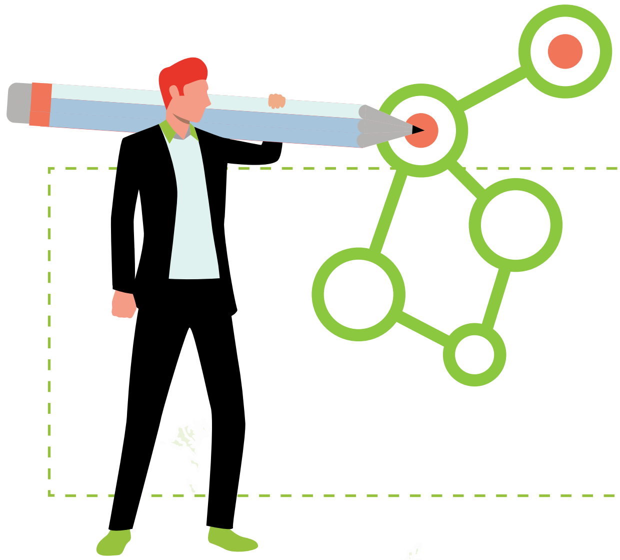
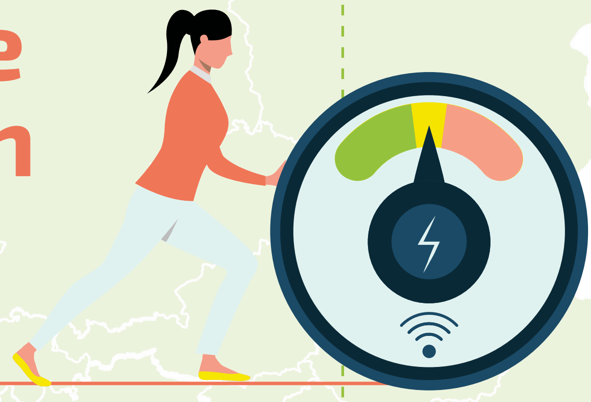
X-tendo



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



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CONTENTS

CONTENTS

CONTENTS

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

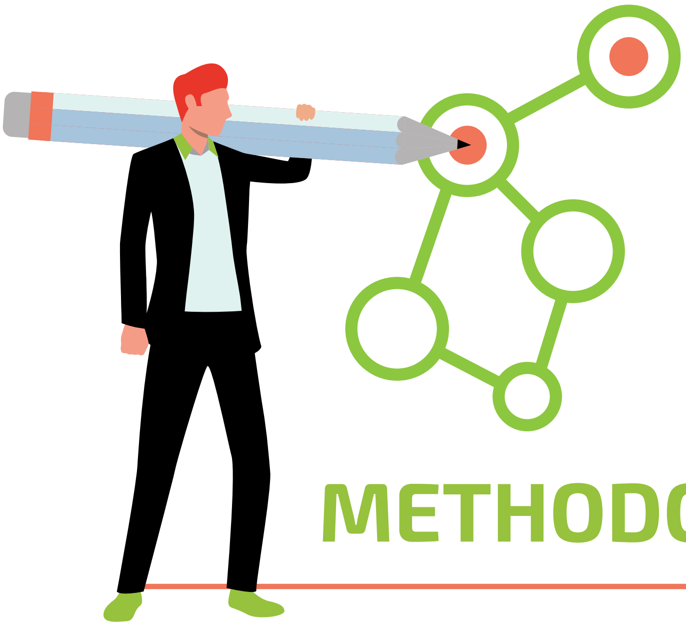
OBJECTIVE OF THE REPORT

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*.

FEATURE 1: SMART READINESS INDICATOR (SRI)

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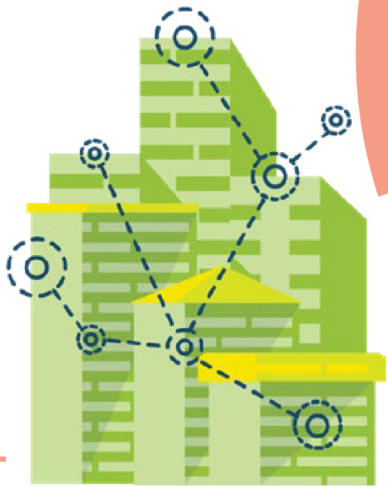


4.1 Overview

The smart readiness indicator (SRI) was first introduced by the 2018 EPBD recast and is reinforced as a voluntary European scheme for rating the smart readiness of buildings, by the 2021 EPBD recast proposal [25]. The SRI measures the capacity of buildings to use information and communication technologies and electronic systems to better suit the needs of occupants and the grid, as well as improve energy efficiency and overall building performance. The SRI was officially adopted by Delegated Regulation (EU) 2020/2155 (European Union; 2020a) and Implementing Regulation (EU) 2020/2156 (European Union; 2020b), both published in 2020 and came into force in January 2021. The SRI is intended to raise awareness about the benefits of smart buildings, including energy efficiency, an optimised mix of various energy sources, user occupancy experience and grid flexibility. In addition, its implementation is expected to stimulate investments in smart building technologies and support the uptake of technology innovation in the building sector.

Two parallel methodologies have been developed and tested so far to speed up SRI evaluation capabilities. These methodologies vary in the amount of information required and the skills needed by the assessor to quantify the level of smartness.

- **Abbreviated method A** is composed of a simplified checklist that can be self-assessed online or by an assessor in 15 minutes. This makes it ideal for assessing single and multi-family dwellings, small commercial and office buildings.

- **Extended method B** relies on an on-site inspection and includes more detailed information about the building smartness components. Its specificity makes it suitable for assessing large private (residential, offices) and public (schools, hospitals, etc.) buildings.

The SRI score of a building is a percentage that expresses how close (or far) the building is from maximal smart readiness. A high score indicates a high smart readiness of the building. The total SRI score is based on a weighted average of scores allocated on seven impact criteria, each evaluated within nine domains (this generates a 7x9 evaluation matrix), which include:

- The **seven impact criteria**: Energy Efficiency, Maintenance and Fault Prediction, Comfort, Convenience, Health and Well-being, Information to Occupants and Energy Flexibility and Storage.

- The **nine domains**: Heating, Cooling, Domestic Hot Water, Ventilation, Lighting, Dynamic Building Envelope, Electricity, Electric Vehicle Charging, and Monitoring and Control.

The final SRI score is provided as a percentage and subdivided into three key smart readiness functionalities:

1. Energy performance and operation
2. Response to user needs
3. Energy flexibility

4.2 Key insights from testing

Table 2 - Test projects summary in implementing countries for SRI

Country	ROMANIA	GREECE	ESTONIA
Type of Testing	In-building Testing	In-building Testing	In-building Testing
Number of testing cases	1 SFH, 1MFH, 1 Office, 1 Kindergarten / school	2 Offices and 2 Apartments.	10 MFH
Tool	In-situ visits and technical documents, calculation tool based on assessment method A		
Testing Period	02/2021 – 10/2021	07/2021 – 09/2021	08/2021 – 10/2021

The evaluation methodology obliges the assessor to go over a checklist of possible smart solutions, while the same list provides recommendations for the end-user.
Some key findings derived from the testing in three countries are given below:

- The assessment tool provides clear and straightforward use while being relevant for smartness assessment and improvement.
- In apartment buildings that were built more than 40-50 years ago a low score was calculated and the same applies to non-residential buildings. However, recently built buildings, less than 15-20 years old, were found to have a higher score due to the installation of more smart control or other technologies.
- Calculation of smartness is more reasonable at the whole building level compared to individual dwellings or zones.
- The effort involved in assessing and documenting complex buildings (e.g. office buildings) was much higher than for simpler buildings like SFH with regard to aspects like time, access to data and its collection on-site.

4.3 Drivers and barriers for a wide uptake of the feature

4.3.1 Calculation method and quality assurance

Different building typologies may require different calculation methods, depending on their smartness capacity. The abbreviated method A is more suitable for single and multi-family dwellings, small commercial and office buildings. The extended method B is most suited for assessing large private buildings, such as offices, or public (schools, hospitals, etc.). Non-residential buildings have overall better SRI scores, often as a result of their management systems. Further testing is needed for commercial buildings, for which method B would be initially more appropriate.

The main driver of this feature is the 2018 and 2021 EPBD recast proposal [25] and the eventual requirement for it to be implemented by the MS as a voluntary assessment scheme within the EPC scheme, or within the digital building logbook and building passport at a later stage.

According to experts, the simplified method is the most suitable to be implemented in the EPC scheme. Testing showed that method A is suitable for both residential, non-residential and public buildings. It is a simple method, which is easily implemented and calculated by the EPC assessor. A complex method could be avoided by the EPC assessors if the tool is voluntary, while some inputs for heating and cooling of method A are already covered by the EPC calculation.

Experts within the consortium from different countries showed different opinions regarding the harmonisation of the method in different MS. Experts in Portugal propose different calculation methods adapted to specific climates, the experts from Romania advocate the same calculation method and – for example - to keep the assessment of cooling as a requirement in all MS. A compromise proposed by the Austrian partner would be to provide the same calculation method of the IAQ, the same wellbeing and health standards while allowing different weighting due to climatic differences.

The existing calculation methods have the following limitations, which could act as barriers to implementation:

- Buildings have different theoretical maximums. Parameters such as type or characteristics will determine the criteria according to which a building will be evaluated. For example, a building without space to integrate an electric vehicle (EV) charging point will not be evaluated on this service, and thus has a lower theoretical maximum.
- Potential divergences in the calculation of SRI for large buildings: some buildings may not have the same smartness capacity although some can have similar SRI scores (methodological limitation).
- One challenge of the SRI scheme will be to deliver a significant volume of assessments in the first years of implementation.
- Smart controls are available in public and in non-residential buildings, especially for maintenance purposes. However, their potential implementation in residential apartment blocks is more difficult because of multiple ownership.

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

SRI scores need to be easily shared with the general public, not only experts. For this purpose, the SRI should be communicated using a logo to immediately visually brand it in users' minds and create an identity for the scheme. The logo will be accompanied by numbers indicating the SRI score. In addition, the SRI should be subdivided into three subcomponents indicating in more detail the building smart readiness for (1) energy savings and maintenance, (2) comfort, ease and wellbeing, and (3) grid flexibility.

However, currently, the SRI is a concept that can be hard to communicate and understand for the general public. Furthermore, according to experts from Austria, the SRI concept is less relevant for the end-user compared to the grid supplier. Experts from Romania stated that the concept of a smart home is not yet developed in Romania, thus the indicator's implementation may be too early. Perhaps, though, an early introduction of the tool in the EPC scheme could raise awareness.

To increase the relevance for the end-user, the benefits of SRI must be communicated very clearly. According to stakeholders of the Workshop in Greece (see Methodology section), 66.6% consider smart homes to have the potential to improve an occupant's comfort, 55.5% think smart homes can save energy, 77.7% believe that smart homes can improve the efficiency of grids and 77.7% think smart technologies will increase the property value.

Important aspects to be considered during the implementation are data protection, GDPR compliance and citizen security (i.e. cybersecurity risks).

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

The two calculation methods require different degrees of skills and knowledge, thus, different types of training. Method B requires an expert degree of knowledge and can be only performed by SRI certified assessors.

Potential barriers to delivering a validated accreditation include training costs and the lack of trained assessors during the first stages of implementation. The costs associated with establishing a pool of qualified assessors would be reduced if training programmes first target experts already certified through other schemes in Member States.

Smart utility solutions are a fast-developing market. The SRI method should be updated when needed to include new technologies, and therefore, also the training.

The implementing partners underlined that Method B could be too complicated and time-consuming for the EPC assessors. If the tool is voluntary in the EPC certification, assessors could avoid using it. On the other hand, implementing partners find the simplified method A rather easy to implement in the existing EPC scheme. Additionally, only limited training is required since many inputs are already covered by the existing calculation methods. According to experts from Austria and Romania, simplicity is key, and an easy implementation should be the main goal.

4.3.4 Economic and market drivers and barriers

While the methodology is ready, some further aspects regarding economic and political feasibility, such as the assessment costs or the different EU Member States' maturity levels on smartness, still need to be evaluated and decided by the implementing authorities.

