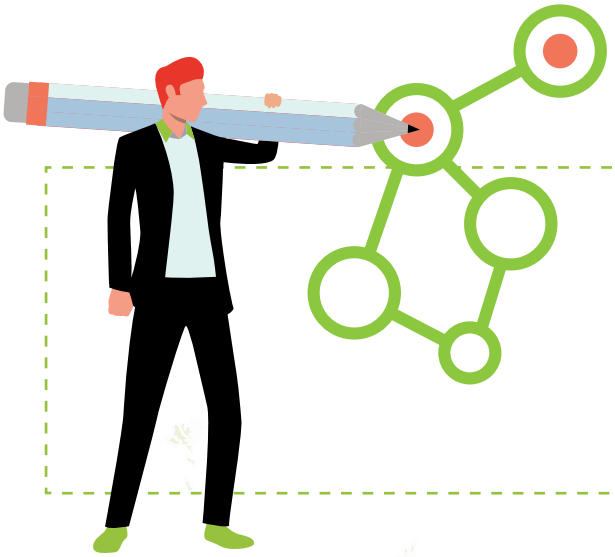

X-tendo

FEATURE 2:
COMFORT INDICATOR

Implementation guidelines and replicability potential of the innovative features for the next generation EPCs

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

BPIE

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CONTENTS

EXECUTIVE SUMMARY

Energy performance certificate (EPC) schemes have not evolved much since their first introduction in the Member States to meet the mandatory requirements set out under the Energy Performance of Buildings Directive (EPBD). With the recent revision proposal of the *EPBD* it has become more important to focus on EPCs critically and increase their usability for stakeholders. Stakeholders have questioned their reliability but at the same time, they have been useful for the real estate industry. All the Member States have legislation in place and existing infrastructure or systems to run EPC schemes. These schemes must evolve with the changing needs of the built environment and consider elements such as enhanced indoor comfort, reducing air pollution and financing options. This should occur alongside energy consumption analysis giving impetus to renovation rates of Member States towards achieving EU 2050 decarbonisation goals for the building sector set out under the *European Green Deal.* Public authorities view EPCs as potential instruments to improve the performance of existing building stock and deeper renovation. Extending the functionalities of existing EPC systems will create several pathways to update and manage next-generation EPCs.

This report presents the implementation guidelines and replicability potential of ten innovative features proposed within X-tendo: (i) smart readiness, (ii) comfort, (iii) outdoor air pollution, (iv) real energy consumption, (v) district energy, (vi) *EPC databases*, (vii) *building logbook*, (viii) *enhanced recommendations*, (ix) *financing options*, and (x) *one-stop-shops*. The outcome of this report is a critical presentation of the barriers and drivers for each feature's wide uptake, their impact if implemented by Member States and the necessary next steps in order to implement the innovative features in certification schemes around Europe. The developed features were tested in nine countries: Austria (AT), UK-Scotland (UK), Italy (IT), Denmark (DK), Estonia (EE), Romania (RO), Portugal (PT), Poland (PL) and Greece (GR). Then the experts who tested them provided deeper insights, appropriate directions and policy perspectives which provided a realistic estimation for its implementation and replicability across different Member States. The replicability potential is mainly analysed based on qualitative information collected from previous investigations in the project and extensive focus groups within project implementing countries. However, an estimation of the quantitative effects of the implementation of innovative features into the EPC schemes is also performed for X-tendo countries based on the results of the testing activities together with use of a building stock model.

Some general conclusions derived for all features include:

- New or revised EPCs must not be burdened with a lot of new information for the end-user. Information on the first page must be prioritised for the end-user application. Thus, which information is presented on the EPC (on paper) and which on the digital EPC or digital building logbook (DBL) should be considered.

- Automation and simplification of procedures is necessary in overcoming major issues regarding interoperability and data exchange.

- User-friendliness of features is highlighted as one of the most important drivers during tests of all features and more research is needed in this regard, because so far, the features were tested with experts, not with end users.

- EPCs must be coherently linked to other instruments such as DBL and building renovation passports to increase their impact.

- Training is required for some features to upskill and improve the competence of the workforce responsible for delivering EPCs. Some features do not require training at all, while others have either simple or complex methods that require different training needs.

- All the features are compatible for different building typologies. For some features, X-tendo developed two calculation methods, one is more simple and requires low effort, while the other is complex and more reliable. Each method can fit different building typologies (e.g. a detailed SRI is needed for large commercial buildings whereas CARP and CORP can be used for school, office and residential buildings).

X-tendo features were developed from this perspective to empower the end-user with more information and help them take necessary actions for renovation. All the features have been found to have relevance in the test countries with differences in needs and application. The X-tendo project has identified a series of recommendations for policy uptake and formulation that would be beneficial in the implementation of new features:

- Establish simplified procedures at MS level to update the EPC with new features followed by individual and detailed studies at national level.

- Recognise the strengths of existing EPC best practices and provide necessary resources for the transfer of knowledge from front runner countries. Use this process to adapt new features for EPCs.

- Conduct detailed assessments of existing EPC input data and prioritise new features with significant overlap of data input with EPCs. In addition, prioritise outputs relevant to the end-user on the EPC. Information relevant for public authorities can be made available on the attachment or DBL.

- Promote the implementation of new features using market and non-market mechanisms to raise awareness among the public and other relevant stakeholders.

- Conduct cost-benefit analyses at a national level to determine the feasibility of features and their economic impact to build trust in markets.

- Carry out selective implementation and independent pilot studies in national contexts to support MS individual policy goals.

- Set up more ambitious and rigorous quality check mechanisms in EPCs, the EPC database and check consistencies within and between databases.

- Require businesses to work on creating an environment and enabling conditions to support job creation and increase investments in renovation with features such as DBL and OSS.

1 INTRODUCTION

This report brings together the outputs of the evaluation of the test projects (T5.2) alongside the insight from end-users and stakeholders gathered in WP6 (Communication and Dissemination) and from end-users in WP2 (Exploring the principles of next-generation EPCs), and include estimations of:

1. The barriers and drivers for the wide uptake of each of the 10 features.
2. The effects (in quantitative and qualitative terms) of the wider implementation of the developed innovative features of EPCs in Europe.
3. The necessary next steps in order to implement the innovative features in the certification schemes around Europe, in particular assessing staff and training needs.

The replication potential is mainly analysed based on qualitative information collected from previous activities in the project and extensive focus groups within project implementing countries. However, we have also estimated the quantitative effects of the implementation of innovative features into the EPC schemes, based on the results of testing activities in the previous task (T5.1 and T5.2) together with the use of a building stock model. An assessment has been carried out on the potential future number of EPCs with the innovative features developed throughout the course of this project. It forms the basis for the identification of the capacity-building implications for delivery bodies, particularly staff and training needs.

Table 1 provides an overview of the 10 innovative features developed in the project X-tendo and tested by partners with relevant expertise in 9 countries: Austria (AT), UK-Scotland (UK), Italy (IT), Denmark (DK), Estonia (EE), Romania (RO), Portugal (PT), Poland (PL) and Greece (GR).

Based on the methodologies of the developed features, three different test categories were used:

- **In-building testing:** In existing buildings this involved testing the new features in use by assessing the time required and viability to collect new data points as part of, or in addition to, a conventional EPC assessment. This process also involved the systematic collection of qualitative data from EPC assessors and building owners/managers on their view of the new process/indicator.
- **Systems testing:** This involved development work with EPC database operators or public authorities to assess the technical and practical viability of the new features. It considered time and cost implications, integration with existing systems, access to data and data privacy issues.
- **User testing:** Surveys were carried out with specific end users or stakeholder groups to understand the usability of the new features.

