying a sufficient number of multi apartment buildings ready to undergo renovation between August and October 2021. The expected risk triggers were withdrawal of subsidies or lack of construction capacity. The second key risk was that the construction market in Estonia would undergo drastic changes during the testing period, triggered by a shortage of construction materials or a change in legislation, which might skew the results. The risk mitigation was to use historical data instead of current tenders.

The main challenges were in the reliability of the data sources and the delay to building renovations caused by the triggering of the second key risk during the pandemic, delaying the actual building renovations beyond the timeframe of the project. The main benefits were in the ability to utilise generalised logbook data.

The timeframe for the testing lasted between May 2021 until October 2021. Yet, TREA is continuing to work to amend the Energiamonitor to include the data that wasn't possible during this project period. Certain tasks could not be performed within the timeframe of X-tendo, as a result of the delays to renovations in Estonia.

The main cost was in the information technology application, for setting up a data matrix for retrieval of historical data and in retrieving renovation measures and related cost data from building logbooks (Energiamonitor + Kredex database).

TREA advised that it is not entirely clear whether the logbook feature is meant as a support for calculating and issuing the EPC, or whether it is meant to be an integral part of the EPC and influencing the overall EPC value. In both cases a unified form of logbook would be essential. This appears to be an impossible task, considering the huge differences among member states.

Overall results of user tests

Portugal (ADENE)

In Portugal, registered homeowners and companies who are user beneficiaries of the pre-existing one stop shop, casA+, were invited to evaluate their experience of newly developed building logbook features for buildings dashboard and consumption monitoring. Their feedback provided recommendations on including these types of functionalities in building logbooks and linking these to the EPC database where possible.

User engagement obtained feedback by survey. The user respondents list for the survey questionnaires was prepared using the existing casA+ database of registered homeowners

and companies. Initial questionnaires were designed to investigate homeowners' current perception of casA+ and resulted in the proposed buildings dashboard and consumption monitoring functionalities. Subsequent questionnaires investigated the user's experience of the implemented buildings dashboard and consumption monitoring functionalities.

Homeowners were required to register in casA+, agree with the portal privacy policy and give consent to casA+ for collection of personal data, in compliance with data protection legislation, as a pre-requisite for testing the functionalities and providing feedback.

Based on user survey results, it was decided to implement 2 new functionalities for Buildings Dashboard and Consumption Monitoring.

The main findings of the questionnaires were as follows:

The user respondents appeared to understand the features well, 'somewhat' liked the features and thought they would be useful. The homeowners would use the feature to know more about their house (93%) and provide a general view of their consumption (80%). They thought they would still find it useful even if they had to manually register some information (e.g., appliances, illumination) (87%).

94% of respondents found that both the Buildings Dashboard and Consumption Monitoring functionalities developed under this feature will be useful.

Homeowners will use the feature to understand more about their house (93%) and consumptions (80%). The feature could be used to reduce their consumption, whether acting at the behavioural level or by adopting improvement measures in their house (87%).

Respondents consider the information provided very useful (94%) highlighting the clarity/organization of the contents presented (87%) to be crucial for enabling understanding of the feature.

The duration of the testing was approximately 4 months (September 2021 until January 2022).

The challenges were, due to changes in casA+ data privacy policy, a larger sample of users was required for the second round of questionnaires, which increased the duration of the testing. Despite this, the number of respondents was considerably smaller than for the initial round of questionnaires. There was difficulty obtaining timely feedback from questionnaire respondents. The mitigation plan for this identified additional respondents among ADENE employees, to supply the necessary feedback. The recommendation is to follow a UEQ strategy and to consult the target audience, if necessary.

The main suggestions for improvement of the casA+ logbook were:

- Increase the number of installers/companies registered and their contacts information.
- Provide faster access to the contents.
- Simplify the registration of additional information (e.g., illumination, appliances).

- Include references for comparison to benchmark the information with other buildings, for example: when presenting energy and water consumption, home owners would like to see a reference value of water/energy consumption from a similar house, or a reference number for more efficient consumption in a similar house for comparison.
- Collect consumption data automatically from the utility.