For residential buildings, abbreviated method A is as effective as extended method B (which is longer and more expensive) to estimate SRI levels

Implementing partners expressed their concern regarding Method B, which could add an additional burden on EPC certifiers. In Denmark they already have a complex and lengthy procedure for the EPC assessment, thus the inclusion of the SRI will add further time, and cost burdens. The implementing partners and stakeholders expressed concern that the increase in cost would be borne by the client, so there is a need for cost-effective business models. Experts from Austria suggested optimisation processes and automation in data collection, achieved by integrating with the building logbook, and the use of smart metering and benchmarking. Those from Romania proposed a collaborative business model with utilities, which would compete for clients and could offer the SRI assessment for free.

The SRI could also be more relevant for large buildings, and its implementation is easier for non-residential ones. Therefore, a targeted implementation of the SRI to specific building typologies could be considered. An impact on the market of the SRI implementation could be an increase in the real estate value of new buildings compared to existing ones.

4.3.5 Consistency with existing policies and standards

The EPBD recast proposal of 2021 [25] foresees the integration of the SRI into the EPC as a voluntary scheme. The smart readiness indicator is particularly beneficial for large buildings with high energy demand; thus Article 13 reinforces the SRI for large non-residential buildings as of 2026. For other building typologies, the SRI rating should be optional. According to the proposal, the goals of the SRI indicator are multiple: the measurement of the buildings capacity to use ICT technologies, adjust to the needs of the occupants and the grid which improves energy performance. It also serves to raise awareness amongst building owners regarding the advantages of building automation.

The differences between country-specific legislation and the market maturity of smart utilities demand a high degree of flexibility when it comes to implementation rules. Differential implementation might increase the technological gap between the Member States. 55.6% of Greek stakeholders of the Workshop consider that some EU countries are better positioned to benefit from the SRI implementation than others.

The identification and analysis of possible options for implementing the SRI at the EU level and at the MS level involved the examination of equivalent frameworks as possible templates. Some models of other initiatives which are instructive for the SRI's governance include the Ecolabelling scheme and CEN/CENELEC standardisation bodies.

Compatibility with the EPC scheme

In contrast to other quantification schemes used in existing EPCs, the SRI calculation is intended to follow the same general methodology across all MS. If well-coordinated with EPC assessment, the SRI scheme might provide not only new information, but help improve current EPC evaluation quality and reliability. This is because some of the input data needed to assess both are the same or come from the same source. An important provision of the EPBD recast proposal [25] is the requirement for MS to set up EPC databases and a 'digital building logbook' which would gather information about the smartness of the building.

The Annex of the EPBD recast proposes the following indicators to be integrated into the EPC, which are relevant for the SRI:

- A yes/no indication whether a smart readiness assessment has been carried out for the building.
- The value of the smart readiness assessment (if available).
- Number and type of charging points for electric vehicles.
- Presence, type and size of energy storage systems.

The X-tendo tool recommends the display of a comprehensive SRI score, subdivided into three subcomponents (1) energy savings and maintenance, (2) comfort, ease and wellbeing, and (3) grid flexibility. Experts agree this is a good strategy because different end-users could be interested in different aspects of the SRI. However, some of them warn that EPC should display information regarding energy performance, and additional features may contribute to information overload with an increase in cost, as well as loss of the goal of the policy tool. Thus, they do not recommend the display of the SRI indicators on the first page. Greek stakeholders had divided opinions regarding the integration of SRI in the EPC assessment, with 44.4% in favour and 55.5% expressing doubts. Some experts advised compulsory implementation only for specific building typologies. However, they admitted that residential buildings, even though displaying low SRI scores, could raise awareness among homeowners. At the same time, Austrian stakeholders expressed the concern that SRI is relevant mainly for energy suppliers, public authorities and funding authorities, and less for homeowners, who would have to pay for it.

4.4 Estimation of the quantitative replicability potential

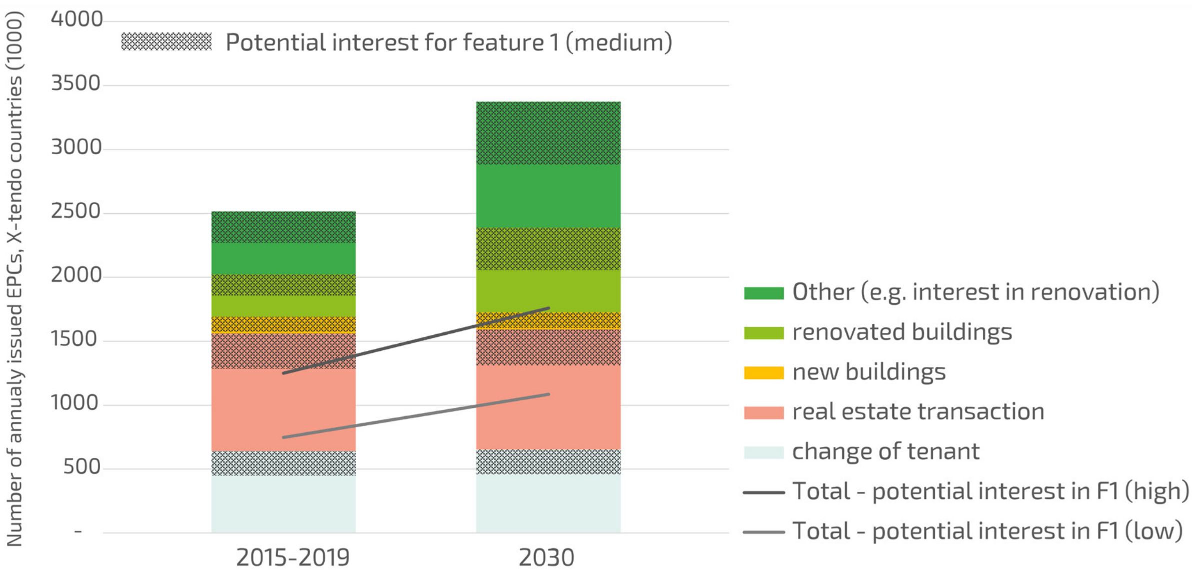
In this chapter, an estimation of the quantitative replicability potential of this feature is provided in the X-tendo countries. This follows the methodology described in section 3.

Figure 1 shows the number of annually issued EPCs, with the different trigger points in the X-tendo countries. In the period 2015-2019, about 2.5 million EPCs were issued annually. The largest part resulted from real estate transactions, followed by new building construction, while EPCs due to the change of tenant and building renovation, according to our data and the chosen assumptions, have lower relevance. In shaded colours, the figure shows the share of EPC end-users which potentially show special interest in this feature, according to the factors determined in *Table 13* and *Table 14*[1] in *Annex 1*. A high relevance is assumed in particular for new buildings and building renovation, leading to a range of 30%-50% of all EPC end-users showing potential interest in the results of the SRI feature. The total number of interested EPC-end-users for all trigger points is estimated to be around 0.75 to 1.25 million in the base year which may increase to 1.09 to 1.76 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 categorised, each representing a range, such as 20-40% of EPC end-users are estimated to be interested. (2) The interest may differ significantly between the buyer and the seller, in particular when a building does not perform very well according to a certain indicator. Therefore, for the "lower" case a lower value of interest (typically the interest of the seller) is assumed whereas for the "higher" case a higher value (typically representing the interest of the buyer) is considered. For Feature 1 no strong difference in interest in the SRI is given for the buyer vs. the seller is estimated. Thus, the difference in results is only from the bandwidth of the estimation.

The share of various trigger points is quite different in the X-tendo countries, with a very different share of rented buildings or real estate transactions. This leads to a different weighting of the number of potentially interested EPC end-users in each country. This is reflected in the results in Table 15 of Annex 1. Since Poland and Romania have the highest share of new building construction as a trigger for EPC issuing, the relevance of this feature is particularly high in these countries (in a range of about 50-70% of all EPCs, while the average in X-tendo countries is 30-50%).

[1] The shaded areas (labelled as medium) in Figure 1 were derived as the average of the low/high range depicted in Table 14.

Figure 1 – Number of annually issued EPCs by trigger points and the estimated share of potentially interested EPC end-users, total of X-tendo countries (Feature 1). Historical data 2015-2019, projection until 2030.



4.5 Next steps for implementation

4.5.1 Calculation method and quality assurance

One of the biggest challenges of the SRI scheme will be to deliver a significant volume of assessments within the first years of implementation. The best way to ensure good market penetration would be to combine the scheme, on a mandatory basis, with other existing schemes such as the EPC. Linking the SRI to new building development and major renovations could also accelerate its deployment. A third promising approach is to develop a market-based voluntary scheme in which self-assessment is supported by online tools or in which certified professionals are hired to perform the evaluation (remunerated by owners and/or state agencies). Additional pilot studies to certify the validity of the method developed may be needed. Hence, the next step would be the selection and testing of the scheme in some targeted areas within the EU territory with a large piloting approach.

Another aspect of realising quality assurance is to provide training in some categories for the EPC assessors, who lack the required technical background. A recommended strategy from the experts is to start with the implementation of the simplified method, which requires less or no training and to implement more complex calculation methods at a later stage. The steps of implementation would be firstly, a voluntary certification which can be applied to all buildings and secondly, an initial mandatory implementation, for office buildings which would be required to meet specific SRI goals.

4.5.2 Capacity building for delivery bodies and training needs for assessors

The training and skills required for SRI assessment depend on the type of method used and the type and size of the building. While an intermediate level of awareness is sufficient to assess SRI levels through method A, method B requires an expert degree of knowledge and can be only performed by SRI certified assessors.

Training needs can therefore be divided between guidance and training to support local self-assessment and training of third-party assessors. Training costs are not yet appropriately estimated and will vary across Member States. Potential barriers to delivering a validated accreditation include training costs and the lack of trained assessors during the initial stages. The costs associated with establishing a pool of qualified assessors would be reduced if training programmes first target experts already certified through other schemes in Member States.

4.5.3 Political discourse/market or end-user awareness

The main strategy for implementation is integrating the SRI with other existing schemes such as the EPC or DBL to reduce costs and provide complementary information. Creating a common assessment framework within the EPC would lead to new market opportunities and the creation of business models for existing and future stakeholders. The next step is to elaborate on further tools to solve the main implementation issues: assessment costs, national divergence, market value, etc. Experts recommend the simplified method for residential buildings.

An important aspect in the development of the common methodology is increasing the accessibility of information through digitalisation of the services. The development of SRI will run in parallel to the development of DBL and the quality assurance of the EPC databases. When Member States implement SRI, the calculation method should be in line with the respective current EPC calculations, ensuring the maximisation of any overlap in inputs. The next steps in implementation are to include it in the EPC software and test beta versions.

The overall SRI score and the three subcomponents (1) energy savings and maintenance, (2) comfort, ease and wellbeing, and (3) grid flexibility are expressed in percentages. This choice of unit is motivated by the difficulty for the end-users to grasp the concept of smartness, as well as of technical units such as kWh/m^2. The experts agree that the choice of percentages and the subdivision of information into three sub-indicators may contribute to the user-friendliness of the tool. However, some concepts such as a percentage of grid flexibility could still be difficult to interpret, thus an additional verbal explanation when the EPC is handed over to the homeowner is advised. Another strategy to make SRI relevant to the homeowners would be to formulate EPC recommendations based on it, ideally tailored and containing cost/benefit analysis.

4.6 Conclusion

The 2021 EPBD recast [25] proposed the mandatory introduction of SRI as a voluntary rating and reinforces the Smart Readiness Indicator for large non-residential buildings as of 2026. To facilitate development of new services related to buildings, a new Article 14 specific to building data ensures that the building owner, tenant and manager or third parties can have access to building systems' data. New rules on data interoperability and access to data are to be laid down by the Commission by means of an implementing act.

Regarding replicability, end-users indicated a high interest in this feature during earlier investigations. This has been affirmed by the quantified impact, based on trigger points, indicated in **Annex 1**. A high relevance is assumed in particular for new buildings and building renovation, leading to a range of 30%-50% of all EPC end-users showing potential interest in the results of the SRI feature. Thus, the total number of interested EPC end-users for all trigger points is estimated to about 0.746-1.25 million during the base year. This may increase to 1.085-1.76 million EPC end-users in the year 2030. Since Poland and Romania have the highest share of new building construction as a trigger for EPC issuing, the relevance of this feature is particularly high in these countries.

