X-tendo

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

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
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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
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Date	15.3.2022
File Name	X-tendo_Deliverable 5.2

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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.

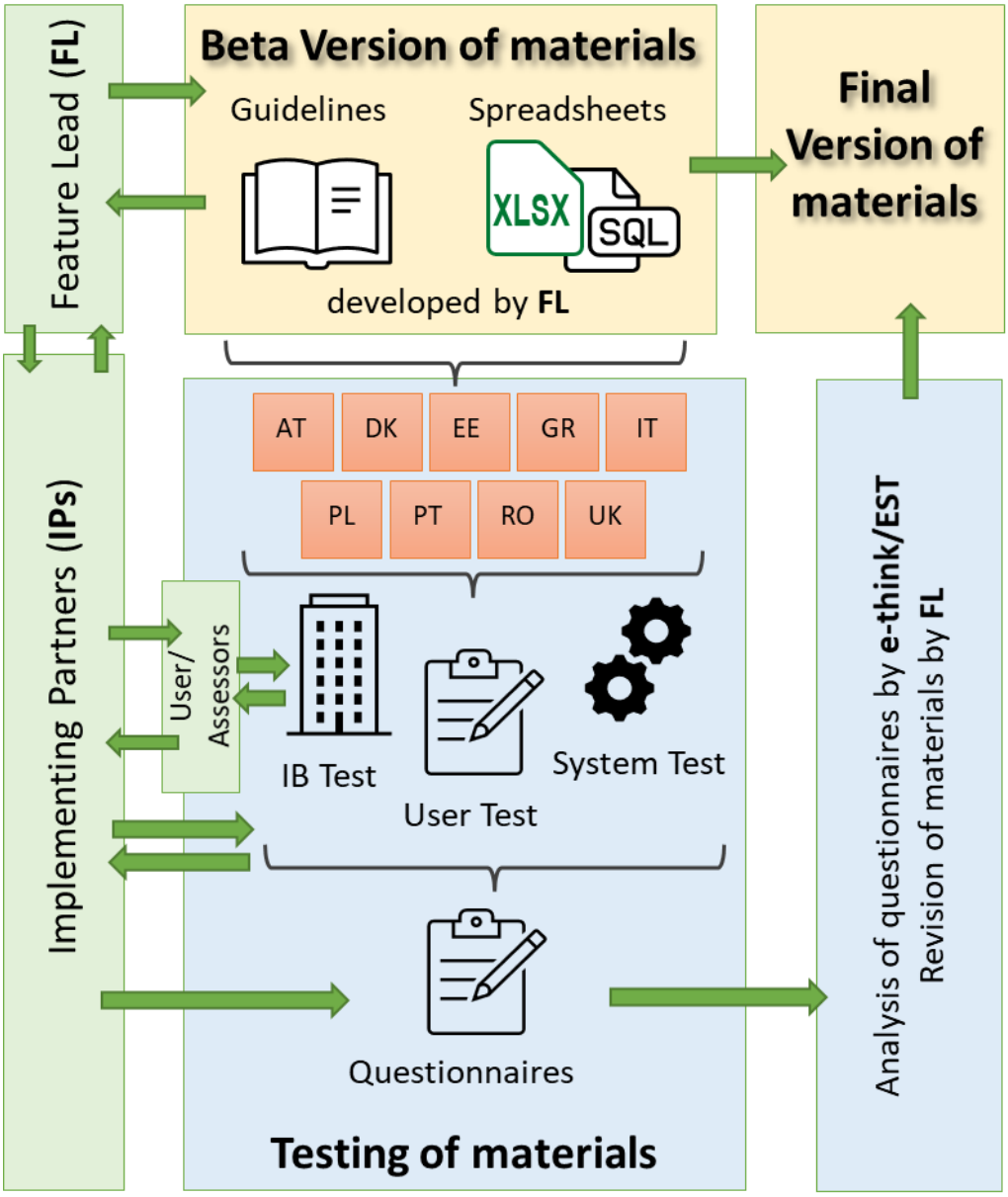

Figure 1: Approach for testing feature materials in the X-tendo project

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 3: OUTDOOR AIR POLLUTION

2.1 Introduction

Air pollution is one of the most important environmental risks to human health and is perceived as the second biggest environmental concern for Europeans, after climate change. In 80% of cities in the EU with available data, the recommended World Health Organization (WHO) levels of pollution have been exceeded. In many cases, people are unaware that they are breathing polluted air. They also do not know that their actions can directly influence it. Buildings affect both the quality of the outside air (pollutant emission) and the purity of the indoor air (air filtration). Currently there is no method to estimate the building's influence on local smog development or its air filtration system's effect on indoor air purity.