Table 1 - Overview of features and implementing partners

Feature number	Innovative feature	Feature lead	Implementing countries
1	Smart readiness	VITO	AT (IB), EE (IB/expert), GR (IB), RO(IB)
2	Comfort	BPIE	AT(IB), GR (IB/expert), PT(IB), RO(IB)
3	Outdoor air pollution	NAPE	PL (IB expert)
4	Real energy consumption	VITO	AT(IB), EE(IB), IT(IB), RO (IB/expert)
5	District energy	E-think	DK (expert), IT(IB), PL(IB), RO(IB)
6	EPC databases	TU Wien	DK (S), GR (S), IT(S), UK (expert)
7	Building logbook	BPIE	EE (U/S) , GR(U/S) , PT (expert)
8	Enhanced recommendations	TU Wien	AT (expert), DK (IB), PL (IB/S), UK (IB)
9	Financing options	ADENE	DK (U/S), PL (expert), PT (U), RO (U/S)
10	One-Stop-Shops	ADENE	DK (U/S), PT(U/S/expert), RO (U) , UK (U)

IB: In-building test; S: System test; U: User test, expert: supporting partner with existing expertise

2

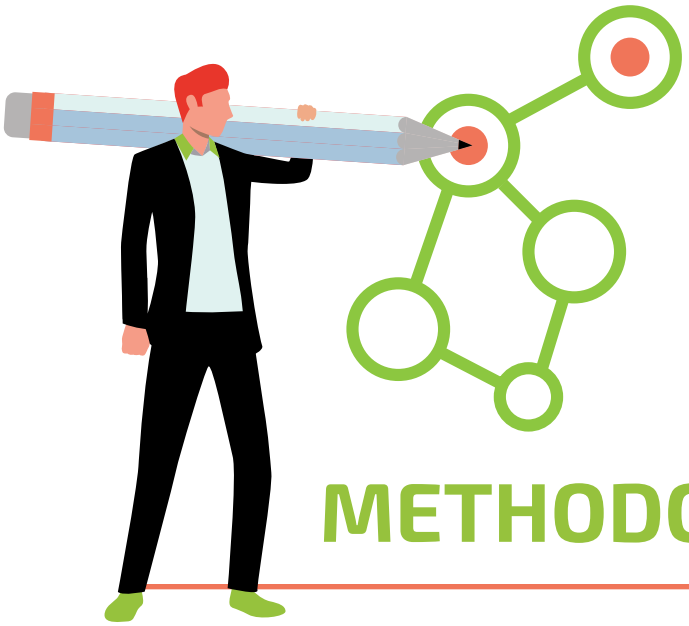
OBJECTIVE OF THE REPORT

This report on the implementation guidelines and replicability potential of the 10 innovative features has been prepared to consolidate useful information to guide public authorities, energy agencies and other relevant stakeholders in the enhancement of EPCs. The report supports the project results' replicability and implementation in different Member States of the EU.

Therefore, the objective of the report is twofold:

1. Provide implementation guidelines for public authorities for the 10 X-tendo features.
2. Estimate the replicability potential in quantitative and qualitative terms.

The implementation guidelines are mainly structured as barriers and drivers for each feature. The identification of the replicability potential is based on qualitative information and quantitative estimations of the potential number of EPCs that will – in future – incorporate the innovative features. Finally, we identify the necessary next steps to implement the innovative features in certification schemes across Europe.



3 METHODOLOGY

Implementation guidelines and replicability potential in this report were prepared through an iterative process of filtering and refining the information and data collected through different project activities. This includes findings from the viewpoints of all relevant stakeholders.

These are briefly described below:

1. **Methodologies and concepts for all features:** Approaches and methods used for the development of the ten features in the X-tendo project [1][2].

2. **End-users needs and perspectives:** A stakeholder survey comprising homeowners, buyers, tenants, sellers and landlords was conducted in 5 European countries (Poland, Portugal, Greece, Romania and Denmark) with 2,563 participants to investigate their needs and identify the relevance of the new features [3]. Interviews and focus groups were also conducted with relevant stakeholder groups for some features to collect their preferences during testing.

3. **Cross-cutting criteria:** The principles used to guide the development and testing of the features for next-generation energy performance certification ensure (i) Quality and reliability, (ii) User-friendliness, (iii) Economic feasibility, and (iv) Consistency with ISO/EN standards [4].

4. **Introductory reports for 10 innovative EPC features:** Brief reports describing the basic concepts, highlight existing cases or best practices, and outline the first steps for implementation [5]–[14].

5. **Evaluation and documentation of test projects:** Monitoring and results reports to assess the practical viability and impact of the ten features. This includes detailed evaluations of the features after testing conducted in nine test countries [15]–[24].

6. **Experience sharing web-calls:** Views gathered from stakeholder representatives within the consortium and from the advisory board.

7. **Workshops and webinars at EU level:** Stakeholder engagements conducted by the test countries with local and national stakeholders to evaluate and receive feedback on the features during their development at EU level.

8. **Online meetings between partners for each feature:** Review of evidence and data collected in the project relevant to each feature with extensive discussion on the replicability potential of each feature.

9. **Estimation of quantitative impact for wider implementation:** Analysis using a building stock model to study the impact on renovation rates of the ten features in Member States. A detailed methodology is described further in this section.

The inputs were analysed to identify drivers and barriers that impact the uptake of each feature. The effects (in quantitative and qualitative terms) of the wider implementation were also analysed for the developed features of EPCs in Europe. Based on these, the necessary next steps were outlined in order to enable their implementation in certification schemes around Europe. To ensure an impartial assessment for replicability, the findings for each feature were triangulated using feedback from testing partners, feature developers and stakeholders.

Methodology for estimation of quantitative impact due to wider implementation

To estimate the quantitative impact of a wider implementation of the 10 features an assessment was conducted for the 10 X-tendo countries using the building stock model. To estimate the impact several trigger points were identified when EPCs can or need to be issued in the X-tendo countries. These trigger points are:

- New building construction
- Major building renovation
- Building sales (if no valid EPC available)
- Renting out (if no valid EPC available)
- Other (e.g. the interest of the building owner in improving the energy performance of the building)

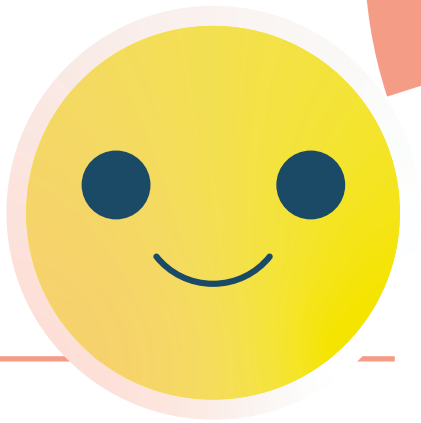
The reference for the above trigger points is drawn from Art 12/1 of the EPBD (2018/844) [25] which states that 'Member States shall ensure that an energy performance certificate is issued for: (a) buildings or building units which are constructed, sold or rented out to a new tenant; and (b) large public buildings'. In Art 17 of the proposed recast EPBD, this is extended to "building units which are constructed, have undergone a major renovation, are sold or rented out to a new tenant or for which a rental contract is renewed".

The different EPC features developed in the X-tendo project will have a different response to the identified trigger points in each Member State. This is due to factors such as public acceptance, real estate needs, market interests, investments, existing state of EPC system etc. The relevance of each trigger point for each feature mentioned above are presented in detail in Table 13 of Annex 1. These trigger points are used to calculate the number of annually issued EPCs until 2030 using historical data of issued EPCs (2014-2019) in the 10 X-tendo countries. The number of EPC end-users potentially interested in a certain feature was determined by estimating the share of interested end-users per trigger point and feature. For the 2030 projection, it was assumed that the number of tenants, real estate transactions and new building constructions follow the same linear trends as in the past 10 years.

More details on calculation method are presented in *Annex 1*.

4

FEATURE 2: COMFORT INDICATOR



4.1 Overview

Adequate levels of indoor air quality, thermal comfort, lighting and acoustics in buildings are among the most important benefits and drivers especially for renovation, as they lead to improved health and comfort of the occupants. These aspects are currently not covered, or only covered in a very limited or indirect way by EPCs of different Member States. The X-tendo feature on Comfort allows the assessment of levels of comfort in terms of Indoor Environmental Quality (thermal comfort, visual comfort, acoustic comfort and indoor air quality) for a given building (residential, office and school) through reliable and evidence-based inputs. Scientific evidence shows that IEQ has a direct effect on health, comfort, wellbeing, and the productivity of the building occupants. Integrating the comfort indicator in EPCs will allow assessment of the IEQ and consequently contribute to reducing negative health effects caused by inappropriate indoor conditions, therefore improving the comfort and wellbeing of building occupants.