These suggestions could be useful requirements or potential improvements for logbooks in general.

Greece (CRES)

In Greece, the objective of user testing was to understand and document the effect of the logbook design elements on the work of stakeholders and administrators. CRES engaged these two user groups to obtain input to the proposed design elements of logbook features, and the design of the standard web-service providing interoperability between a building logbook and an EPC registry. The engagement consisted of one-to-one web meetings with users to discuss how the developed features would affect their work, followed by a questionnaire to obtain user feedback.

Ten administrator and stakeholder users were engaged in webinars and as questionnaire respondents. Two to three administrator respondents were IT system and database administrators working for public authorities administrating the EPC Registry, for example, as government personnel supervising the registry and checking the validity of EPCs. The remaining five to six stakeholder respondents were working with EPCs, as energy auditors, energy inspection software developers, researchers working on building energy issues and technical administrators of public buildings. The designs of the questionnaires were tailored for each of the two respondent groups – administrators and stakeholders. Data privacy legislation and policies were adhered to.

The duration of the user testing was approximately a month with additional time for analysis and reporting.

There were two main risks. The first main risk was low participation in web meetings which was mitigated by holding one-to-one meetings. The second main risk was limited feedback from questionnaire respondents, which was mitigated by more intensive communications.

The 10 respondents chosen had different scientific and professional profiles and therefore, certain questions in the surveys were only relevant to specific subgroups of respondents, which posed a challenge.

The stakeholder respondents appeared to understand the features well, liked the features well and thought they would be useful. The responses indicated that the logbook would be useful functionality for building owners; and would facilitate interoperability between public sector IT applications.

The conclusion is that a central building logbook would be beneficial. The logbook should be implemented by a governmental agency, and extensible by others. There is need for relevant legislation to support this. At a technical level, the RESTful-JSON architecture is the best solution for communication between the logbook components. CRES recommended that the logbook could be improved by establishing data exchange standards for building data, for example, gbXML should be explored.

Cross cutting criteria

Quality and Reliability – System Test

All implementing partners advised that the required input data was clearly requested, and results were shown clearly. TREA had measures to ensure that the data collected was verified (e.g., for completeness, accuracy and timeliness). ADENE had similar measures, and some data input was limited to specific options, rather than free text. ADENE did not attempt to improve the data quality (e.g., interpolation, removing outliers etc.). TREA partly improved the data quality but considered that it is possible that "improving data quality" does not apply to certain items in building logbooks, such as historical data. CRES and TREA reported the data to be in a consistent format, improving interoperability. ADENE found this to be only partly true, when inputting and extracting data directly from the EPC database.

Quality and Reliability – User Test

ADENE reported that the required input data for user testing was clearly requested, and results were shown clearly. However, measures to ensure that data collected was verified for completeness, accuracy and timeliness were only partly foreseen. Similarly, data was not always in consistent formats to facilitate interoperability. Measures to improve data quality, such as interpolation, removing outliers (etc.) were not planned.

CRES concluded that legislation is required to ensure that data collected is verified, e.g., for completeness, accuracy and timelines. Data was only partly in a consistent format to facilitate the level of interoperability between logbook components, and better consistency would reduce the possibility of incorrect data and improve data quality.

It is clear that the building logbook doesn't improve the quality and reliability of the EPC itself, but it can be used in an effort to enhance quality and reliability of the frameworks. For example, including real-time energy data in the logbook could help address the issue of the "performance gap" and overall contribute to a better understanding of our buildings.

User-friendliness – System Test

ADENE and TREA thought that the feature was explained in clear, easy to understand language. TREA had a glossary containing the technical terms, but ADENE did not. ADENE provided references to required documents. TREA found that some documents behind numeric results, for example for the EPC, were difficult to locate. ADENE had access to graphics to help them understand the feature, but TREA did not. For ADENE, the results were

presented in graphical way. This was partly true for TREA, although some data could not be presented graphically.