Key takeways:

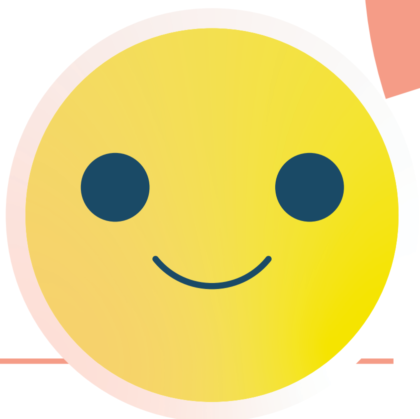
- The simplified method appears to be best suited for the first stage of the implementation of SRI since it does not require too much additional training and costs.
- Specific building typologies such as large-scale non-residential buildings with high energy demand might require a more detailed method and minimum requirements to be set at later stages.
- If included in the EPC scheme, the overall SRI indicator should be complemented with three sub-indicators, which should not be placed on the first page of the certificate.
- End-users might have difficulties grasping concepts such as smartness or grid flexibility, thus a link between the SRI and EPC recommendations would make these concepts more relevant for the homeowners.
- For residential buildings, the simplified method would contribute to raising awareness among building owners and help them understand the value of automation in saving energy while increasing comfort.

Key action points:

- Define national strategies for implementation as voluntary or mandatory schemes of the two methods depending on the building typology.
- Test communications strategies of the indicators, focusing on the relevance for the end user.

5

FEATURE 2:
COMFORT INDICATOR



5.1 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) **indoor 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.

5.2 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.

5.3 Drivers and barriers for a wide uptake of the feature

5.3.1 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

5.3.2 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.

5.3.3 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.

5.3.4 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.

5.3.5 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.

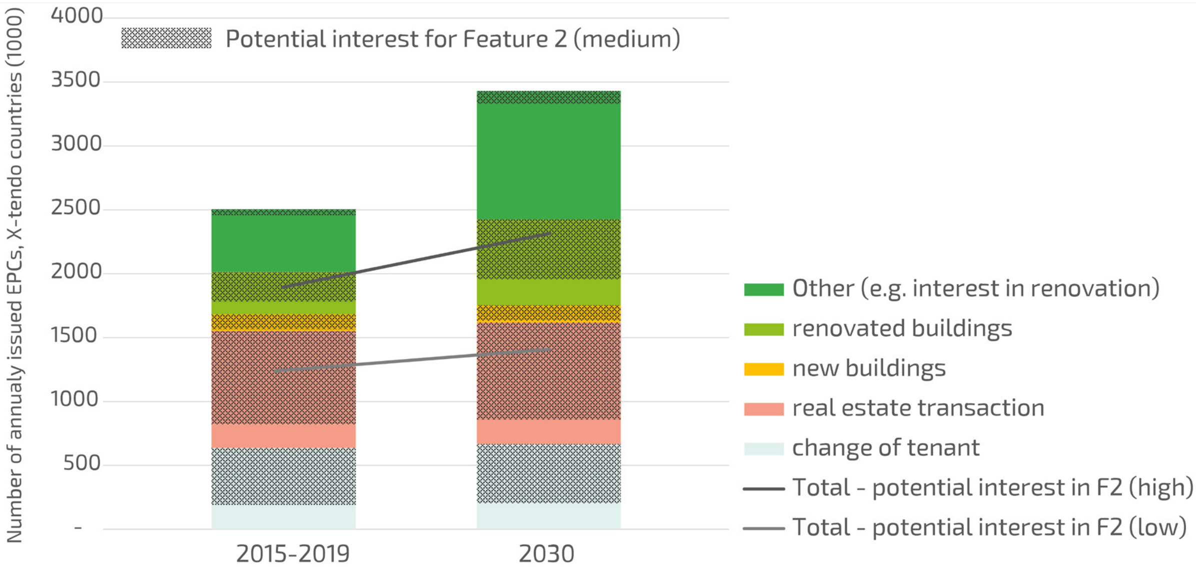
5.4 Estimation of the quantitative replicability potential

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.



5.5 Next steps for implementation

5.5.1 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.

5.5.2 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.

5.5.3 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.

5.6 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 takeaways:

- 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.

FEATURE 3: OUTDOOR AIR POLLUTION INDICATOR

6.1 Overview

Air pollution is one of the most important environmental risks to human health. Buildings affect both the quality of the outside air (pollutant emission) and the purity of the indoor air (air filtration). The aspect of air pollution in the EPCs of different Members States is covered mainly by the CO_2 emission indicator. However, other pollutants are also very important e.g. in situations where local smog develops. Air is supplied into buildings for hygienic reasons thus the quality of outside air influences the indoor conditions. The developed methodology takes into consideration the actual quality of external air, as well as the efficiency of the air filtration system and is defined with two indicators:

1. Local Air Pollution Contributor Index (LAPCI) which assesses potential building influence on local smog development.
2. Indoor Air Purity Index (IAPI) which assesses the efficiency of air filtration in the ventilation system of a building.

The methodology is based on a comparison of pollutant emissions from assessed buildings with the values for reference buildings. Weightings are assigned to the main pollutants (PM2.5, PM10, NOx, SOx, CO_2) in order to calculate the final indicator value. The Local Air Pollution Contributor Index estimation methodology is inspired by the Air Quality Index (AQI) and applies the same scale and methods for assessing pollutants. The methodology is adjusted to different countries, with varying references for the energy source. Both indicators can be calculated for buildings with mechanical or natural ventilation. In the case of buildings with mechanical ventilation, the filtration efficiency will be assessed, while in the case of natural ventilation, the quality of the outside air will be assessed.

6.2 Key insights from testing

Table 4 - Test projects summary in implementing countries for outdoor air pollution

Country	POLAND	POLAND
Type of Testing	User testing	In-building testing
Number of testing cases	31 users	10 buildings with different use / 1 building in 6 different locations
Tool	Calculation tool and Questionnaire	Calculation tool
Testing Period	09/2021 – 11/2021	04/2021 – 11/2021

User testing

The user testing was based on a survey of assessors for the indicators (i) Local Air Pollution Contributor Index, (ii) Indoor Air Purity Index. A total number of 31 respondents (e.g. energy auditors, local and national authorities and researcher) participated in an online survey and a majority of them had experience with Energy Performance Certificates of up to 10 years. Most of the respondents used real EPC data for testing, some at least partly, and only a few used pseudo information. Some of the findings from the user-testing are:

Local air pollution contributor index

- Calculation tool layout and user guide are user-friendly and useful to respondents.
- More than 50% of respondents reported less than 1 hour is required for the calculations.
- Very few respondents reported any difficulty in obtaining the data and knew most of the data required for calculations.
- Most of the respondents indicated methodology and results are straightforward and clear.

Indoor Air Purity Index

- Most of the respondents (>50%) indicated that the calculation tool is user-friendly and easy to use.
- About 78% of respondents used actual information in their EPC calculations either partly or completely.
- Most of the respondents took less than 1hr to complete the indoor air purity calculations.

In-building testing

In the case of the Local Air Pollution Contributor Index calculation, data from EPC was sufficient to provide calculations. Indoor Air Purity Index calculation required additional information about the filter class and access to the air quality statistics. The testing was used to validate the functionality of the calculation tools. Review of the assessment process for in-building testing identified some issues both for the Local Air Pollution Contributor Index and Indoor Air Purity Index.

- Local Air Pollution Contributor Index can achieve the same or worse score even if the thermal modernization has been done, and the heating source has been changed to a renewable energy source.
- Sources based on the combustion of oil receive a much worse rating than those based on gaseous fuel (in the case where the reference fuel is gas) which is caused by a large disproportion of emission NOx and SOx between these fuel types.
- In the Local Air Pollution Contributor Index the data availability issue of PM2.5 and PM10 for specific localization has been noticed.
- The information about the class of the filter used in the ventilation system is often not included in the EPC.

6.3 Drivers and barriers for a wide uptake of the feature

6.3.1 Calculation method and quality assurance

The Local Air Pollution Contributor Index and Indoor Air Purity Index 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.

One of the main drivers for the implementation of the feature alongside the EPC scheme is the inclusion of more than one pollutant (five in Local Air Pollution Contributor Index and two in Indoor Air Purity Index). At the same time, this requires the availability of data, such as AQI, which is not available for all the Member States.

In Poland, where the feature was tested, a system of air quality monitoring stations exists and some are even installed by private entities. Besides, it contributed to the integration with other databases– i.e. EPC database and Central Register of Emissivity of Buildings. In big cities and especially smart cities, there is available data, while in the countryside it is considered a range of 50km from the building. However, a wider implementation of the feature in other countries would require additional data and could act as a driver for the installation of measuring stations.

Limitations of the existing calculation method which must be addressed include:

- The result is a function of reference data that can differ from year to year.
- Maintenance of the energy source and filtration system is not considered.
- The uncertainty associated with emission rates used in the calculation.
- Data on emissions cannot be verified through measurement.

Possible solutions to overcome these limitations could be to verify input data availability in implementing countries, develop and expand the outdoor air quality monitoring system and develop national databases of pollutant emission factors from energy sources.

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

Given that Poland faces issues with air pollution and public awareness, the stakeholders, including policymakers, as well as different associations (Polish Green Building Council, Energy Auditor Association) showed a high interest in this feature. The two indicators should be integrated into the EPC scheme to assess buildings and are more relevant for residential, SFH buildings. Users of public buildings are more aware and the EPCs are compulsory for public buildings. Changes are being implemented to make EPCs compulsory for building transactions for residential buildings. For residents of SFH, it will be more relevant to know the emission of the building to increase awareness and encourage a change of the energy source or switch to renewables. The choice of different heating system types or more efficient boilers could be encouraged. Currently, solid fuel boilers are very common in Poland for existing or new buildings and there is intention to use biomass boilers. However, the PM2.5 emissions from biomass are very high. Besides Poland, it is debatable whether the feature should be implemented in the other Member States or some cities with lower levels of pollution. Even in countries with lower levels of pollution than Poland or Romania, such as Denmark, surveys show that this aspect is of high importance to the general public.

The terminology used for the feature and its methodology is not strictly technical and engineering related. The indicator, data needs and calculation methods can be explained using common terminology, which is easily understandable for end-users or public authorities. The outputs of the feature are presented using a scale (values: very low, low, moderate, bad, very bad, hazardous) and colours ranging from blue/green (very good) to dark red (very bad), increasing users' understanding of the feature. However, the graphical representation of the outcomes was tested only by experts and more research is needed regarding the intelligibility and user-friendliness for the general public. For example, how concepts such as the Local Air Pollution Contributor Index are understood and interpreted by the homeowners.

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

The introduction of this feature could contribute to a change in the construction sector, shifting from a focus solely on mechanical ventilation for energy performance, to reducing indoor air pollution.

For the calculation of the Local Air Pollution Contributor Index and Indoor Air Purity Index some additional inputs are required compared to the existing EPC. Additional data should be collected regarding the quality of filtration in the HVAC system. Data on outdoor air pollution concentration can be gathered from an online database. Thus, in countries where EPC assessors have an engineering background as in Poland, they do not need additional training.

6.3.4 Economic drivers and barriers

Indoor air quality is gaining increasing importance, moreover after the Covid-19 pandemic. Currently, when boilers or heat pumps are advertised, only the economic benefits are highlighted. The two indicators on the health and environmental aspects can help advertise the heating systems.

Similar to other features, the implementation within the EPC scheme would reduce the costs considerably. As previously mentioned, with the existing database on outdoor air pollution concentration, no additional inputs are required for the Local Air Pollution Contributor Index and this will be the case for all the Member States.

6.3.5 Consistency with existing policies and standards

In Poland, the issue of air pollution is very important and many national/regional support programs could benefit from the introduction of the two indexes. These can be used for funding or subsidizing energy efficiency renovation measures. The use of the data from this feature for different policy goals would require, however, a collaboration between ministries and public agencies.

The Annex of the 2021 EPBD recast proposal [25] suggests the introduction of the following indicator on the EPC:

- Operational fine particulate matter (PM2.5) emissions.

PM2.5 is one of the pollutants included in the tool, alongside PM10, CO, NOx, SOx, which are not stipulated in the recast proposal. However, choosing different outcomes might yield different results, for example, PM2.5 results are affected by the reference energy source and it would not be the right proxy for all the emissions. Therefore, it is important to consider and display all pollutants.

Assessment of the air filtration system is part of environmental certification methods like BREEAM, LEED, or WELL, but none of these provide an indoor air quality index. At the EU level, Eurovent is a harmonised certification for IAQ. For outdoor air pollution, the method is not linked to the Polish national calculation method, but to the existing database. The tool is a procedure, which can be used with different databases.