Four main indicators are assessed within the comfort feature: (i) **thermal comfort**, (ii) i**ndoor air quality**, (iii) **visual comfort**, and (iv) **acoustic comfort**.

The comfort assessment approach for calculation is divided into two types:

1. **Comfort Asset Rating Procedure (CARP)**

   The comfort asset rating procedure is meant for buildings that are newly constructed, renovated or existing buildings that are yet unoccupied, and it is based on checklists to be used by the assessor during an on-site visit. Asset rating for comfort may be granted for buildings for transactional or business purposes.

2 **Comfort Operational Rating Procedure (CORP)**

The comfort operational rating procedure is undertaken when the building is occupied, providing real information about how comfortable the building is based on its actual use. The rating is based on measurements (temperature, relative humidity, CO2), surveys and checklists undertaken in the occupied building by the assessor. The method assumes that the building has been occupied and used for more than a year after construction or renovation. The operational rating records the actual comfort level of occupants over a given period.

4.2 Key insights from testing

Table 3 - Test projects summary in implementing countries for comfort

Country	ROMANIA	PORTUGAL	GREECE	AUSTRIA
Type of Testing	In-building Testing	In-building Testing	In-building Testing	In-building Testing
Number of testing cases	1 SFH, 1MFH, 1 Office, 1 Kindergarten/ School	1 SFH, 3 MFH, 1 Office, 1 School	2 Apartments, 2 Offices	4 SFH, 4 MFH, 1 School, 1 Public building
Tool	CORP and CARP Tool	CORP and CARP Tool	CORP and CARP Tool	CORP and CARP Tool
Testing Period	02/2021 – 12/2021	06/2021 – 02/2022	07/2021 - 12/2021	05/2021 – 12/2021

Both CARP and CORP were tested on different building types such as Single-family houses (SFH), Multi-family houses (MFH), Offices and Schools with varying functionality and occupancy. The objective of the testing was to assess user comfort in different types of buildings by quantifying thermal comfort, indoor air quality, visual comfort, and acoustic comfort, each on a scale of 1-10, with an overall comfort indicator also on a scale of 1-10. While the results of CARP were mainly based on building plans and documents, CORP needed additional measurements, user surveys and checklists. Some key findings derived from the testing in four countries are given below:

- Significant differences in all tests were found mainly for thermal comfort indicators which, in turn, led to substantial differences in the overall comfort rating.
- Acoustic comfort is mainly influenced by the location of the building (e.g. proximity to roads, public transport, urban/rural area etc.).
- CARP is comparatively easier to assess than CORP.
- CARP has the capacity to be used as a design tool for buildings.

- Acoustic and lighting were generally the indicators with poor scores in CORP.
- Both CORP and CARP have smaller deviation between them in the final comfort ratings and CORP rating was found to be lower than CARP.

4.3 Drivers and barriers for a wide uptake of the feature

4.3.1 Calculation method and quality assurance

Both methods, CORP and CARP, meet the requirements to provide ratings for existing and new buildings, which is certainly a driver for real-estate agents and owners looking to conduct property transactions. Experts from Romania, Greece, Austria and Portugal agreed that the method is robust and built on state-of-the-art knowledge, which makes it very likely to be successfully implemented in the building sector. CARP was found to be simpler and easier than CORP by the experts due to a smaller number of parameters and no measurements required.

Certain barriers were also identified during the development and testing of the feature. These are presented below:

- The CORP tool has a large number of parameters required for calculation of the comfort rating which is a barrier to its use. CARP is simpler and easier to use due to a smaller number of parameters.
- The calculation method needs adjustment using national standards and threshold values in the indicator calculation for better acceptability and accurate results.
- Accounting for behavioral impact on comfort is rather limited in the methodology, however, it is more focused on the capability of the building to provide comfort.
- Current assessment methodology is limited to only the most occupied zones (e.g., living room, classroom etc.).
- National benchmarking would be necessary for both of the tools based on the building types.
- Due to measurements CORP is more accurate in its estimation of thermal comfort and IAQ than CARP.
- Feasibility to evaluate multiple zones in a building is limited in the methodology.
- The methodology does not fully consider the impact of one indicator on another due to dynamic relationships. E.g., the relationship of thermal comfort and its impact on IAQ is not considered in these calculations.

It was highlighted by the Portuguese experts that one week of measurements for T, RH and CO_2 are very much representative of the high summer and low winters in Portugal, making it a suitable duration to take measurements for CORP. Romanian experts outline that the use of one device for measurements in different buildings is challenging and it present risks like loss of data.

In addition, stakeholders from Greece also indicated that the outdoor weather should be monitored along with indoor data due to frequent fluctuations and weather instability. Estonian experts confirmed that some aspects of comfort are well addressed in both the methodologies such as air quality and thermal comfort, while noise reduction and visual comfort relatively less so. Greek experts emphasized that while the methodology is well accepted by the assessors, some doubts remain on the representativeness of the spot measurements (T, RH and CO_2) as these cannot provide actual conditions data throughout the year. The survey is considered as a source of bias in the methodology by the assessors, which may be reduced through appropriate measures

4.3.2 Social drivers and barriers (occupants/owners' perspective)

Comfort is very important for occupants/ end-users/ homeowners, but it is often not objectively understood due to complex indicators and its relationship with energy, monetary or health impacts. One of the main issues in developing the comfort feature was therefore the user-friendliness of the scale used to present all indicators. This is graphical and intended to have a very a clear meaning (very bad, bad, acceptable, good and excellent).

Experts from Romania, Portugal, Austria and Greece found the assessment process well developed for the assessor because it can be easily conducted for different building types (residential, office, school) that would also be comfortable for owners and occupants. Some key social barriers for the comfort feature identified from a social point of view are:

- From the investigation and testing projects it was reported that the owner or end-users were not always willing to fill in the questionnaire for several reasons (e.g., time, education, understanding, age etc.)

- Another major barrier identified is getting the consent from the homeowner for the installation of the measuring equipment and data collection in their buildings because it was considered a threat to their privacy and security.

Austrian stakeholders stated that CORP and CARP are very relevant in the political discourse as the topic of comfort is considered important at national level. It has gained attention mainly for non-residential buildings such as schools, offices and public buildings which are more prone to poor IEQ and could serve as role models for the comfort feature for the entire building stock. They also found the outputs of the tool clear and useful for integration in their national EPCs. Estonian experts highlighted that though the end-users are aware of the importance of indoor comfort (specifically indoor air quality) and its impact on health, the tools developed are useful in giving reasonable outputs that are beneficial to end-users. Greece found that the end-users are not aware or have a very low degree of understanding of indoor comfort, however, the comfort feature on EPCs will increase awareness in end-users in parallel to energy efficiency.

4.3.3 Construction sector (upskilling, construction industry, investors, developers etc.)

An enabling factor for the comfort feature is its suitability, acceptance, and demand in the construction sector. Assuming that the assessor is an experienced energy expert with basic knowledge (e.g., of HVAC systems), then training would only be required in some IT software skills in relation to the simulation of the thermal conditions. For some Member States, this is already included in their EPC; however, if it is not, the training could last for about a half to afull day.

Some of the barriers for the comfort feature from the industry standpoint are given below:

- The assessor should have some fundamental technical and soft skills as well as intermediate expertise or knowledge of the subject for asset rating (CARP) as it is primarily based on checklists. Additional intermediate skills are required for operational rating (CORP), requiring additional training.

- The availability of affordable and accurate monitoring equipment in the market is necessary for the wider uptake of the comfort feature.

- To be able to conduct reliable assessments familiarisation with the calculation procedures is required before use of the CORP and CARP tools.

4.3.4 Economic and market drivers and barriers

The success of the comfort feature is dependent on the economic and market drivers that are instrumental in its wider update and acceptance. Some of these were reported during the investigation:

- The opportunity for businesses to promote their properties, products and services showcasing the impact in relation to comfort rating. Especially with the impact of Covid-19 it is clearer that comfort plays an important role in everyday life.