In course of X-tendo two indicators for measuring air pollution with the aim to integrate them into the standard EPC assessment have been developed: 1) The Local Air Pollution Contributor Index (LAPCI), and 2) Indoor Air Purity Index (IAPI). Both are assumed to increase the awareness of building owners and users on the impact of their buildings on smog development as well as the air- filtration efficiency. This should encourage people to take action to eliminate the sources of local emissions of pollutants and to use efficient air filtration systems where necessary.

The LAPCI and IAPI methodology can be applied to both residential and non-residential buildings, as it does not depend on building function but on the type of energy sources (e.g., local gas boiler, district heating substation, electrical grid) and on the air filtration devices in mechanical ventilation systems. The methodology can be used to assess new buildings, existing buildings and buildings under renovation. It is suitable for buildings located in rural areas, where individual energy sources dominate, and in urban sectors where centralised systems (district heating networks) are present.

The IAPI takes into account air filtration, so is applicable only when mechanical ventilation is present in the assessed building. The LAPCI can make building owners or users take action to modernise their buildings, leading to diminished energy needs and/or less polluting energy sources, while the IAPI can persuade them to invest in mechanical ventilation with effective air filtration.

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

Feature 3 was tested in Poland (NAPE). NAPE undertook an in-building test on multiple buildings and - as a user test – a survey of energy auditors. The following table shows an overview of the buildings selected for in-building tests on this feature.

Table 2 – In-building test objects for F3 – Outdoor air pollution indicator

Poland (NAPE)		
building category	**const. year**	**type**
MFH	2002	B
MFH	1930	B
MFH/Public	1988	B
School	1979	B
School	1979	B
Office	1986	B
Health-care	1953	B
Health-care/Residential	1974	B
Health-care/Residential	1975	B
Cultural center	1920	B

B … whole building

The steps for the **in-building tests** of this feature were the following:

1. Administration / data collection – including gathering of building data, distribution of tasks and establish a testing strategy
2. Assessor evaluation – including on-site visits and the evaluation of the assessor
3. Calculation – including the entry of inputs into the calculation sheets and performing the calculation of the indicators

The Local Air Pollution Contributor Index (LAPCI) was tested on 10 buildings from different types: 3 residential buildings (2 multi-family, 1 residential/public building), 3 health-care buildings (2 of them are healthcare/residential), 1 office, 1 cultural centre, and 2 schools. For each of the buildings the building documentation has been collected.

The Indoor Air Purity Index (IAPI) was tested on residential buildings (single-family houses) in 6 different locations. The only difficulty was determining the air pollution in the case that data was not available for a given location (the building was far away from the location with available data).

As a **user test** a survey within energy auditors was performed. Energy auditors were motivated to test the tool and afterwards fill a questionnaire. The intention was to receive feedback on the understandability and user-friendliness of the developed tool. The survey hereby was divided into three parts:

1. Basic information about the respondents
2. Questions related to the Indoor Air Purity Index
3. Questions related to the Local Air Pollution Contributor Index

The sections related to the indices was divided into three parts: feedback on input and calculation sheets, feedback on output sheets, and general feedback. In total the survey consisted of 25 questions. For most questions different options were defined as answers to choose from, providing the possibility to add comments. The invitation to participate in the survey was sent out to around 2000 persons. The target was to have at least 30 respondents.

2.2 Results of the testing activities

Overall result of in-building tests

NAPE found it "somewhat easy" to implement the feature and to explain it to the assessors. All steps of the testing procedure were possible to perform. The only difficulty reported was to determine the air pollution for the Indoor Air Purity Index in case that data was not available for a given location, i.e. when the building was far away from the nearest location with available data.