In Poland, there is a database on emissions from buildings and the EPC database. The purpose is to communicate to the EC the track on the energy performance evolution and to assess areas to be tackled with incentives to transform the building stock. The building logbook can help with reporting and tracking additionally, at the building level.

Compatibility with the EPC scheme

The main input data required for the assessment of the Local Air Pollution Contributor Index and Indoor Air Purity Index are part of the EPC data. The developed methodology is independent of the building type. The data required for this feature is standard or easily obtainable from public sources and no measurements are foreseen.

Even with relatively easy incorporation of the feature into the EPC scheme, a first step would be the willingness of policymakers to include it. For example, currently in countries such as Estonia outdoor air pollution is not addressed in connection with the EPC scheme and there are no steps planned in this direction.

6.4 Estimation of the quantitative replicability potential

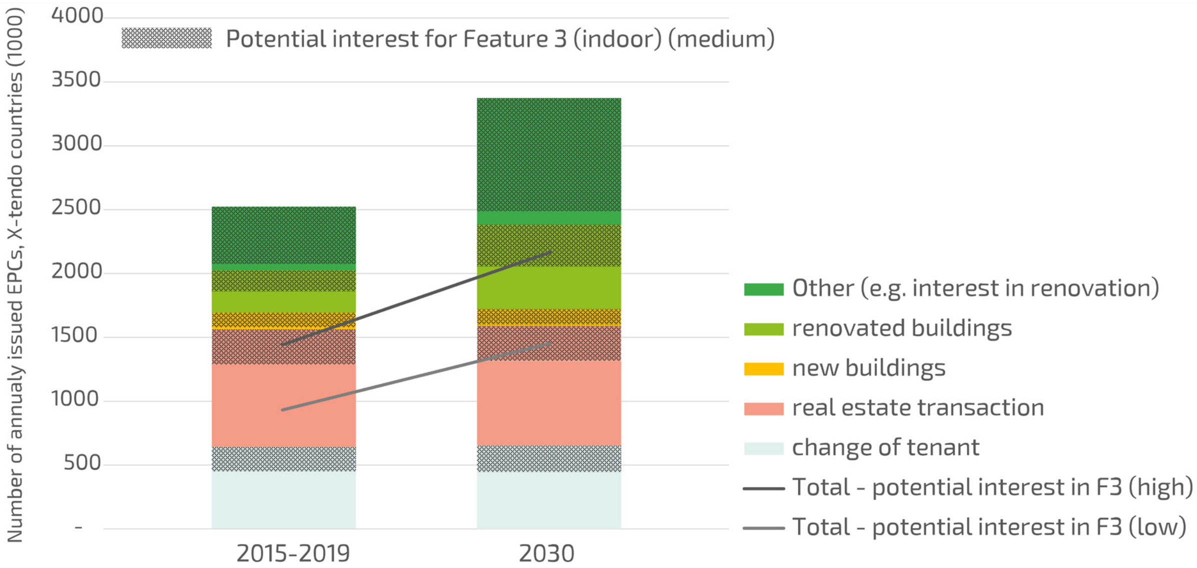
In this chapter, an estimation on the quantitative replicability potential of this feature is provided in the X-tendo countries. This follows the methodology described in section 3. *Figure 3* and *Figure 4* show the number of annually issued EPCs, by the different trigger points in the total of X-tendo countries. Due to the different characteristics of the two indicators (indoor air purity vs. contribution to outdoor air quality), separate analyses were carried out for these two cases. In the period 2015-2019, about 2.5 million EPCs were issued annually. The largest part results from real estate transactions, followed by new building construction, while EPCs due to change of tenant and building renovation according to the available data and the chosen assumptions have lower relevance. In shaded colours, the figure shows the share of EPC end-users which potentially show special interest in this feature, according to the factors determined in *Table 13* and *Table 14*[3] of *Annex 1*. A high relevance is assumed in particular for new buildings (outdoor) and building renovation (indoor), leading to a range of 38%-58% (indoor) and 22%-42% (outdoor) of all EPC-end-users showing potential interest in the results of the Outdoor Air Pollution feature. The total number of interested EPC end-users for all trigger points is estimated to about 0.95 -1.45 million (indoor) and 0.55 – 1.06 million (outdoor) in the base year which may increase to 1.48 – 2.16 million (indoor) and 1.08 – 1.76 million (outdoor) 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, like 20-40% of EPC-end-users are estimated to be interested. (2) The interest may differ significantly between the buyer and the seller, in particular in the case where a building does not perform very well according to a certain indicator. Thus, for the "lower" case a lower value of interest (typically the interest of the seller) is assumed, whereas for the "higher" case a higher value (typically representing the interest of the buyer) is considered. For Feature 3 it is estimated that no strong difference in the interest is given for the buyer vs. the seller. Thus, the difference results only from the bandwidth of the estimation.

[3] The shaded areas (labelled as medium) in Figure 3 and Figure 4 were derived as the average of the low/high range depicted in Table 14.

While the indoor air purity indicator is expected to be perceived by EPC end-users as directly affecting their quality of living and health, for the indicator on the contribution to the outdoor air quality, this is only indirectly the case. Thus, we estimated that in particular for real estate transactions and new building construction EPC end-users only show low to medium interest in the outdoor air-quality contributor index. This leads to a significant difference between these two indicators.

For the indoor air purity indicator, the share of potentially interested EPC-end-users is quite evenly distributed in most X-tendo countries, with the exception of Portugal, Greece and Belgium, with lower values. These countries show the lowest share of new buildings as the trigger point for EPC issuing. Since we estimated that the relevance of this indicator is particularly high for EPCs triggered through new building construction, this is the reason for the relatively low resulting interest.

Figure 3 – Number of annually issued EPCs by trigger points and the estimated share of potentially interested EPC end-users, total of X-tendo countries (Feature 3 indoor). Historical data 2015-2019, projection until 2030.



6.5 Next steps for implementation

6.5.1 Calculation method and quality assurance

For all Member States, to aid the eventual implementation of the feature into the EPC scheme, the first step should be to check public and stakeholder opinion on the two indicators. The second step would be to set up a database on outdoor air pollution. The third step is to implement the calculation method in the software. For Poland, the incorporation of the feature into the EPC would imply the following steps:

- Implementation in the existing EPC software.
- Redefinition of existing provisions in EPC regulations.
- Defining new energy classes for buildings.

If a choice is necessary, the local air pollution contributor index would be preferred over indoor air purity by policymakers in Poland.

The methodology is based on EPC data, thus it can be easily adjusted and implemented in all the EU countries. The assessment of the filter class in the calculation methodology is according to standards ASHRAE 62.1-2010 or EN 779- 2002. For the emission rates, standard values are used. In the methodology, default values are given for reference, and the possibility of implementation of national values is foreseen. Since the reference building energy use changes in time or by country, country-specific data should be used instead of the proposed default data.

6.5.2 Capacity building for delivery bodies and training needs for assessors

The estimation of both indicators is rather simple and straightforward. With a technical background, an energy auditor's basic knowledge is sufficient to perform the calculation required to assess this feature, thus additional training and courses are not required.

6.5.3 Political discourse/market or end-user awareness

If a narrow perspective in assessing the cost of the feature is applied, it may appear economically feasible and easy to implement. Most of the inputs are already gathered during the EPC assessment, thus little additional workload is needed from the EPC certifier. Also, the implementation of the feature would imply limited cost in adjusting the EPC software.

If we apply a wider perspective, data from outdoor air pollution is needed, thus the installation of additional measurement stations might be necessary for many locations. In Poland, besides the public ones, many private actors installed measurement stations with a bottom-up approach. In the other Member States, it could imply additional public or private investments, however, the data could be useful for other policies besides the EPC scheme.

So far, the tool has been tested only with experts, thus further research is needed to assess the user-friendliness of the outcomes for the public. The research should not be limited to user-friendliness, but should also investigate how lay people understand the formulation of the indexes, for example, 'Local Air Pollution Contributor Index' might be difficult to interpret. Simple graphical indicators, as well as the renaming of the indexes, might be necessary so that homeowners can easily grasp the concepts.

6.6 Conclusions

The implementation of this feature into the EPC scheme is of high relevance both for the public authorities, as well as the end user. Outdoor air pollution is the main driver of climate policies and therefore, better measurement and tracking is crucial for the implementation of those policies.

The Annex of the 2021 EPBD recast proposal (EC, 2021) suggests the introduction of only operational fine particulate matter (PM2.5) for emissions on EPCs. PM2.5 is one of the pollutants included in the feature developed, alongside PM10, NOx, SOx and CO which are not stipulated in the recast proposal. However, choosing different outcomes might yield different results, for example, PM2.5 results are affected by the reference energy source, and it would not be the right proxy for all the emissions. Thus, it is important to consider and display all pollutants.

While the indoor air quality indicator is expected to be perceived by EPC end-users as directly affecting their quality of living and health, the contribution of the outdoor air quality indicator is only indirect. It is estimated that for real estate transactions and new building construction in particular, EPC end-users would only show low to medium interest in the outdoor air-quality contributor index. This leads to a significant difference between these two indicators.

Key takeways:

- In Poland, where air pollution is a major concern among the population, a bottom-up approach encouraged the installation of measuring stations by private actors. In other Member States where data regarding outdoor pollution is missing more measuring stations would be necessary to set up the database.
- The second set of parameters regarding the IAQ is also of high relevance for the end-user, to make them aware of the multiple benefits of the renovation. After Covid-19, the general public is more aware of the importance of the IAQ.
- CO_2 and PM2.5 may not be the right proxy for all the emissions.

Key action points:

- Set up additional installations for measuring outdoor pollution.
- Set up national databases for outdoor pollution.
- Besides the existing CO_2 indicator and the proposed PM2.5 by the 2021 EPBD, additional pollutants such as PM10, NOx, SOx and CO should be displayed in the EPC.

7

FEATURE 4: REAL ENERGY CONSUMPTION

7.1 Overview

The gap between real energy performance and EPC calculated performance can be significant and usually is a source of confusion to EPC users. Methodologies that integrate on-board monitoring data and diagnose the difference between measured and calculated energy use (e.g. to adjust for real weather or occupant conditions) aim to explain the difference between the measured and calculated energy use to increase trust in the EPC. The inclusion of measured energy use data also enables automation of procedures and simplification of on-site inspections. The improved accuracy and better link with meter readings and billing information enhances user acceptance. Energy performance improvement measures can be better tailored to the specific building, augmenting the quality of renovation advice. It is anticipated that this will lead to increased market trust and trigger more investments in building energy renovations. Furthermore, a better link with measured energy use will improve policy instruments for monitoring of energy performance of the building stock and targeted policy measures in view of achieving the long-term energy performance of buildings objectives.

Therefore, the Measured Energy Performance Indicator (MEPI) developed in X-tendo is a method to determine the real energy consumption of a building based on the measured energy use. Measurements of final energy delivered per energy carrier and for different applications, together with electrical energy exported, are translated into an indicator expressing the total annual primary energy consumption, the renewable energy ratio and CO_2 equivalent emissions of the building at standard conditions of climate and use. The methodology integrates on-board monitoring data which requires monitoring infrastructure including submetering. To enable inter-building comparison, the measured energy use is normalised to a unit of floor area and corrected so that it represents standard conditions of climate and use. This procedure takes by default the following aspects into account:

- Size of the building unit (useful/reference floor area).
- External weather conditions (heating and cooling degree days method).
- Energy carrier (primary energy factors).

7.2 Testing results

Table 5 - Test projects summary in implementing countries for real energy consumption

Country	ESTONIA	AUSTRIA	ITALY	ROMANIA
Type of Testing	In-building Testing	In-building Testing	In-building Testing	In-building Testing
Number of testing cases	3 Schools	5 SFH, 5 MFH	2 MFH	1 SFH, 1 MFH
Tool	Calculation tool	Calculation tool (accompanied with user survey and checklists)	Calculation tool	Calculation tool
Testing Period	06/2021 - 10/2021	05/ 2021 - 12/ 2021	05/ 2021 - 12/ 2021	02/2021 - 10/2021

The testing for real energy consumption was performed with the measured energy performance indicator (MEPI) calculation tool. It uses measurements reflected in energy bills over a full year, the existence of local meters per energy carrier and per application (utility), surveys/questionnaires addressed to users, real and statistical climate data, and the assessors experience in separating energy consumption to use per application when possible. Available data, metered or estimated, was corrected for indoor temperature (different from the reference used in the EPC), for outdoor temperature and solar radiation (different from the references used in the EPC for heating and cooling), for the use of DHW (subtracted from the energy use by energy carrier), and for primary weighting and emission factors. Some key findings derived from the testing in four countries are given below:

- For EPCs based on real energy consumption reliable data acquisition is the most important requirement.
- Absence of sub-metering of energy use in buildings (e.g. DHW, ventilation systems with heat recovery) was an issue during testing.
- In case that metering is not available a simple method to allocate consumption values from energy bills to different use categories is considered very important.
- Real energy consumption data and analytical EPCs did not match mainly due to the difference in user behaviour.
- The methodological module to correct for indoor temperature is optional.
- Comparison of real energy consumption to EPC calculations revealed the impact of user behaviour.