- The comfort feature is most important for buyers and renters who are forced to make subjective assessments of apartments, homes etc. in absence of any indication on the EPC about comfort.

- The use of multi-functional measurement devices would be cost-effective in making assessment easier and affordable .

- The method is cost-efficient compared to other traditional assessments (e.g. LEED, BREEAM etc.).

- The assessment costs including monitoring instruments, training, on-site visits etc. must be kept to a minimum while assuring all necessary technical specifications and effectiveness.

Some barriers identified from the market perspective are the following:

- Testing indicated that the cost of the comfort assessment might be a barrier for its implementation.

- Comfort mainly depends on individual preferences therefore, it would be challenging to provide standardized information for a building objectively.

Experts from Greece and Austria reported that the cost of CARP and CORP are high relative to the existing EPC costs. The market may respond to this differently as EPCs have not gained a high level of trust and are sensitive to value for money. For Austria, the comfort feature adds as much as 60% more to the EPC costs and it is more significant for residential buildings compared to non-residential buildings. However, Greek experts highlighted that the financial remuneration of the assessor for the extra time and workload would be a positive impact. A potential solution is for a customer to install the equipment correctly eliminating the need for a first visit just for installation.

Portugal is already planning to include a specific section in their national one-stop-shops (OSS) where the owner can request an EPC to be issued including a comfort rating. A feasible direction to enable the wide application of the comfort feature would be to align it in the business models related to OSS, EPCs, building logbooks and building renovation passports. In contrast, Greek experts advised that the mandatory calculation of a comfort indicator in national financing incentives would be the most effective measure.

4.3.5 Consistency with existing policies and standards

To create an environment for implementation and replicability of the comfort feature it is necessary to adapt the existing policies at a national level and harmonise with national standards. During the course of feature development and testing some of the drivers identified were:

- The integration of the indicator in national EPCs would require policy support and decisions to be made regarding assessors' fees, possibly mandating the requirement in relative national incentive programs.
- All policy instruments have the potential to promote comfort (EPC databases, building logbooks, renovation passports etc.).
- Comfort is not the focus in national regulations, but it is one of the most important drivers for renovation.
- Integrating IEQ assessment in EPC schemes will enable a market push for better-performing buildings as the tool is built on well-known ISO EN standards (e.g., EN 16798: 2017) and frameworks and indexes (e.g., Level(s), LEED, WELL, DGNB etc.) accepted by the market in EU member states.
- The results of the comfort feature are easily comparable across Member States due to the methodology.

Austrian experts highlighted that the comfort feature should be a part of public tenders to promote the indicators and encourage wider acceptability. Experts from Portugal, Greece, Austria, and Romania have expressed varied interests in the four indicators of comfort based on the quality of their building stock, national preferences, and usefulness. Romanian experts emphasised that the best place to show the comfort indicator will be on EPC and that would be instrumental for raising awareness about healthy buildings. While in Greece there are no issues or conflicts with their existing national standards as the comfort feature is built on European level standards, however, adjustment and benchmarking of the tools may be required according to the national climatic classification. It was highlighted in Romania that EPBD [25] has no specification regarding comfort evaluation, therefore, this is a good opportunity to adopt a methodology that is homogenous in the EU.

Compatibility with the EPC scheme

Experts found that comfort should be a part of public tenders and that would make it more compatible with the system. It would work better in cases where there are a large number of users in the buildings (e.g. schools). The current national policy framework is not supportive of the comfort feature integration in national EPCs as the level of information overstrains the EPC system in general.

Estonia on the other hand has policy frameworks that support indoor climate quality which includes comfort. In their national and political context, it receives a lot of attention. The national policy framework and national EPC system in Greece does not support comfort integration, and the main barriers found to this were: (i) lack of mandatory obligation and (ii) lack of calculation methodology. The enabling factors could include integrating relevant fields on comfort in EPCs and the obligation for an on-site energy audit.

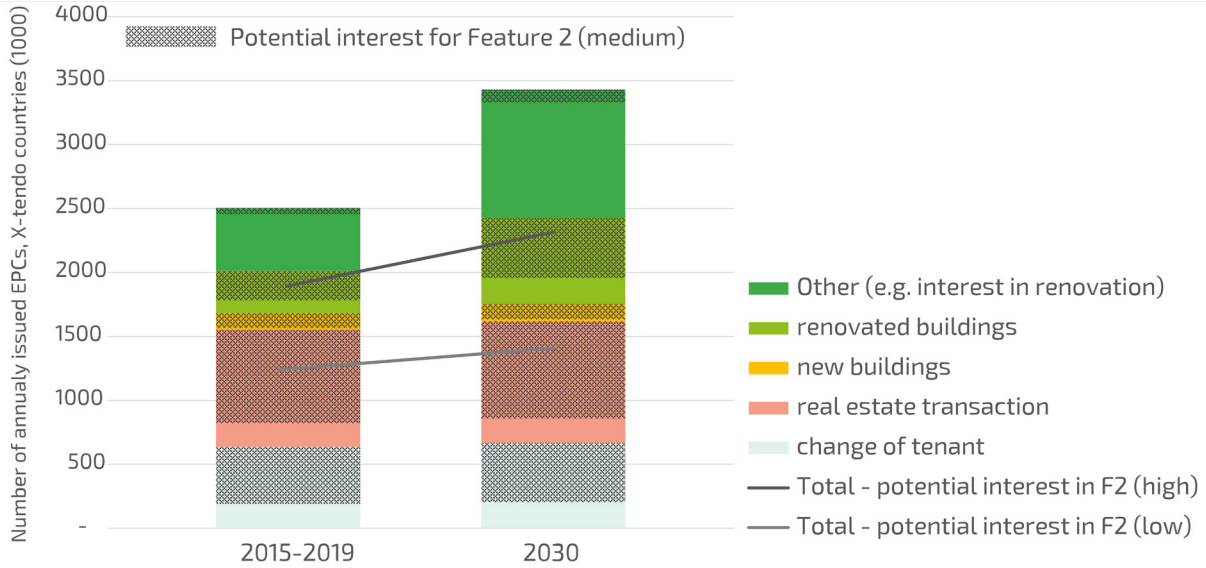
4.4 Estimation of the quantitative replicability potential

In this chapter, an estimation on the quantitative replicability potential of this feature is provided in the X-tendo countries. This follows the methodology described in section 3. The number of annually issued EPCs with the different trigger points in all the X-tendo countries is shown in *Figure 2*. In the period 2015-2019, about 2.5 million EPCs were issued annually. The majority result from real estate transactions, followed by new building construction. EPCs issued due to change of tenant and building renovation, according to available data and assumptions, have lower relevance. In shaded colours, the figure shows the share of EPC end-users who potentially show special interest in this feature, according to the factors determined in *Table 13* and *Table 14*[2] in *Annex 1*.

A high relevance is assumed in particular for new buildings and real estate transactions (interest of the seller), leading to a range of 57%-69% of all EPC-end-users showing potential interest in the results of the comfort feature. The total number of interested EPC end-users for all trigger points is estimated to about 1.24 -1.93 million in the base year which may increase to 1.46 - 2.32 million EPC end-users in the year 2030, which is indicated by the grey lines. The bandwidth (low-high) results from two factors: (1) The potential interest of EPC end-users was assigned by categories, each representing a range, e.g. 20-40% of EPC-end-users are estimated to be interested, and (2) The interest may differ significantly between the buyer and the seller, in particular in the case that a building does not perform very well according to a certain indicator. Thus, for the "lower" case we assumed the lower value of interest (typically the interest of the seller) whereas for the "higher" case we considered higher value (typically representing the interest of the buyer). For Feature 2, it is estimated that there could be a difference in the interest in the comfort for the buyer vs. the seller. The difference results from the bandwidth of the estimation plus the difference of the perspective (seller-perspective for the lower boundary, buyer perspective for the higher boundary). It is estimated that there is a significant potential interest in this feature for every trigger point. Therfore, the country results shown in *Table 4* of the *Annex 1* do not show big differences.

[2] The shaded areas (labelled as medium) in Figure 2 were derived as the average of the low/high range depicted in Table 14.

Figure 2 – Number of annually issued EPCs by trigger points and the estimated share of potentially interested EPC end-users, total of X-tendo countries (Feature 2). Historical data 2015-2019, projection until 2030.