ADENE's logbook is purely aimed at homeowners and their residential buildings but could be adapted to other building types. In Estonia, requirements for application of the logbook to other building types were clearly outlined, but a universal logbook would need to include more comprehensive information.

The economic calculation by TREA includes benefits that help to promote the use of building logbooks, although other promotion methods, such as benchmarking, and monitoring are considered more useful.

TREA advised that the user benefits in additional non-financial ways following logbook assessments.

User-friendliness – User Test

ADENE reported that the logbook features were explained in straightforward language, the references to documents were provided, graphics were used to increase user's understanding of the feature and results presented in graphical way. However, the technical terms used were not provided in a glossary. The logbook functionalities can be adapted to other building types in future. However, the current logbook is orientated towards homeowners and therefore the focus is on residential buildings.

CRES reported that the feature was explained in straightforward language. However, the technical terms used were not provided in a glossary. The user benefits from IT functionality for managing building data in the logbook.

Economic feasibility – System Test

None of the implementing partners considered that the building logbook increased EPC costs.

However, they did see a need for additional EPC data. Data for linking to external databases, for Land Registry number, Owners' VAT number, etc. was suggested by CRES. External information on specific cost of renovation works was suggested by TREA. ADENE suggested that homeowners should be able to add information. Gathering this extra data was expected to take less than an hour, with no additional on-site visit or measurement required, except for the data suggested by TREA, where on-site testing might be required.

Economic feasibility – User Test

ADENE concluded that this feature does not increase EPC costs. It uses EPC data directly, but it is not mandatory to have an EPC. The methodology partly requires additional data to that already included in current EPCs, but the homeowner can also add information to that currently made available through the EPC. Gathering this additional data does not take longer than 1 hour, and no additional on-site visit or measurement is required.

CRES concluded that this feature does not increase EPC costs. The methodology requires additional interoperability data in addition to that already included in current EPC. However, gathering the additional data does not take longer than 1 hour, and no additional on-site visit or measurement is required.

Consistency with ISO/CEN standards – System Test

All implementing partners reported that the data required is only partly covered by the existing EPC. ADENE suggested that, in Portugal, energy consumption, water consumption, lighting and appliances information should be added by the homeowner. CRES advised that some required data is currently not included or only optional (e.g., Land Registry number). TREA advised that previous renovation information is not included in the EPC.

Consistency with ISO/CEN standards – User Test

ADENE concluded that the data required for their feature is already covered by the current EPC.

CRES concluded that data required for their feature was not already covered by the current EPC.

2.3 Conclusions and discussion

The concept of building logbooks is not universally well understood. In Greece, CRES discovered that most of the stakeholders did not have a clear understanding of the logbook concept and its usefulness. Understanding of the concept of building logbooks could be improved by dissemination activities. The launch of a building logbook ought to be accompanied by an information campaign, which successfully been achieved in Flanders, Belgium.

In Estonia, TREA advised that it is not entirely clear whether the logbook feature is meant as a support for calculating and issuing the EPC, or whether it is meant to be an integral part of the EPC and influencing the overall EPC value. TREA advised that, in both cases, a unified form of logbook would be essential, but this appears to be an impossible task, considering the huge differences among member states. Public authorities that are planning to launch a building logbook are advised to first identify their main purpose of introducing the instrument. The identified benefits must be larger than the incurred cost.

In relation to system testing, a common finding was that most of the costs were absorbed by ICT subcontractors and in the production of ICT systems. ADENE advised that the best way to minimise these costs is to plan and manage the technical development carefully, ideally involving technical design teams already familiar with the platforms being integrated, to reduce effort, costly mistakes and rework. CRES found that the major challenges were in design of the protocol and the software to achieve interoperability with external applications of logbook data providers (e.g. Land Registry, Tax Dept.). CRES found that the major costs were in the software design and development, and the collaborative

work of the various stakeholders, and that these costs can be minimised using simple and widely adopted IT technologies. TREA found that the main cost was in the information technology application, for setting up a data matrix for retrieval of historical data and in retrieving renovation measures and related cost data from building logbooks (Energiamonitor + Kredex database).