- The estimated real energy consumption was in the range of ±20% of the EPC calculations.
- The testing evaluation shows that the process of collecting real energy consumption data is a time-consuming task.
- Corrections would be needed to be able to compare calculated vs. measured energy consumption. For example, the number of hours the heating system is operational.

7.3 Drivers and barriers for a wide uptake of the feature

7.3.1 Calculation method and quality assurance

Specific aspects of the MEPI method related to the building types may require additional points of attention (e.g. energy by end-user) and require different applications to differentiate metered energy by its use. There are some drivers that could potentially impact the acceptance of the measured energy performance indicators and these are:

- For new or renovated buildings, a period after commissioning may be required to obtain the necessary input data.
- For some buildings, like residential or small offices, compliance with privacy legislation may require additional attention.
- Measurement infrastructure is required and it is an advantage if smart metering infrastructure is foreseen in the regulations.
- To enable correct inter-building comparison, correction of the measured energy use to standard user behaviour and climate is required.
- Method development for benchmarking and setting requirements is necessary per building type, e.g. residential, office.

Some of the barriers to its implementation are:

- Requirement of sub-metered data is a barrier in buildings without individual meters.
- Historical energy use data may be less helpful as a reference in assessing the real performance of existing buildings where the use profile varies, especially those with variable/limited numbers of occupants such as single-family dwellings or rental dwellings with frequently changing residents.
- Some parts of methodology may still need modelling, e.g. domestic hot water use.
- Inter-building comparison is not fully justified with real energy consumption and it may be limited to only inform the user.
- The calculation is strongly dependent on the energy carrier and it is difficult where the main fuel is wood.

Austrian experts mention that there should be a system to gather information after each user ends the rental agreement and benchmarks could be extrapolated from the EPC database after data from different user profiles are available. Sub-metering presents many challenges in Italy and Austria, however, if there is one supplier for all the dwellings in an apartment building, it would be easier to collect the data. In Estonia, since the EPCs are for entire building no sub-metering is required and calculation is simpler to perform. Experts from Romania also outline that there are two problems with real energy consumption: a) absolute weighting factors for energy carriers that are variable in different regions and b) dependence of consumption on behaviour which is also variable. However, experts from Italy doubt the reliability of data for some specific cases (holiday houses, uninhabited buildings, buildings without a space heating service, buildings with wood stoves with difficulty in quantifying consumption) and on the possibility of correctly gathering consumption data that is too tied to user behaviour.

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

One of the main barriers regarding this feature is in the monitoring and accompanying data handling, data protection and security that must be ensured under the General Data Protection Regulation (GDPR) requirements. This puts this feature in a much more challenging state for collecting the data necessary for evaluation. There are also risks of citizen data security (e.g. cybersecurity risks) and fraud (e.g. manual meter readings, bulked energy carrier quantification).

Some of the drivers include:

- Improved accuracy and a better link with meter readings and billing information enhance user acceptance and gives higher acceptability.
- The output is a measured energy performance indicator for real energy consumption, representing the yearly specific primary energy use of the building. The output also includes yearly CO_2 emissions and, optionally, the renewable energy ratio.
- The feature gives the user a more precise idea of how much they would spend on their energy bill.
- The feature would make savings immediately clear to the user giving more reliable information.

For this feature, Italian experts reported that two opposing positions emerged from their national context: (i) condominium administrators and real estate agents show an interest in using the real energy consumption data, and (ii) public authorities and technicians have expressed doubts about it.

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

The real energy consumption feature overcomes the limitations and reliability of the existing EPCs calculations with an approach that requires additional infrastructure. Some drivers proposed for its implementation are:

- If energy use data is not available, a measurement period of at least 12 months should be considered to determine the average energy use of the building.
- The current qualification of energy assessors mostly covers the skill required for the evaluation of the real energy consumption feature.

- The aspect of correction that is done using the climatic data requires a lot of manual work and is therefore, very important to have at municipal level to minimize the effort.

In Italy, only limited training is required as the EPC assessors have the required background. Conversely, Romanian experts emphasised the need for training due to the complex calculation method and formulas used in the construction of the tool. In contrast, Estonian experts consider the tool to be oversimplified and for this reason it is not well accepted by assessors. Therefore, a more complex tool with training would be viable in their national context.

7.3.4 Economic and market drivers and barriers

A main driver for homeowners will be improved tailored renovation advice using the real energy consumption feature including a cost-benefit analysis.

- If the difference between the calculated energy use and actual energy use is significantly higher it may present a barrier in its application and use.
- The impact of user behaviour can be significant for renovated buildings, thus actual energy consumption will show the behavioural patterns to owners, and they can take corrective actions to control their finances.
- There are opportunities for automation, simplification of procedures and improvement of instruments that could support the calculation method and monitoring.

In Estonia, two EPCs are generated, one with calculated energy consumption to show the potential of the building and another with the metered energy for the user, showing the real energy performance. Italian experts highlighted that real energy use would not be useful for recommendations on building systems, but it can be used for smart controls for heating and electricity etc. In Romania, the real energy consumption feature could be used potentially to provide personalised advice to end-users for changing their use patterns in buildings resulting in better energy performance.

7.3.4 Consistency with existing policies and standardss

An improved link of EPCs with measured energy use will improve policy instruments and targeted policy measures for monitoring and improving the energy performance of the building stock. One of the strengths of the measured energy performance indicator is that it can be included in EPCs for all types of buildings. The inclusion of real energy use data also enables automation of procedures and simplification of on-site inspections. Some barriers for this feature are:

- Some country-specific complicating issues may be expected related to legal aspects (e.g. access to and use of energy use data).
- Proprietary and diverse communication protocols may affect broad replication (e.g. building energy monitoring and management systems facilitating interoperability and connectivity).

Stakeholders from Austria highlight that there are no existing policies that could support the real energy consumption feature, however, there are some policies related to the heating database for boilers. The advice is to connect real energy consumption to existing databases to enable its use. Italy has no standards on real energy consumption, but it is used for energy audits which could be useful if linked to EPCs. Romanian experts emphasise the need to have the same assessment method across the EU based on standards such as EN ISO 52000-1: 2017, however it would not be too scientific.

Compatibility with the EPC scheme

The MEPI determination method follows the general principles as described in EN 52000-1 series. It is also inspired by other methods, such as the Swedish energy performance determination method based on measured energy used data and extended with optional modules to allow for inter-building comparison. One of the barriers is that the method requires the input of measured space heating, space cooling, domestic hot water and other energy uses, separately and per energy carrier, while excluding non-EPC related energy use. Only the domestic hot water use monitoring can be replaced by using a calculation model if its associated energy consumption cannot be separated from other uses of the same energy source.

In Estonia, the EPC is calculated for new buildings and renovations (design phase) in comparison to existing buildings where the EPC is based only on real energy consumption. It is also recommended that the focus should also be to use measured indoor climate data to make the real energy consumption feature more reliable. Experts from Italy outlined that there are objections to the use of real energy by public authorities as it is difficult to measure consumption such as biomass, stoves with wood etc. For national implementation in EPCs good case studies are required and it looks to be more feasible for non-residential and public buildings. Differing opinions were found between stakeholders from Romania, Austria, Italy and Estonia on the presentation of real energy consumption data on the first page of the EPC that may or may not overburden or confuse the homeowner.

7.4 Estimation of the quantitative replicability potential

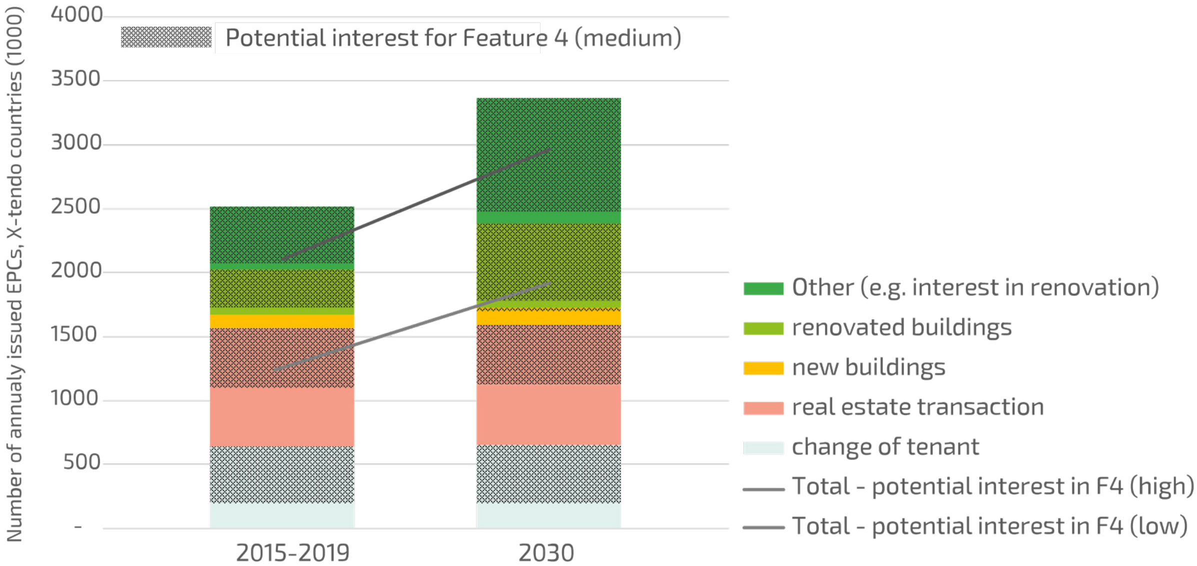
In this chapter, an estimation of the quantitative replicability potential of this feature is provided in the X-tendo countries. This follows the methodology described in section 3.
Figure 4 shows the number of annually issued EPCs, by the different trigger points in the total of X-tendo countries. In the period 2015-2019, about 2.5 million EPCs were issued annually. The largest number resulted from real estate transactions, followed by new building construction, while EPCs due to the change of tenant and building renovation, according to our data and the chosen 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*[4] . A high relevance is assumed in particular for building renovation and general interest in the potential improvement of building energy performance, leading to a range of 49%-83% of all EPC-end-users showing potential interest in the results of the real energy consumption feature. The total number of interested EPC-end-users for all trigger points is estimated to about 1.23 -2.10 million in the base year which may increase to 1.90 – 2.95 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, like 20-40% of EPC end-users are estimated to be interested.
(2) The interest may differ significantly between the buyer and the seller, in particular in a case where a building does not perform very well according to a certain indicator.

[4] The shaded areas (labelled as medium) in Figure 4 were derived as the average of the low/high range depicted in Table 14.

Thus, for the "lower" case a lower value of interest (typically the interest of the seller) is assumed, whereas for the "higher" case a higher value (typically representing the interest of the buyer) is considered. For Feature 4 a difference in the interest in the Real energy consumption is assumed for the buyer vs the seller. Thus, the difference in 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).

The highest interest in this feature for the trigger point 'renovation' is assumed, followed by 'change of tenant' and 'real estate transaction' (buyer-perspective). Thus, countries with high shares of these trigger points show the highest interest in this feature, which are Italy and Greece (about 55%-85% of all EPC end-users).

Figure 4 – Number of annually issued EPCs by trigger points and the estimated share of potentially interested EPC end-users, total of X-tendo countries (Feature 4). Historical data 2015-2019, projection until 2030.