4.5 Next steps for implementation

4.5.1 Calculation method and quality assurance

It is important to highlight the sub-indicators (thermal comfort, visual comfort, acoustic comfort and indoor air quality) to the beneficiary from the methodology as it gives a clear indication of the problems that can be remediated. The comfort rating can be presented on the first page of EPC with details of sub-indicators in subsequent pages. One main consideration to be made at national level would be the setting up of weights for each indicator after a deeper analysis of their building stock. Asset rating must be followed by operational rating for a more accurate assessment when the building is occupied. In the long term, depending on measurement capabilities, additional parameters may be considered to refine the assessment.

In general, Romania welcome suggestions for improvement to EPCs every 5 years to be presented as a cost-effective method for implementation. However, the issues are mainly bureaucratic and entail a cost to change the EPC format as the most recent version was developed a few months ago. In Greece, a thermal comfort rating is already being included in the EPCs, but it is in a format of a simple checklist for the assessor. There is a possibility to include other indicators after discussions with the ministry and a period of consideration. Portugal is also testing a new thermal comfort indicator mainly based on overheating, however, based on the comfort feature, it will extend the methodology for enhanced reliability and usefulness.

4.5.2 Capacity building for delivery bodies and training needs for assessors

Experts from Romania and Portugal outlined that the tool is quite user-friendly and only minimal training would be necessary for the assessors to use the tool for comfort assessment. However, Austrian experts pointed out that the natural ventilation calculation would require a better explanation for the assessors.

Greek experts agreed that the tool is easy to use, and the training would depend on the experience of the assessor. The national programs would be required to upskill people on this new feature which is of high relevance for the existing building stock in Europe.

4.5.3 Political discourse/market or end-user awareness

Portuguese experts advised that comfort is an important factor in Portuguese buildings and was identified as the main issue when designing the long-term decarbonisation strategy. Energy poverty is an ongoing issue and it is important to link the comfort indicator in EPCs in the future. The major players need to understand the building stock and reduce discomfort. Romania advised that while energy prices are high, new problems are emerging with comfort and energy which are making end-users realise its importance. Energy poverty is leading to underheating in winter and undercooling in summer. It is important to improve comfort with existing resources. Greece agrees and advises that the government has a huge interest in the comfort feature.

4.6 Conclusions

According to experts from Romania and Greece, CORP tool is more rigorous and relevant however, CARP is faster and effective. Overheating is an important issue for which both the methodologies CORP and CARP have been designed to evaluate. The comfort indicator is mature and well prepared, but it is important to work further on the future EPC format. It was highlighted by Portugal that if in future smart sensors and controls are already installed in dwellings that it will be easier to conduct CORP assessments. In addition, it emphasised that this feature is more relevant to private buildings than commercial ones. It is advised that current legislation is not sufficiently ready for mandatory implementation of the feature however, it would be possible to mandate certain indicators that are relevant in particular countries e.g., thermal comfort in Portugal, acoustic comfort in Poland etc. Deeper consideration of studies will be needed at a national level to determine what is relevant for the EPC in each country.

In the new EPBD recast proposal [25], there is not enough emphasis on creating regulations on comfort for new and existing buildings or on making it a mandatory aspect of EPCs. However, it is advised that Member states to carry out energy efficiency upgrades to improve indoor environmental conditions, plus there is an indication that Renovation passports and Building Renovation Roadmaps should include multiple benefits related to health and comfort. National Building Renovation Plans have been asked to pay attention to energy poor households with inadequate thermal conditions. It is imperative that evaluation of comfort is made more mainstream and awareness is raised among the owners and occupants, especially following Covid-19. The comfort feature is designed to fill this gap and would be instrumental in raising awareness about healthy and comfortable homes.

The results of the end-user survey showed a high interest from homeowners and renters in the comfort related information on EPCs. The quantitative estimations indicate that there is noteworthy interest from end-users for every trigger point investigated, though a difference in the interests of the buyer and seller exists. The share of potentially interested EPC users for comfort is estimated to rise significantly by 2030 for real estate transactions as well as new construction.

All the X-tendo countries show a more or less similar increase (40-66%) in the share of interested EPC users using the comfort feature by 2030. A high relevance is assumed in particular for new buildings and real estate transactions (interest of the seller), leading to a range of 57%-69% of all EPC-end-users showing potential interest in the results of the comfort feature. The total number of interested EPC end-users for all trigger points is estimated to be about 1.24 -1.93 million in the base year which may increase to 1.46 – 2.32 million EPC end-users in the year 2030.

Key takeways:

- The comfort feature methodology is adaptable for different building typologies.
- CORP tool is more rigorous, while CARP is faster and effective for on-site assessment.
- Existing legislation in the EU is not sufficiently ready for mandatory implementation of the comfort feature.
- Overheating is an important issue in MS for which both the methodologies CORP and CARP have been designed to evaluate.
- The comfort feature is designed to fill the awareness gap about healthy and comfortable homes.
- There is a very high interest from homeowners and renters in comfort related information on EPCs.
- Asset rating must be followed by operational rating for more accurate assessment when the building is occupied.

Key action points:

- Policy makers need to understand the performance of the existing building stock and create appropriate legislation and regulations to reduce discomfort.
- National programs are required to upskill people on this new feature and increase awareness among professionals.
- Deeper studies are required at a national level to determine which comfort indicators are relevant for national EPCs.

5

CONCLUSIONS AND POLICY RECOMMENDATIONS

Overall, the ten features developed and tested in the X-tendo project provide a promising direction to advance the existing EPC schemes. It would not only support taking necessary measures for enhancing the energy performance but extend it beyond that as well. Provision of information to owners and tenants as well as relevant market actors is necessary to give a push to renovation rates and depths across the EU. Each feature aims to enrich the EPCs with such information that enables decision-making by stakeholders. The features developed in the project were tested in X-tendo countries and then the experts who tested them provided deeper insights and appropriate directions, drivers and barriers investigated from social, economic, market and policy perspectives which provided a realistic estimation for its implementation and replicability across the different Member States. Quantitative impact assessments using the trigger points for each feature were conducted to evaluate the impact of feature implementation in terms of increase in share of EPCs. While it is clear that most of the features are directly useful to the end-user, others are meant for quality assurance such as EPC database, tracking progress by public authorities such as district heating, and planning and setting targets for environmental policies using the outdoor air pollution feature.

Each feature is distinct in its application and entails careful planning for its implementation across the Member States. Findings stated thereof in this report from the X-tendo countries are promising and could be replicated in other Member States after careful evaluation in the context of their existing EPC regime. The developed features are provided in the form of a toolbox for public authorities so that it enables effective implementation of more than one feature in the update of the EPC system. All the features build on existing EPC data with additional data inputs that may entail additional training for EPC assessors.

Some key general conclusions derived for all the features are:

- An underlying need for all the features is the establishment of the right conditions and quality assurance of EPC databases at national level giving access to public and other relevant stakeholders.

- New or revised EPCs must not be burdened with a lot of new information for the end-user. Information on the first page must be prioritised for the end-user application. Thus, it should be considered which information is presented on the EPC (on paper) and which on the digital EPC or DBL.

- New features must not overload the assessor's work because it risks the quality, cost and reliability of EPCs.

- Automation and simplification of procedures are necessary for overcoming major issues regarding interoperability and data exchange.

- User-friendliness of features is highlighted as one of the most important drivers during tests of all features and more research is needed in this regard, because so far, most features were tested with experts, not with end users.

- EPCs must be coherently linked with other instruments such as DBL and building renovation passports to increase their impact.

- Training is required for some features to upskill and improve the competence of the workforce responsible for delivering EPCs. Some features do not require training at all, while others have methods, either simple or complex, with different training needs.

- New features must be voluntary in the initial stages of implementation and should be integrated once they showcase acceptance and demand in the building sector.

- All the features are compatible for different building typologies and construction periods. Some features have two calculation methods, one more simple and less reliable, while the other is more complex and reliable. Each method can fit different building typologies (e.g. a detailed SRI is needed for large commercial buildings, CARP and CORP of the comfort tool can be used for school, office and residential buildings).