ADENE found that clearly defining data flow, data structure and data access for different stakeholders is important. Obtaining owner consent for sharing data under specific conditions is necessary.

ADENE found that testing was made easier when there is a pre-existing one stop shop, with a database of contacts in place.

CRES advised that the logbook should be implemented by a governmental agency, and extensible by others. There is need for relevant legislation to support this. At a technical level, the RESTful-JSON architecture is the preferred solution for communication between the logbook components. CRES recommended that the logbook could be improved by establishing data exchange standards for building data, for example, gbXML should be explored.

Another common finding for IPs was that interoperability between systems was easier to achieve when at least one of the systems already held the required data.

In relation to the user testing, the main challenges were in obtaining sufficient responses to surveys and working within data privacy and security policies.

ADENE found that due to changes in casA+ data privacy policy, a larger sample of users was required for the second round of questionnaires, which increased the duration of the testing. Despite this, the number of respondents was considerably smaller than for the initial round of questionnaires. There was difficulty obtaining timely feedback from questionnaire respondents. The mitigation plan for the risk of low user responses identified additional respondents among ADENE employees to provide necessary feedback. The recommendation is to follow a UEQ strategy and to consult the target audience, where necessary.

CRES found that the more varied the sub-groups of user contacts, the more varied the requirements will be from the functionalities provided.

To mitigate the risk of low participation and reduced user feedback, CRES engaged their respondents using one-to-one web meetings and relatively more intensive communications.

The user testing in Greece involved respondents with varying scientific and professional profiles. This required questionnaires to be tailored for the different audiences which increased the complexity of testing.

The responses CRES received indicated that user respondents appeared to understand the features well, liked the features well and thought they would be useful. The responses indicated that the logbook would be useful functionality for building owners; and would facilitate interoperability between public sector IT applications.

ADENE found that the main suggestions for improvement from users were:

- Increase the number of installers/companies registered and their contacts information
- Provide faster access to the logbook contents
- Simplify the registration of additional information (e.g., illumination, appliances)
- Include references for comparison to benchmark the information with other buildings, for example: when presenting energy and water consumption, homeowners would like to see a reference value of water/energy consumption from a similar house, or a reference number for more efficient consumption in a similar house for comparison.
- Collect consumption data automatically from the utility.

There are clear advantages to building owners, and other organisations requiring building information, to have building information accessible in one location. Building owners were enthusiastic about data being visible in a single location and the ability to update that information. ADENE found that the main advantages of the logbook features were to hold information related to a building in one location, and to allow the homeowner to add and modify information for their property. CRES found that the main advantages of the logbook features were integration of building information into a central system owned and, with the potential to be directly operated by the building owners themselves. TREA found that the main benefits were in the ability to utilise generalised logbook data.

The conclusion of IPs is that a central building logbook would be beneficial, supported by relevant legislation. There was agreement between all IPs that legislation, policies and standards were essential in relation to building logbooks. For easy and efficient interoperability between systems, data exchange standards are required. Legislation is required to govern data security and privacy.

CRES discovered that most of the stakeholders did not have a clear understanding of the logbook concept and its usefulness and suggested that understanding of building logbooks could be improved through dissemination activities.

TREA advised that more clarity was required in the relationship between the building logbook and EPCs, and that a unified form of logbook would be essential but challenging to implement across member states.

CRES suggests establishing data exchange standards for building data, for example, using gbXML. For easy and efficient interoperability between systems, data exchange standards are required.

In relation to calculation of future building costings, TREA advised the simplest and roughest approach for calculations would be to calculate a statistical average of a full renovation of

residential multi apartment building per square meter of area (net closed area; living area; heated area). Obviously, this kind of statistic simplification will serve its purpose in cases of large scale approximations but is not helpful for homeowners of a particular building. The next steps will be taken in two directions:

- Specifying the renovation works needed for a particular “standard” building to achieve an excellent renovation status
- Calculating correction factors for different renovation works for different sizes of buildings.

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.

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