7.5 Next steps for implementation

7.5.1 Calculation method and quality assurance

Experts from Estonia shared that it is complicated the difference between the two EPCs (real and calculated energy) to end-users. The authorities need to devise measures to make the distinction clearer to homeowners. This aspect should also be taken into account in methodology so that the outputs are harmonised with other information provided in the EPCs. Regarding the issue of sub-metering, which is difficult at the moment in Italy and Romania, the next steps suggested to overcome these limitations are to use alternatives such as data from bills as well as the installation of advanced sub-metering in building units for each energy carrier in the future. Italian experts also proposed that for electricity consumption, which is generally combined from appliances and heat pumps, it would be logical to model and manipulate the aggregated data. These aspects would enhance the quality of EPCs and advance their current status quo that relies mainly on calculated energy consumption.

7.5.2 Capacity building for delivery bodies and training needs for assessors

Calculating the real energy consumption needs the input of basic information that can be gathered from different sources, e.g. energy bills, and that may require limited pre-processing. Basic reading, writing, calculation and computer operation skills are required. In addition to these basic competences, a limited training of half a day should be sufficient to get acquainted with the basics of the methods.

If energy use data is not available, a measurement period of at least 12 months should be considered to determine the average energy use of the building. Experts suggest that the detailed building level approach or stock model development should be executed by a certified assessor, namely an engineer or mathematician/statistician with expert knowledge on building energy performance modelling or statistical modelling. This kind of analysis is time-consuming and is not elaborated within X-tendo. In deciding whether to include real energy consumption in the EPC assessment in individual Member States, the suggestion is to carry out a preliminary cost-benefit analysis at the national level, taking into account the infrastructure that is present in the building stock, legal boundaries, potential reuse as well as the feasibility and cost burden of introducing the new procedures.

7.5.3 Political discourse/ market or end-user awareness

Energy performance improvement measures can be better tailored with real energy performance data for each specific building, augmenting the quality of renovation advice. It is anticipated that this will lead to increased market trust and trigger more investments in building energy renovations. In Italy the end-users and building managers are very interested in this feature while public authorities, utility suppliers and district heating operators are not so interested. Real estate agencies show interest as well, however, they express doubts about the convenience of sharing consumption data if they are very high. While in Estonia energy consultants are mostly interested, more specifically after fluctuations in energy prices in the recent past. In Romania many private actors on the market have shown interest in the real energy consumption data.

7.6 Conclusions

A better link between EPCs and the real energy consumption feature will improve policy instruments for monitoring energy performance of building stock and targeted policy measures with a view to achieving the long-term energy performance of buildings objectives. The feature would also ensure a realistic monitoring of one's own energy consumption giving the opportunity to adjust or alter behaviour. Specific issues regarding data collection were highlighted to enable its operation, however, challenges remain concerning the sub-metering in different Member States. Overcoming the limitations of GDPR would be instrumental in making real energy consumption more popular by reducing the risks associated with privacy and data use.

In the EPBD 2021 recast proposal, revisions emphasise use of 'metered' energy consumption alongside calculated energy consumption for calculation of energy performance of buildings. Member States are asked to ensure that the typical energy use (for space heating, space cooling, domestic hot water, ventilation, built-in lighting and other technical building systems) is used representing actual operating conditions for each relevant typology reflecting the typical user behaviour. The real energy consumption feature uses correction methods to reflect these operating conditions, thus making it highly relevant in the current policy context encouraging use of metered energy consumption in the EPCs. However, making it mainstream in EPC calculation methodologies entails significant updates at Member State level.

The total number of interested EPC-end-users for all trigger points is estimated to about 1.23 -2.10 million in the base year which may increase to 1.90 – 2.95 million EPC end-users in the year 2030. To estimate the impact of this feature with the assumption that the highest interest is for the trigger point 'renovation', followed by 'change of tenant' and 'real estate transaction' (buyer-perspective), the countries with high shares of these trigger points show the highest interest in this feature, which are Italy and Greece (about 55%-85% of all EPC end-users) in this case.

Key takeways:

- The real energy consumption feature has the capacity to improve policy instruments used for monitoring energy performance of the building stock such as tailored renovation advice.
- The main barrier to the collection of data is the lack of sub-metering of energy uses (e.g. heating, cooling, DHW etc.) in buildings.
- European legislation supports the use of 'metered' energy consumption alongside calculated energy consumption for calculation of energy performance of buildings.
- GDPR limits and restricts the application and use of the real energy consumption feature.
- Current qualification of the assessors covers all the skills required for assessment in the real energy consumption feature.
- The methodology follows EN standards and is inspired by other methods such as the Swedish EPC method that applies measured energy use data.
- The method is extended with optional modules to allow for inter-building comparison.
- The feature uses correction methods that represent real operating conditions in buildings such as weather and building use.

Key action points:

- Renovation can be better tailored with measured energy use of the specific building, augmenting the quality of renovation advice.
- Devise measures to make the distinction clearer to homeowners between measured and calculated energy consumption.
- Conduct a preliminary cost-benefit analysis at the national level, taking into account the infrastructure that is present in the building stock, legal boundaries, potential reuse and the feasibility and cost burden of introducing the new procedures.

FEATURE 5: DISTRICT ENERGY

8.1 Overview

The temperature demanded for comfortable spaces during the heating season usually lies in the range of 18 to 22°C. However, heat supply and distribution systems installed in many buildings operate at supply temperatures well above these required temperatures. Decreasing the supply and distribution temperatures for space heating systems in buildings would allow for higher efficiency in the heat supply and for using low-temperature heat sources like solar thermal or waste heat via district heating (DH) networks. At the same time, many DH systems still use very significant amounts of fossil fuel for heat generation and need to be decarbonised.

The district energy (DH) indicator informs residents about the efficiency and climate effect of the nearby DH or district cooling network. It also shows whether the building can be connected to a low-temperature DH grid. The DH indicator has two sets of parameters. The first indicates the efficiency, the carbon content and the share of renewables of the nearest DH grid to end-users. These parameters will also be presented for a future point in time, thus showing the ambition of the DH grid operator to the end-users. The second set of parameters consists of information related to the building's heat distribution- and heat transfer system. These indicate the building's suitability for low temperature heat supply and for being connected to different types of DH systems. The parameters related to the building's heating system are based on rough estimations by an expert. In cases where the nearest DH network is far away from the building, the first set of parameters contains the average values of all national DH systems, and a note is included that no network is available in the immediate vicinity.

The following three parameters are integrated into the first parameter set:

- **Primary energy factor** – indicates how much primary energy is used to generate a unit of usable thermal energy delivered to the consumer.
- **Carbon emission coefficient** – converts activity data (process/processes) into CO_2 emissions, calculated based on primary energy.
- **Renewable energy factor** – gives the share of renewable energy in the heat supplied by the DH system, calculated based on primary energy.

The second set of parameters looks at the heat distribution and heat transfer system in the building to give an indication of how far the building is suited to being supplied by a low-temperature heat supply or a connection to a low-temperature DH system. It includes the following indicators:

- The minimum predefined temperature sets for adequately heating the building under the most difficult conditions throughout the year with the existing heat distribution system together with related information.

- Information relevant for estimating the expected return flow temperature of the existing heat distribution system.

These indicators are easy to collect and can further be used to roughly estimate the **minimum supply temperature** and the **expectable return temperature** of a building's heating system. Both temperatures have the ability to indicate the building's feasibility of installing a low-temperature heat supply system or being connected to an existing or a planned DH network.

8.2 Key insights from testing

Table 6 - Test projects in implementing countries for district energy

Country	ROMANIA	ITALY	POLAND
Type of Testing	In-building testing	In-building testing	In-building testing
Number of testing cases	1 MFH, 1 School	2 MFH	4 MFH, 2 SFH, 2 Offices, 5 others
Tool	Calculation tool	Calculation tool	Calculation tool
Testing Period	02/2021 - 10/2021	05/ 2021 - 12/ 2021	04/ 2021 - 11/ 2021

In the test projects only, the indicators related to the buildings were calculated, as these are the indicators that are then to be calculated by EPC assessors. To use the calculation tool, additional data, with respect to those currently collected for the usual EPC issuing process in the different countries was collected during the on-site visit, and additional calculations (i.e. the heat load of the representative room) were performed. The results form more adequate recommendations for users, local authorities and energy suppliers in their decisions to connect more buildings to a local DH grid, thus improving the energy performance of buildings as well.

Some key findings derived from the testing in the two countries are given below:

- It is important to provide estimation tables for additional radiator types as well as heat transfer system types (e.g. fan coils) and their respective thermal output at different temperature levels to ease the estimation of the indicators for the EPC assessors. This is considered crucial for the real implementation of the feature.

- In the presence of fan coils or other heat transfer systems, the feature, in the tested version, cannot perform an estimation of the actual heat transfer system at different temperatures, which can be very difficult and makes the feature's implementation rather impractical.

8.3 Drivers and barriers for a wide uptake of the feature

8.3.1 Calculation method and quality assurance

The first set of parameters, for the nearest DH network, should be calculated by accredited engineers who have practical knowledge. To receive accreditation, the engineer must prove they have the skills or experience to calculate these parameters according to the given standard. The accredited engineer then calculates the parameters using activity data provided by the DH operator. A relevant authority, e.g. the national district heating association or the national authority responsible for DH regulation, receives these parameters from the accredited engineers and collects them in a database. The parameters will then be available for the EPC assessor when preparing the EPC. For example, in Austria, data collection is done by utility and they are obliged to provide this data. The experts are certified by National District Heating Association and offer their services to calculate the parameters for the utilities. The National District Heating Association recalculates these parameters and finally accredits the values to be used by the EPC assessors.

The second set of parameters serves to estimate the minimum supply temperature as well as the expectable return temperature of a building's heating system. This set of parameters is a collection of indicators related to the heating system in a building and are collected by the EPC assessor. To keep the time and the effort collecting these parameters to a manageable level, the establishment of a national radiator database is proposed. The database should provide assessors with the heat output of frequently applied heat transfer units in the buildings. For assessing the building, the EPC assessor has to identify the dominant type and the geometry of the heat transfer unit in a single representative room of the building. Then they should look for the corresponding heat transfer unit in the radiator database and its corresponding heat output at different levels of supply-, return- and room temperature. The temperature set, at which the heat transfer unit's heat output sufficiently heats the representative room while having the maximum heat load, is chosen as the minimum temperature set. The maximum heat load can be estimated by breaking down the total heat load of the building to the heat load of the representative room via the relation of the heated floor area.

A barrier to the implementation of the feature would be the uneven distribution of the heating system across a country, for example in Italy it is present only in the North. Another limitation of the method is the difficulty to assign a representative room for non-residential buildings.

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

The implementation of this feature could benefit both the end-users and policymakers. The homeowner can compare the efficiency of his/her own heating system with the DH, however, the lack of information on DH prices may make it hard for end-users to compare the benefits of switching. DH planners can benefit from an open database of parameters and plan the connection to a new network more easily with DH parameters and flow rate.

In Italy, stakeholders consider that DH is not an important issue on the political agenda. The role of DH in the energy transition is not well known by the public either. In Austria the end-user does not show much interest, however, the public authority does. The building-related indicator can provide useful information, such as whether it is possible to supply and at what temperature. It is more relevant for an area with a high density of buildings that are not yet connected to the grid. If the building is already connected, then it is useful to know if the supply temperature could be lowered. Also, in Poland, this information is not relevant for the homeowner. If the goal is to encourage them to switch their heating system, experts consider that homeowners do not have the knowledge to compare the two heating systems.

Thus, experts agree that the outcomes of this feature are not so relevant for the end-user and can be displayed on subsequent pages of the EPC. For example, to show the advantage, a graph could show the required size of the radiator at minimum supply temperature. It would be useful to change perspective by setting first the minimum temperature to allow the use of renewable energy. This outcome can be displayed for all buildings, even if not connected to the grid. At the same time, experts agree that it is necessary to collect information about this feature and store it to be used by public authorities for planning a DH network.

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

The first set of parameters, for the nearest DH network, should be calculated by accredited engineers who have practical knowledge. To receive the accreditation, the engineer must prove they have the skills or experience to calculate these parameters according to the given standard. The accredited engineer then calculates the parameters using activity data provided by the DH operator. A relevant authority, e.g. the national DH association or the national authority responsible for DH regulation, receives these parameters from the accredited engineers and collects them in a database.

For the second set of parameters which are used to estimate the minimum supply and return temperature, the stakeholders from Italy identified an issue for apartment buildings. An EPC expert would have to do an energy analysis of the entire building instead of the single building unit, however, currently the expert is not being paid for such an extensive analysis and would not have the ability and knowledge to inspect the entire building.