- Calculation methods were adjusted for individual test countries. However, this presented challenges in different aspects such as missing databases to complete calculations, measurement issues, regional restrictions due to Covid-19, etc.

- All the features have the potential to increase the uptake of renovation if implemented, however, this varies for features that are more directed toward public authorities.

- Stakeholders consider GDPR to be a major barrier for many of the features. Therefore, it requires careful evaluation at Member State level for successful implementation, since it can be shown that the understanding of GDPR issues in the context of EPC data is very different in different EU Member States.

- It is important to establish partnerships and alliances between public and private stakeholders to overcome the market barriers and enable affordable solutions for the implementation of the features.

- Some features demonstrate a marginal increase in cost burden for the end-users of EPC, while some need specific mechanisms to be set up to function (e.g. enhanced recommendations, EPC databases).

Achieving a balance between targets, standards and support measures is necessary to achieve the decarbonisation of the building sector and EPC is a promising policy instrument capable of advancing the EU in this direction. The revised EPBD emphasises that better coverage of the building stock with EPCs is a precondition for its improvement, but at the same time Member States would need to ensure that they are affordable. It also mentions that the EPC should provide additional information to the owner or tenant to foster renovation of the building sector. This would provide a necessary push to unlock private and public funding and subsidies.

X-tendo features were developed from this perspective to empower the end-user with more information and help them take necessary actions for renovation. All the features have been found to have relevance in the test countries with differences in needs and application. Experts found that all the data gathered by the new features is highly relevant for public authorities, but not all outputs are relevant to the end-user. They stressed the importance that the EPC should not lose its main focus and purpose (energy performance) and other outputs can be provided in the DBL.

National policies are framed under the regulations set out in EPBD, thus the X-tendo project has identified a series of recommendations for policy uptake and formulation that would be beneficial in the implementation of new features. These have been compiled below after rigorous development and testing of features in the X-tendo countries.

Next steps for a successful implementation

Plan and prepare mechanisms to link EPCs with new instruments such as Building Renovation Passports, DBL and SRI.

Revise EPC calculation methodologies with a vision to integrate new features developed following the European Standards.

Set up independent control systems to ensure data for EPCs is of high quality.

Ensure that the EPC schemes are in line with more ambitious EU and national goals and targets.

Promote the implementation of new features using market and non-market mechanisms to raise awareness among the public and other relevant stakeholders.

The new features can help to track the progress on policies and support in enforcing mandatory standards by using EPCs for compliance.

Conduct cost-benefit analysis at national level to determine the feasibility of features and their economic impact to build trust in markets.

Selective implementation and independent pilot studies in national contexts would support in meeting MS individual policy goals.

Evaluate national or regional building stock characteristics and estimate the need for new developed features.

Incorporate medium and long-term horizons for the upgradation of the EPC system and on-set of new features.

Advancing comparability and consistency

Promote comparability of features across Member States by following harmonised approaches at EU level.

Consistency with regional policy and standards must be maintained to promote acceptability and reliability of new features.

Set up more ambitious and rigorous quality check mechanisms in EPCs, EPC databases, and check consistencies within and between databases.

Phase-out redundant EPC systems and provide continuous access to interoperable databases, thus increasing transparency and trust.

Adopt standards, methods and tools that promote transparency and accountability in the EPC system.

Market, business models and training needs

Encourage an integrated approach to renovation using the new features and promoting wider benefits such as health and environmental benefits.

Foster collaboration between private and public actors in creating an environment and enabling conditions for supporting job creation and increase investments in renovation with features such as DBL and OSS.

Consider GDPR in data handling of the new features, ensure that data is owned by the homeowner and avoid business models based on trading data.

Promote more collaborative and open-source knowledge systems for EPCs.

Promote the implementation of new features using market and non-market mechanisms to raise awareness among the public and other relevant stakeholders.

Support the implementation of additional features with a more complex methodology including the training and upskilling of EPC assessors.

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ANNEX 1

7.1 Methods and data for estimation of the quantitative impact of implementation of new EPC features

For each country and considered year the following equations were applied to estimate the number of annually issued EPCs (E).

$$E = E_{tenant} + E_{sales} + E_{new} + E_{reno} + E_{other}$$

with

E	Number of annually issued EPCs
E_{tenant}	Number of annually issued EPCs triggered through the change of a tenant
E_{sales}	Number of annually issued EPCs triggered through the sale of a property
E_{renov}	Number of annually issued EPCs triggered through building renovation
E_{other}	Number of annually issued EPCs triggered through other occasions, e.g. the need for advice for renovating the building

In case of rented single family houses or in case that in a certain country an EPC needs to be issued for each apartment of an apartment buildings, E_{tenant_1} applies:

Under the assumption that

$$T_{contract} > T_{EPC}, E_{tenant\_1} = \frac{n_{tenant}}{T_{contract}}$$

Whereas, for apartment buildings in countries where for these buildings only one EPC needs to be issued, E_{tenant_2} applies:

Under the assumption that

$$T_{contract} > T_{EPC}, E_{tenant\_2} = \frac{n_{tenant}}{n_{dwell}(T_{EPC} + \varepsilon)}$$

with

$T_{contract}$	Average duration of Tenancy contracts
T_{EPC}	Validity period of EPCs
n_{tenant}	Total number of rented dwellings and non-residential buildings
n_{dwell}	Average number of dwellings per building
ε	Factor, considering the deviation of changing tenants and the validity of EPCs over time; assumed to be 20% of the validity period of EPCs

For the other trigger points j, the following equation is applied:

$$E_j = \sum_i n_{j,i} \cdot f_{j,i}$$

with

$n_{j,i}$ Number of trigger point (i.e. number of dwellings and non-residential buildings being sold (excluding new buildings, being constructed, being renovated or other) in building category i.

$f_{j,i}$ Correction factor, considering e.g. that some non-residential buildings might not need an EPC, or that for apartment buildings in some countries only one EPC per building needs to be issued.

The number of EPC end users potentially interested in a certain feature k (E_k^*) was determined by estimating the share of interested end-users per trigger point j and feature k ($S_{j,k}$)[12] in certain ranges and partly distinguishing whether the interest refers to the buyer or the seller (or the tenant/landlord) of property. Subsequently, the number of potentially interested EPC end-users is estimated by following equation:

$$E_k^* = \sum E_{j,k} \cdot S_{j,k}$$

As described in *Table 13* and *Table 14*, the factors $S_{j,k}$ were estimated by project partners leading the development of the feature in the project. Thus, there is some subjectivity in the assessment and comparison between features is possible only to a limited extent.

For the 2030 projection, it was assumed that the number of tenants, real estate transactions and new building constructions follows the same linear trend as in the past 10 years, while all the factors specified above remain the same. For the number of renovated buildings, we assumed a doubling of the number from the period 2015-2019. In addition to the renovated buildings, it is assumed that another 50% of building owners is interested in receiving advice for building renovation (i.e. the trigger point "other"). Overall, a strong increase in building renovation activities, moving towards the targets of the fit-for-55 package is assumed.

According to the approach described in *chapter 3*, the number of EPCs issued for each trigger point are estimated. For this purpose, historical data is used on the trigger points, i.e. on the number or real estate transactions, number of rented dwellings and building permits, if available by type of building according to sources in *Table 12*.