The testing also revealed for the Local Air Pollution Contributor Index that sources based on the combustion of fuel oil receive a much worse rating than those based on gaseous fuel. This is caused by a large disproportion between NO_x and SO_x emissions between fuels.

Overall result of user tests

In total 31 filled out questionnaires were received in the survey. Most of the respondents were energy auditors (21), some of them installation designer (8) and 2 university researchers. Most of them indicated a background in HVAC engineering (18) and in environmental engineering (17). Most respondents report over 10 years of experience with EPCs (19) with plenty (11) or some (6) experience in EPC calculation.

Local Air Pollution Contributor Index

Most of the respondents rate the understanding of user guide (25) and calculation tool (27) good or very good. Nearly 60% of them needed less than 1 hour for the calculation with the tool. Most of the participants of the survey reported that they did not (12) or sparsely (11) encounter difficulties obtaining the required data and that most (16) or all (6) data was available when issuing an EPC. 22 respondents rated the understandability of the method good or very good, 29 rated the understandability of the results good or very good. Overall, more than 75% of respondents rate the tool useful or very useful.

Indoor Air Purity Index

Most of the respondents rate the understanding of user guide (24) and calculation tool (28) good or very good. 16 participants of the survey reported that they did not or sparsely encounter difficulties obtaining the required data, 12 reported some difficulties and 3 plenty of difficulties. 23 respondents rated the understandability of the method good or very good, 29 rated the understandability of the results good or very good. Overall, around 2/3 of respondents rate the tool useful or very useful.

Estimated time and costs per EPC

Depending on the case between 20 and 80 minutes were needed for data collection and between 10 and 30 minutes for application of the spreadsheet tool. Around 50 EUR additional costs per EPC were estimated by NAPE.

ross cutting criteria

Quality and reliability

NAPE found that the calculation methods are clearly described, and the required input data is clearly asked. Also, the results are shown transparently, and the user has access to weightages in the tool. They have a partly access to formulas. For the Local Air Pollution Contributor Index the user can select two methods of determining the reference emission, for the Indoor Air Purity Index the user can select default values of the filtration efficiency or use his own values (if they are known). The user is provided with fundamental technical knowledge to understand the feature and has access to reliable information.

User-friendliness

Graphs are used to increase the user's understanding the feature. The feature considers flexibility to be adapted to different building types. However, it is reported that for the Indoor Air Purity Index it was not clear what to do in case that the building has mechanical ventilation with a filtration system only on a part of the usable area, not on all the area.

A stepwise description of the feature assessment and the incurred calculation process is provided in the guidelines as well as in the spreadsheet tool.

Economic feasibility

The feature would increase the costs of EPCs mainly due to the need to collect additional data. For the Indoor Air Purity Index the value of the annual mean concentration of PM10 and PM2.5 for a given location and information about the air ventilation filtration system in the assessed building must be compiled. However, it is estimated that in most cases this does not take longer than 1 hour. Further on-site visits, additional infrastructure in the form of servers etc. or high skills of the assessors are not needed. Overall, it is estimated that the EPC costs for end users will increase around 20 EUR.

Consistency with ISO/CEN standards

NAPE reports that no national regulations have been used in the methodology of this feature and that there are no restrictions in changing the methodology to own needs.

2.3 Conclusions and discussion

The method to calculate the Local Air Pollution Contributor Index (LAPCI) and the Indoor Air Purity Index (IAPI) was tested in Poland via two different types of tests: in-building tests in 10 different buildings in different locations, and a user test consisting of a survey within energy auditors that were invited to test the tool.

The tool and the guidelines were overall rated as well understandable and useful for both indicators. It was estimated that the additional costs per EPC would be around 20 EUR for end-

users. Challenges were identified for certain cases like finding air quality data for locations where no measuring points are nearby. Also, the interface with the European Environmental Agency did not work partly when the tool was used, and it was suggested to add a glossary of technical terms.

As a future direction for testing the recommendation could be piloting at scale with building owners.

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

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AAECR Asociația Auditorilor Energetici pentru Clădiri din România

adene Agência para a Energia

BPIE

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