8.3.4 Economic drivers and barriers

The main driver for introducing this feature into the EPC scheme is to encourage the development and connection to the DH and deployment of low-temperature heating systems compatible with renewable energy systems, thus, increasing the share of renewables in the energy mix. Countries such as Estonia, with an extensive DH grid and legislation that favours DH in new buildings are the most suitable for implementing this feature. Other conditions can enable its implementation in Estonia, such as the presence of smart metering and the start of the implementation of district cooling in bigger cities. In the EPC scheme of Estonia, DH grids are assigned a weighting factor depending on the type of fuel used.

Another market driver for implementing the feature could be redesign of the size of the radiators, which are often oversized in renovated buildings. Thus, the information about the supply temperature is useful for a proper design of the radiators, even in dwellings without access to the DH. However, if the size of the radiator is adjusted to existing high supply temperatures, there is the risk of the lock-in effect, which would hinder the transition to low-temperature heating systems. Therefore, this set of parameters could be more relevant for the public administration than the end-user.

8.3.5 Consistency with existing policies and standards

The methodology used to generate these indicators consists of: (a) a straightforward assessment methodology that gives a clear indicator for a complex issue and (b) a general framework for calculated energy requirements and utilization rates for district heating and cooling networks. The approach is inspired by the European standard EN 15316-4-5:2017 (CEN; 2017b), which is applied in modified forms in countries such as Germany and Italy.

For parameters related to the efficiency, carbon content and share of renewables of the nearest DH system, a similar system to the one proposed is currently implemented in Germany. The AGFW, the German DH association, is the authority accredited to educate and certify engineers for calculating primary energy factors for DH systems in Germany. The calculation is performed according to regulation FW 309 published by the AGFW[5]. At present, however, these factors are not included in the German EPCs. For the parameters related to the temperatures in the building's heat distribution system, the current standards are not relevant, while it is important to consider the standards in place when the radiator was installed.

Compatibility with the EPC scheme

The introduction of this feature in the EPC certificate can inform and influence decisions to connect to DH, if the individual heating system is high in CO_2 emissions, thus contributing to the extension of the GH grid. The EPBD 2021 recast proposal [25] foresees the following indicator to be integrated into the EPC:

- Feasibility of adapting the heating system to operate at more efficient temperature settings.

The information regarding the DH types of fuels, CO_2 emissions and extension can be useful for other policies and planning besides the EPC. The second set of parameters are useful for the building logbook, as well as tailored recommendations of the EPC or building passport. For example, if the radiators after placing insulation are oversized, they could be either used at lower temperatures or redesigned. From a planning perspective, knowing the supply temperature of the DH can help authorities lower it in a district, in parallel planning the renovation of the buildings.

Many EU Member States have already included the DH parameters in the EPC calculation method; thus, many necessary inputs are already available. Currently, the DH parameters are used in the calculation for the primary energy and CO_2 emissions, thus the implementation of this feature can improve the quality of these inputs. The feature is also useful in rural areas with no DH connection, because of the second set of parameters regarding the temperatures.

[5] AGFW. 2014. Arbeitsblatt AGFW FW 309 Teil 1 - Energetische Bewtung von Fernwärme - Bestimmung der spezifischen Primärenergiefaktoren für Fernwärmeversorgungssysteme.

8.4 Estimation of the quantitative replicability potential

In this chapter, estimation of the quantitative replicability potential of this feature is provided in the X-tendo countries. This follows the methodology described in section 3. *Figure 5* and *Figure 6* show the number of annually issued EPCs, by the different trigger points in the total of X-tendo countries. Due to the different characteristics of the two indicators (one related to the suitability of low-temperature heat sources and the other to the primary energy factor of district heating), the results are distinguished below.

In the period 2015-2019, about 2.5 million EPCs were issued annually. The largest number resulted from real estate transactions, followed by new building construction, while EPCs due to the change of tenant and building renovation according to available data and the chosen assumptions have lower relevance. In shaded colours, the figure shows the share of EPC end-users which potentially show special interest in this feature, according to the factors determined in *Table 13* and *Table 14*[6]. A high relevance is assumed in particular for 'new buildings', leading to a range of 24%-66% (low-temp) and 10%-44% (DH-PEF) of all EPC end-users showing potential interest in the results of the District energy feature. The total number of interested EPC end-users for all trigger points is estimated to about 600-1,656 thousand (low-temp) and 0.24 – 1.11 million (DH-PEF) in the base year which may increase to 1.10 – 2.34 million and 0.41- 1.46 million (DH-PEF) 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, like 20-40% of EPC-end-users are estimated to be interested. (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 the lower value of interest (typically the interest of the seller) is assumed, whereas for the "higher" case higher value (typically representing the interest of the buyer) is considered. For Feature 5 a difference in the interest of EPC end-users is assumed for the buyer vs. the seller. Thus, 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).

The highest share of potentially interested EPC end-users for the trigger point 'new building construction' is estimated. The relevance of this trigger point in the past was significantly lower in Greece and Portugal than in other countries. This explains why these two countries show the lowest share of potentially interested EPC-end users. This also coincides with the low relevance of district heating in these countries, which was not explicitly factored in, because at least the first of the two indicators are relevant for each type of low-temperature heat source.

[6] The shaded areas (labelled as medium) in Figure 5 and Figure 6 were derived as the average of the low/high range depicted in Table 14.

Figure 5 – Number of annually issued EPCs by trigger points and the estimated share of potentially interested EPC end-users, total of X-tendo countries (Feature 5 low-temp). Historical data 2015-2019, projection until 2030.

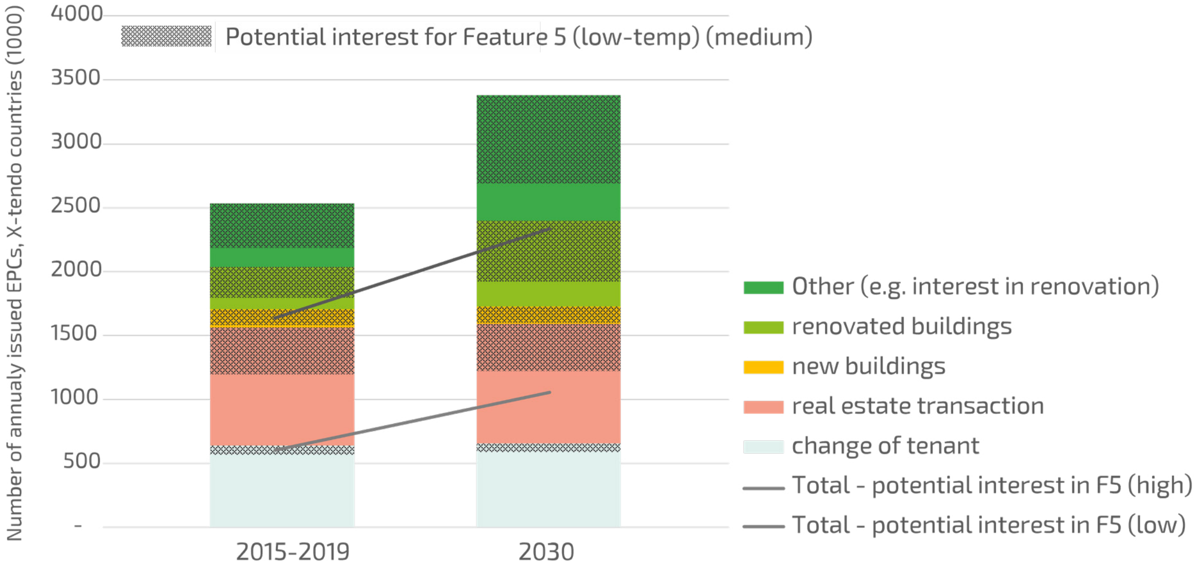
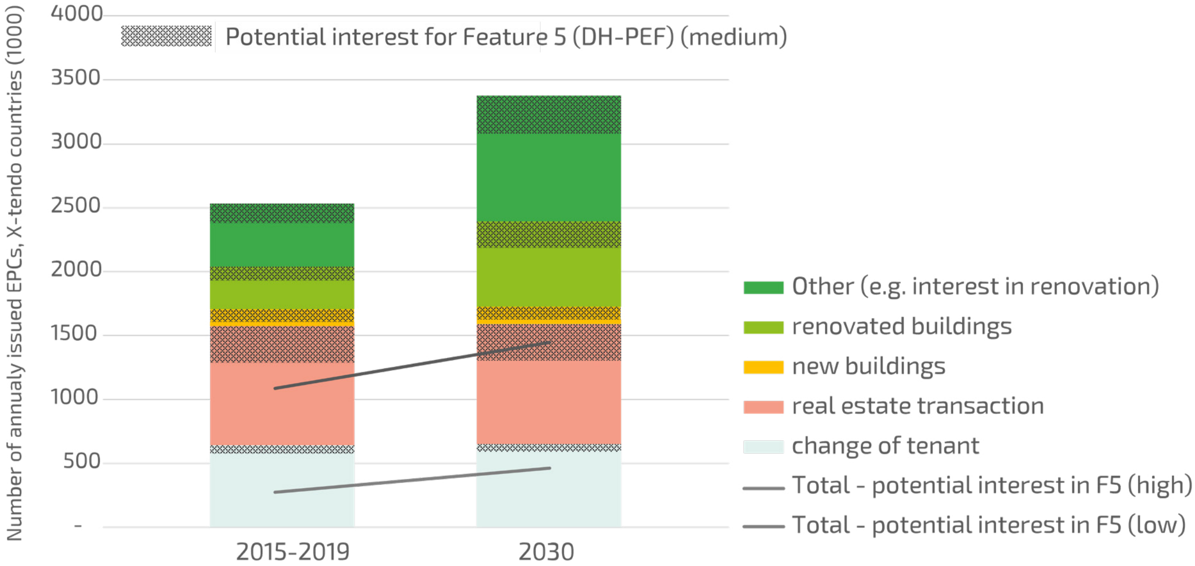


Figure 6 – Number of annually issued EPCs by trigger points and the estimated share of potentially interested EPC end-users, total of X-tendo countries (Feature 5 DH-PEF). Historical data 2015-2019, projection until 2030.



8.5 Next steps for implementation

8.5.1 Calculation method and quality assurance

For the implementation of this feature first of all there have to be provisions in place to set up two databases. The first database will gather DH parameters, should have open access and should gather the existing and future plans of the DH operators. It has to contain the DH types of fuels and their respective CO_2 emissions. The second database concerns the parameters of the radiators, with the specifications and national standards from the time when the radiators were installed.

The technical spreadsheets from manufacturers will include the specifications of the different temperature levels (supply-, return- and room temperature) heat output.

These two databases are a precondition for the integration of the feature into the EPC scheme. The next step would be tackling the limitations of the calculation method. For example, currently, the method requires the specification of the representative room which is not currently being implemented in the EPC scheme. For some building typologies such as large commercial buildings, it is difficult to assign a representative space. Another issue to be tackled is the representative spaces in apartment blocks. The representative rooms can be located in different orientation with different heat losses in the various apartments. In several Member States, such as Italy, the EPC is provided for the apartment unit, not for the entire building, therefore this feature would be relevant only for the apartment owner, and less so for public authorities. Thus, the experts find the implementation of the first set of parameters regarding DH easier than the second one regarding the temperature levels.

For the two sets of parameters, standards from the EU were used to align the feature towards common standards between MS. Thus, these must be maintained to enable harmonised calculation methods.

8.5.2 Capacity building for delivery bodies and training needs for assessors

Experts highlight that a brief training is needed for architects, but no training is needed for engineers who are already trained on the parameters used in district heating. To be able to build the capacity of public authorities and EPC assessors, updates to regional and national databases would enable access to information. Additionally, there should be databases for different types of heating systems, so that the EPC assessors can look up this information case by case, saving them time and money while making the assessment cost-effective.

8.5.3 Political discourse/market or end-user awarenesss

There is a strong interest from stakeholders in Poland into the implementation of the feature, however, the first step would be to convince public authorities to implement it. If public authorities are persuaded, the basics would have been set up such as the database on the standards of radiators, and others previously referred above.

Since the feature is of greater interest to public authorities, it is important to show the economic feasibility of district heating, to involve the general public in urban planning, to engage people in finding solutions and planning district heating.

Experts from Romania and Poland agree, though district heating is not always the best solution as it depends on a mix of renewable energy, for a dense population it is most efficient. Therefore, we need to convince people to connect, meaning this feature should be included in the EPC while also focusing on renovation to make existing buildings more energy efficient.