[12] See Table 13 and Table 14

Table 12 – Data sources of trigger points

Country	Data sources
Austria	European Central Bank - Statistical Data Warehouse. *https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=430.RESH.A.AT._T.N._TR.NTRA.AT2._Z.N._Z*. 22 Feb 2022; Österreichische Nationalbank. *https://www.oenb.at/Publikationen/Volkswirtschaft/immobilien-aktuell.html.* 09 Feb 2022; Statistics Austria. *http://www.statistik.at/web_en/statistics/PeopleSociety/housing/housing_conditions/index.html.* 09 Feb 2022; Statistics Austria. *https://statcube.at/statistik.at/ext/statcube/jsf/tableView/tableView.xhtml.* 09 Feb 2022; Statistics Austria. *https://www.statistik.at/web_de/statistiken/menschen_und_gesellschaft/wohnen/wohnungs_und_gebaeudeerrichtung/fertigstellungen/026021.html.* 03 March 2022;
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Estonia	European Central Bank - Statistical Data Warehouse. *https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=430.RESH.A.EE._T.N._TR.TOOT.EE2._Z.N.RO.* 24 Feb 2022; Republic of Estonia Land Board. *https://www.maaamet.ee/kinnisvara/htraru/Result.aspx.* 03 Feb 2022; Statistics Estonia. *https://andmed.stat.ee/en/stat/majandus__ehitus__ehitus-ja-kasutusload/EH045/table/tableViewLayout2.* 14 Feb 2022; Statistics Estonia. *http://andmebaas.stat.ee/Index.aspx?lang=en&DataSetCode=KVE01#. 24* March 2022; Statistics Estonia. *https://andmed.stat.ee/en/stat/majandus__ehitus__ehitus-ja-kasutusload/EH046/table/tableViewLayout2.* 15 Feb 2022;

Country	Data sources
Greece	European Central Bank - Statistical Data Warehouse. *https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=430.RESH.A.GR._T.N._TR.NTRA.GR2._Z.N._Z*; 21 Feb 2022; European Central Bank - Statistical Data Warehouse. *https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=430.RESH.A.GR._T.N._TR.NPRO.GR2._Z.N._Z.* 21 Feb 2022; European Central Bank - Statistical Data Warehouse. *https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=381.SHI.A.GR.TOOT.P.* 21 Feb 2022; European Central Bank - Statistical Data Warehouse. *https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=381.SHI.A.GR.TRAT.P.* 21 Feb 2022; Hellenic Statistical Authority. *https://www.statistics.gr/en/statistics/-/publication/SOP03/2021-M10.* 17 Feb 2022;
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Country	Data sources
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Romania	European Central Bank - Statistical Data Warehouse. *https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=430.RESH.A.RO._T.N._TR.NPRO.RO2._Z.N._Z.* 15 Feb 2022; European Central Bank - Statistical Data Warehouse. *https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=381.SHI.A.RO.TOOT.P.* 15 Feb 2022; European Central Bank - Statistical Data Warehouse. *https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=430.RESH.A.RO._T.N._TR.TRAT.RO2._Z.N.RO.* 15 Feb 2022; National Institute for Statistics – ROMANIA. *http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table.* 22 Feb 2022; Paul Cosmin Alin ENACHESCU & Genifera Claudia BANICA, 2019. "Analysis Of The Real Estate Market In Romania From The Point Of View Of The Number Of Transactions During 2009-2018," Scientific Bulletin - Economic Sciences, University of Pitesti, vol. 18(3), pages 39-46. *https://ideas.repec.org/a/pts/journl/y2019i3p39-46.html.* 08 Feb 2022;
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For the countries AT, DK, EE, PL, and PT it is considered that in case of apartment buildings, in most cases there is only one EPC issued for the whole building, not for each apartment. For the countries BE, GR, IT, RO and the UK (Scotland) it is considered that EPCs need to be issued for each apartment.

The resulting historical time series for the issued EPCs were then compared to the total number of issued EPCs according to reports [27][28] and selected sources from Table 12. The deviations were calibrated using the approach to the historical and observed data. Subsequently, the relevance of trigger points for each feature is estimated. For this purpose, the share of EPC end-users is estimated, for which the feature might be interesting along the various trigger points. As the tables below indicate, the relevance might differ between the buyer and seller perspectives. This was taken into account by considering both perspectives, where relevant and adding this to the range of results (high/low).

Table 13 – Relevance of trigger points for each feature: Share of EPC end-users for which the feature might be interesting in different trigger points

	New building construction	**Building retrofitting (mandatory or not)**	**Real estate transaction**	**Other (e.g. interest in the improvement of building's energy performance)**
SRI F1	High; insight in impact is relevant for the owner of the new building for the 3 key functionalities; 1) comfort; 2) energy efficiency and operational performance; 3) interaction with the grid.	Medium; insight in impact is relevant for the owner of the building for retrofitting for the 3 key functionalities; 1) comfort; 2) energy efficiency and operational performance; 3) interaction with the grid.	Medium-Low for the seller; unless it shows good results as a selling argument. For the buyer, insight in impact is relevant for the 3 key functionalities; 1) comfort; 2) energy efficiency and operational performance; 3) interaction with the grid.	Medium; SRI scores SRI in 3 key functionalities; 1) comfort; 2) energy efficiency and operational performance; 3) interaction with the grid; not all relate directly to energy performance.
Comfort F2	High; because Comfort (thermal, IAQ, acoustic, visual) has a direct relevance to the end-user especially in the residential sector.	Medium-High; if retrofitting is not mandatory and High if retrofitting is mandatory. Comfort assessment would be preferred by owners.	Medium-High; for buyers, High for sellers and Medium-high for renters. The interest would vary based on the type of transaction.	Low; co-relation of energy performance and comfort not very clear to the end-user.

	New building construction	Building retrofitting (mandatory or not)	Real estate transaction	Other (e.g. interest in the improvement of building's energy performance)
Outdoor air pollution F3	High; in terms of Indoor Air Purity Index, as the quality of internal environment is important for the users. Medium-Low; in terms of Local Air Pollution Contributor Index. The pollutant emissions from the building are less important for the users.	Medium; in terms of Indoor Air Purity Index, as the retrofitting measures might increase the quality (purity) of internal air. Medium; in terms of Local Air Pollution Contributor Index. The index can be used by the users to verify the environmental results of the modernisation.	Medium-Low; in terms of Indoor Air Purity Index, the value of the property can be higher if a better indoor environment is assured. In terms of Local Low, air Pollution Contributor Index. The pollutant emission for the building are not the most important parameters considered in real estate transaction.	High; both indexes can be used in verification of the building modernization results. In this case the Local Air Pollution Contributor Index has a higher value as the goal of the modernisation is to decrease emission.
Real energy consumption F4	Low; similar to EPC, but the indicator will only be available after a one-year operational period. May be implemented for commissioning and as such have indirect influence.	High; indication of actual energy performance forms the best basis for energy retrofitting decisions.	Medium-High for the buyer; is very relevant for indication of actual energy performance and cost. Medium-low for the seller; unless it shows good results as a selling argument.	High; indication of actual energy performance forms the best basis for energy retrofitting decisions.
District energy F5	Low; the main benefit of the feature for building owners / user is to a) compare performance of own system with nearby DH, or b) see if other decentral low-temperature supply options are interesting; both not relevant in case of new construction.	Medium-Low; benefit is as described in column new construction; in case of renovation this can be a bit more relevant; however, potentially other aspects will play a more important role.	Low; for rental will probably not be relevant, for buying most probably other factor more important.	Medium-Low for building owners/user; the feature is more relevant for public dministrations and their urban planning. Thus, the more data is available from issued EPCs, the better.

	New building construction	Building retrofitting (mandatory or not)	Real estate transaction	Other (e.g. interest in the improvement of building's energy performance)
EPC databases F6	Medium-High; the quality of the EPC and trust in the information is important and can influence the decision of buyers of a new building.	Low; the quality of the EPC may be less relevant in the cases where the building is occupied by the owner because they may assess the building's performance more based on their own behaviour.	Medium-High; the quality of the EPC and trust of the information is important and can influence the decision of buyers of existing buildings.	High; In general. many actors have high quality EPCs and trustworthy information on that document.
Logbook F7	Medium; the construction phase is key to collect detailed information about the building, material and embodied carbon levels. Registering this data in a logbook can be linked to various private certifications, which can be valuable to the building owner.	Medium-High; logbooks enable better decision-making throughout the building lifecycle, including for energy renovations. Having all the information in one place is something building owners have been requested and something that can simplify the renovation process.	Medium; the construction phase is key to collect detailed information about the building, material and embodied carbon levels. Registering this data in a logbook can be linked to various private certifications, which can be valuable to the building owner (i.e. increase the financial value of the asset).	Medium-High; logbooks enable better decision-making throughout the building lifecycle, including for energy renovations. Having all the information in one place is something building owners have requested and something that can simplify the renovation process.
Enhanced recommendations F8	Low; the main benefit of the feature for building owners / user is to a) compare performance of own system with nearby DH, or b) see if other decentral low-temperature supply options are interesting; both not relevant in case of new construction.	Medium-Low; benefit is as described in column new construction; in case of renovation this can be a bit more relevant; however, potentially other aspects will play a more important role.	Low; for rental will probably not be relevant, for buying most probably other factor more important.	Medium-Low for building owners/user; the feature is more relevant for public dministrations and their urban planning. Thus, the more data is available from issued EPCs, the better.

	New building construction	Building retrofitting (mandatory or not)	Real estate transaction	Other (e.g. interest in the improvement of building's energy performance)
Financing schemes F9	Low; since usually financing schemes are given for energy efficiency improvement of existing buildings.	High; since usually financing mechanisms are related to the building renovation, namely the improvements related to energy efficiency.	High; EPCs are usually mandatory to be issued during the buy or rental of buildings, and therefore there might be some specific mechanisms that use the EPC as eligibility criteria. This can also be relevant to buyers to advise if there are financing mechanisms available to improve their future house.	High; the interest in improving the building energy performance of a house can be the trigger point for looking for funding.
One Stop Shop F10	Low; since usually one-stop-shops have information about the existing building and provide technical assistance to improve the existing house.	High; since usually one-stop-shops have information about the existing building and provide technical assistance to improve the existing house.	Low; since usually it is necessary to be a homeowner to have access to the information/ technical assistance available in the one-stop-shop. A potential buyer does not have access to the information of the house available in the OSS unless they are the owner.	High; the interest in improving the building energy performance of a house can be the trigger point for using the OSS to search for funding opportunities, technical assistance and get closer to the construction market.

Note

Rating	Percentage range
High	100-80%
Medium-High	80%-60%
Medium	60%-40%
Medium-Low	40%-20%
Low	20%-0%

The qualitative arguments, the rating table and discussion points were transferred into the following table, which was then used for the calculation of the share of EPC end-users for which the feature might be interesting, considering upper and lower boundaries as "high" and "low".

Table 14 – Quantitative summary - Relevance of trigger points for each feature: Share of EPC end-users for which the feature might be interesting in different trigger points

	Change of tenant	Real estate transaction (buyer)	Real estate transaction (seller)	New building construction	Building retrofitting (mandatory or not)	Other, in particular: general interest in the potential improvement of building energy performance
F1	20%-40%	20%-40%	20%-40%	80%-100%	40%-60%	40%-60%
F2	60%-80%	80%-100%	60%-80%	80%-100%	60%-80%	0%-20%
F3 (indoor)	20%-40%	20%-40%	20%-40%	80%-100%	40%-60%	80%-100%
F3 (outdoor)	0%-20%	0%-20%	0%-20%	20%-40%	40%-60%	80%-100%
F4	60%-80%	60%-80%	20%-40%	0%-20%	80%-100%	80%-100%
F5 (low-temp)	0%-20%	60%-80%	0%-20%	80%-100%	60%-80%	60%-80%
F5 (DH-PEF)	0%-20%	40%-60%	0%-20%	60%-80%	20%-40%	20%-40%
F6	60%-80%	60%-80%	60%-80%	60%-80%	0%-20%	20%-40%
F7	40%-60%	60%-80%	20%-40%	40%-60%	60%-80%	60%-80%
F8	0%-20%	80%-100%	0%-20%	0%-20%	60%-80%	80%-100%
F9	0%-20%	80%-100%	0%-20%	0%-20%	60%-80%	80%-100%
F10	0%-20%	0%-20%	0%-20%	0%-20%	60%-80%	80%-100%

With $n_{t,i}$, the number of EPCs issued in year t due to trigger point i, the number of potentially interested EPC end-users in feature j is calculated as $\sum_i n_{t,i} f_{i,j}$, while the values in *Table 14* represent the shares $f_{i,j}$, where the lower and the upper range from *Table 14* is considered as the "low" and "high" result in the quantitative assessment of each feature.

Table 15 – Share of potentially interested EPC end-users by feature and country, 2030

		F1	F2	F3 (indoor)	F3 (outdoor)	F4	F5 (low-temp)	F5 (DH-PEF)	F6	F7	F8	F9	F10
LOW(+)	AUSTRIA	40%	66%	40%	12%	40%	32%	20%	50%	40%	10%	10%	10%
	BELGIUM	34%	46%	44%	30%	51%	33%	14%	39%	42%	31%	31%	31%
	DENMARK	41%	56%	47%	22%	42%	37%	21%	47%	42%	19%	19%	19%
	ESTONIA	38%	41%	53%	38%	49%	42%	18%	36%	44%	38%	38%	38%
	GREECE	28%	46%	38%	26%	64%	24%	8%	41%	46%	29%	29%	29%
	ITALY	34%	39%	48%	39%	60%	39%	14%	32%	47%	43%	43%	43%
	POLAND	46%	63%	49%	16%	24%	39%	26%	54%	35%	10%	10%	10%
	PORTUGAL	24%	61%	24%	2%	33%	6%	4%	59%	29%	1%	1%	1%
	ROMANIA	48%	56%	55%	27%	32%	47%	28%	45%	40%	22%	22%	22%
	SCOTLAND	40%	63%	42%	11%	23%	30%	20%	56%	32%	6%	6%	6%
HIGH (*)	AUSTRIA	60%	89%	60%	32%	66%	62%	47%	70%	67%	43%	43%	30%
	BELGIUM	54%	73%	64%	50%	84%	73%	47%	59%	75%	78%	78%	51%
	DENMARK	61%	80%	67%	42%	69%	68%	48%	67%	69%	53%	53%	39%
	ESTONIA	58%	67%	73%	58%	83%	81%	51%	56%	77%	85%	85%	58%
	GREECE	48%	68%	58%	46%	88%	50%	32%	61%	70%	57%	57%	49%
	ITALY	54%	64%	68%	59%	90%	72%	43%	52%	76%	81%	81%	63%
	POLAND	66%	91%	69%	36%	59%	82%	61%	74%	70%	60%	60%	30%
	PORTUGAL	44%	92%	44%	22%	76%	61%	47%	79%	72%	68%	68%	21%
	ROMANIA	68%	83%	75%	47%	65%	86%	60%	65%	73%	68%	68%	42%
	SCOTLAND	60%	93%	62%	31%	63%	80%	60%	76%	72%	66%	66%	26%

(*) Low and High shares result from the ranges indicated in *Table 14*.

GLOSSARY OF TERMS

AQI	Air Quality Index
BIM	Building Information Modelling
BREEAM	Building Research Establishment Environmental Assessment Method
CARP	Comfort Assessment Rating Procedure
CHP	Combined Heat and Power
CO_2	Carbon Dioxide
CORP	Comfort Operational Rating Procedure
Covid-19	Infectious disease caused by SARS-CoV-2 virus
DBL	Digital Building Logbook
DGNB	Deutsche Gesellschaft für Nachhaltiges Bauen
DH	District Heating
DHW	Domestic Hot Water
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certificate
GDPR	General Data Protection Regulation
GHG	Greenhouse gas
HVAC	Heating, Ventilation and Air-Conditioning
IAPI	Indoor Air Purity Index
IAQ	Indoor Air Quality
IEQ	Indoor Environmental Quality
LAPCI	Local Air Pollution Contributor Index
LEED	Leadership in Energy and Environmental Design
LTRS	Long-term Renovation Strategies
MEPS	Minimum Energy Performance Standards
MFH	Multi-Family House
MS	Member State
MVHR	Mechanical Ventilation and Heat Recovery
nZEB	Nearly Zero-Energy Building
OSS	One-Stop Shop
PA	Public Administration
PEF	Primary Energy Factor
RH	Relative Humidity
ROI	Return On Investment
SFH	Single-Family House
SRI	Smart Readiness Indicator
T	Temperature

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AAECR Asociația Auditorilor Energetici pentru Clădiri din România

ENEA

BPIE

КАПЕ CRES

Danish Energy Agency

adene Agência para a Energia

ENERGIE AGENTUR Steiermark

energy saving trust

ethink ENERGY RESEARCH

NAPE NATIONAL ENERGY CONSERVATION AGENCY

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