Information about district heating can inform and influence decisions to connect to district heating if the individual heating system is high in CO_2 emissions. It could be a motivation for environmentally conscious homeowners, thus they should be informed if the district heating is lower in CO_2 emissions

8.6 Conclusions

The EPBD recast proposal [25] foresees the inclusion of information on the feasibility of adapting the heating system to operate at more efficient temperature settings in EPCs. While it also mandates MS to take necessary measures to supply buildings with district heating or cooling. The information from this feature regarding the DH types of fuels, CO_2 emissions and extension can be useful for other policies and planning besides the EPC, such as the DBL and the building renovation passport. For example, if the radiators after placing insulation are oversized, they could be either used at lower temperatures or redesigned. From a planning perspective, knowing the supply temperature of the DH can help authorities lower it in a district, in parallel planning the renovation of the buildings. Many EU Member States have already included the DH parameters in the EPC calculation method; thus, many necessary inputs are already available.

District heating parameters (the first set) in Italy would not have a big impact because of unequal geographical distribution (district heating only in the North), thus a big part of the country is not interested in district heating. But the second set of parameters is interesting for Italy where for renovations it is mandatory to be able to connect to district heating. The EED foresees that the country should report on the strategy for district heating/cooling, thus part of the feature can be used to assess the progress on the district heating. It can also be used by the national strategy to assess how to modernise and renovate buildings to adapt to low-temperature district heating systems.

The impact of this feature from the quantitative estimations identified that the highest share of potentially interested EPC end-users for the trigger point 'new building construction' is most relevant. However, this trigger point is not very significant for Greece and Portugal compared to other countries due to the low relevance of DH.

Key takeaways:

- Experts find the feature useful for all urban and rural areas, even those not connected to the DH grid, because of the second set of parameters on temperature flow.
- The main objective is to inform and assist public authorities in decision making by providing an overview of hot water parameters and distribution for planning and management of existing and future hot water networks.
- For homeowners, this feature aims to equip them with information that helps them to switch to DH with lower emissions. It may also encourage low temperature heating systems.
- The second set of parameters are useful for the building logbook, as well as tailored recommendations of the EPC or building passport.

Key action points:

- For the implementation of this feature there have to be provisions in place to set up two databases with DH parameters and parameters of the radiators at national level.
- It is important to show the economic feasibility of district heating, to involve the general public in urban planning, engage people in finding solutions and planning district heating.

9

FEATURE 6: EPC DATABASES

9.1 Overview

EPC databases store all EPCs and underlying data. They are an important tool for public authorities to source building stock information and check compliance with the national assessment methodology. Quality assurance processes and data verification are key to ensure the reliability and accuracy of the information stored in the database.

EPC databases have, so far, been voluntary for Member States. Most Member States have now set up databases, but the approaches vary from country to country. While some countries only collect the input data about the building (in part extracted from an XML file, for example), others go further and perform the EPC calculation within the registry. Some Member States store the detailed input data required to generate the EPC, while others collect a PDF copy of the certificate but no data. In all cases, it is highly relevant to store all EPC data and, preferably, to provide authorised stakeholders with easy access to relevant information. The database has different potential uses, such as data mining for country/sector reports, interoperability with other databases and publication of market-relevant information to different stakeholders: building owners, construction companies, real estate actors, public authorities, etc. The database can become a powerful instrument for public authorities, if used to identify and target homes where renovation support is most urgently needed, as in the case of Scotland.

In this direction, the proposed EPC database methodology focuses on the development and implementation of routines, which are able to identify outliers and to validate EPC data. This consists of a four-step approach, starting right after the EPC is logged in the database:

1. First check: "gross" threshold value check.
2. Second check: "narrow" threshold value check.
3. EPC flagging: indication of inconsistencies per EPC.
4. Feedback loop to energy auditor: identify and indicate commonly made mistakes and communicate to energy auditor training courses.

The first action required for the successful implementation of the EPC database methodology is programming the code that will perform the verification checks. An automatised interface between the national EPC database and the core code is developed, allowing the extraction of the EPC data; this interface and the data format will be country specific.

9.2 Key insights from testing

Table 7 - Test projects summary in implementing countries for EPC databases

Country	DENMARK	ITALY	GREECE
Type of Testing	System testing	System Testing	System Testing
Number of testing cases	138 EPC data	Approximately 2 million of EPCs in the Italian National EPC Database	Number of checks: 460,000
Tool	Risk based testing	Software code developed in X-tendo	Data mining software & software code developed in X-tendo
Testing Period	01/01/2019 - 31/12/2019	01 2021 - 03/2022	06/2021 - 12/2021

The system testing was conducted on Danish, Italian and Greek EPC data.

The test in Denmark on EPC data from 2019 indicated the benefits of a risk-based control scheme regarding successful hits, outcomes, resources etc. and provides possibilities of using the results in the EPC scheme. The purpose of the control is to identify EPCs with errors in the input parameters, or EPCs showing indications of possible errors in the input parameters. The risk-based control showed a total of 319 errors on input parameters across all 138 EPCs chosen for a manual check from a total of 8233 EPCs. The risk-based control was applied on parameters over ventilation, air tightness and windows/doors. Four directions could be considered to establish a complete feedback loop in the EPC scheme for enhancing the EPC data:

- Increase the information on the role of the EPC consultants in performing EPCs for new and existing buildings e.g. through webinars or technical newsletters.
- Regular evaluation of education of EPC consultants and upskilling opportunities.
- More validation checks of data to avoid errors and mistakes (e.g. digital and automatic control of input parameters).

The test in Greece showed that a considerable percentage (about 13%) of the 460,000 EPCs were not useful for this kind of detailed analysis, due to incompatibilities between the various EPC processing software applications used by energy experts.

Therefore, as first learnings from the testing activity, it is as an absolute priority to develop standards based, machine-readable definitions of the XML format used by the national EPC calculation. From the remaining XML files, a small percentage (about 6%) was found to violate elementary data quality rules (1st level check). A statistical analysis was performed on the same sample of EPCs, yielding parameter values to identify EPC outliers (2nd level check) with regards to similar buildings and about 12% of the sample were found to be outliers in at least one parameter. It is proposed by Greek experts that an EPC failing a 1st level check should lead to an error, while failing a 2nd level check should lead to a warning message to the EPC expert when uploading the XML file in the EPC registry. The EPC assessor can then decide if any action should be taken. Moreover, the second level checks can be used to identify faulty EPCs for further check by the EPC registry administrators.

In Italy, the National Italian EPC Database was tested on a "test environment" database containing nearly 2 million EPCs. The software code was used to perform two levels of checks: (i) 1st level checks, which control the presence and the correct data typology of 46 chosen parameters (i.e. global energy performance for renewable and not renewable energy, energy label, etc.), and (ii) 2nd level checks, which control that the values of 11 parameters (i.e. global energy performance for renewable and not renewable energy, etc.) are within a range defined by a certain percentile value, calculated by ENEA considering the EPCs present in the database. This level of checks aims to identify possible significant differences from the bulk of the EPCs stored in the database.

- The major challenge in Italy is the high execution time of the code. With the actual code execution time, it is possible to run it on the whole database only a few times in a year.
- Special attention must be paid to the definition of the rules. When defining 1st level rules, it is very important to avoid interdependencies with involved "critical" parameters.
- Through post-processing of the output provided by the code, it is possible to identify the faulty EPCs, the riskiest building clusters, and the parameters presenting the highest number of non-compliant EPCs.

9.3 Drivers and barriers for a wide uptake of the feature

9.3.1 Calculation method and quality assurance

The implementation and improvement of EPC databases include aspects such as how to set up an EPC database, how to gather the data, how to establish the interoperability of different databases, and how to use data and extract relevant insights from it. Finally, ensuring the reliability and accuracy of the information stored in the database through quality assurance processes and data verification remains a key requirement common to all EPC schemes. The EPC database feature in X-tendo focuses on defining and establishing routines and analyses for quality control of EPCs in the EPC Databases. One of the main drivers is that the methodology can be applied to any EPC database, national or regional and is replicable to other countries. However, the main condition is that the EPC data is automatically updated through an appropriate file format (for example, XML). EPCs in a PDF format do not allow the data to be automatically read. Also, the method is replicable to other countries but country-specific adaptations, such as the choice of parameters to be checked, are necessary. The modular interface between the core code and the EPC database allows for the code structure to be easily adapted to specific countries.

Some of the identified barriers include:

- Manually controlling and correcting (if necessary) the EPC is not part of the scope of this methodology. This can be overcome by creating override mechanisms that are more controlled in databases. The outcome of this methodology can help to select the EPC, that will be manually verified, based on a riskiness of the EPC (and not randomly, as done in many Member States.

- Possible fault categories for the final EPC score are defined with different levels of their gravity: very serious, serious or less serious faults. These definitions need more explicit details based on Member States databases.

In Denmark, data is automatically transferred to the national EPC database. It has already tested and implemented the concept of an automatised EPC database analysis, and the results were also used to provide feedback on how to improve education programs for energy auditors and other professionals responsible for issuing EPCs. This learning from Danish experts supported the development of the EPC database feature. Greece and Italy implemented and tested the new EPC database feature for the first and second level verification checks that were used to flag EPCs.

In Italy, both in the national and in the regional databases, EPCs are stored as machine readable data. In the national EPC database, only data present on the certificate is stored. At a regional level, it depends on the region/autonomous province: in some regions a wider set of data is stored in the regional database, whereas in other regions only the data present on the certificate is stored. The databases are not currently interoperable and the official level for EPCs control is regional.

In Greece, there are no issues with data upload, but there is an issue with verifying the uploaded data and the calculation engines. There are inconsistencies which make the use of data problematic. Theoretically, the data is available, but in practice the data does not show reliable results due to the fact that data is structured in different ways with different software used.

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

Often EPC databases have restricted access and are not publicly available for different stakeholders. Quality assurance of the EPC databases using the developed feature can contribute significantly to improving trust in EPCs. This feature has some of the main barriers that restrict its availability in public domains:

- The GDPR is highlighted as the main barrier in giving access to end-users and other beneficiaries in most of the countries. Partial access is often a solution however, different opinions exist in the interpretation of the regulation.

- The feature is not directly relevant for end-users but more so for public authorities. There is interest in the public availability of data on areas at the municipal level.

Italian experts highlighted that not everyone in public authorities has access to the database, only permitted personnel are allowed to access it due to GDPR issues and thus testing presented no issues. In Denmark, the GDPR applies only to information that is identifying with a person. There is no issue in releasing information about the building and there is no confidential information about it. For all experts it was more feasible to test the feature without any major issues since all of them are EPC database managers. However, in Greece there are limitations regarding access to data which is not accessible to the public and special permission is needed from the Ministry. Even public authorities have restricted access to the data, like in Italy.

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

An EPC database has different potential uses, such as interoperability with other databases and publication of market-relevant information to different stakeholders: building owners, construction companies, real estate actors, public authorities, etc. To be able to provide these uses, EPC databases must inherently provide support to test these functionalities. Among the main drivers are the provision of automatic verification checks performed by experts with a good knowledge of IT and big-database handling and statistical analysis skills. Expert programming knowledge is essential for database management. This is required to execute the code and provide quality assurance checks.

In Italy, due to the GDPR, only permitted personnel are allowed to access the national database's microdata. At a provincial level, some aggregated data and some statistical analysis are publicly available. Similarly in Greece, the database is not easily accessible and requires special permission from the authorities to conduct any statistical analysis. However, the EPC database has been in operation for more than 10 years and stakeholders of the market (both professionals in the field and building owners are well aware of the issuance process and of the features of the database). In contrast, Denmark is quite flexible towards granting access to its public database for testing purposes.

9.3.4 Economic and market drivers and barriers

Code structure that does not entail additional investments in the update of EPC databases can be easily adapted to specific countries. With the shift in the real estate and construction industry, several stakeholders are becoming more aware of the potential use of these databases to seek opportunities in the renovation sector. Often these databases are useful in developing products and conducting feasibility analyses. Stakeholders and experts see that there are opportunities for the market to exploit these databases. However, this strongly depends on the level of information that would be available for commercial or public use once the new EPBD 2021 recast is implemented in Member States.

9.3.5 Consistency with existing policies and standards

The EPC database feature would contribute to a higher quality of EPCs in the database and would support all the other aspects in EPBD like Building Stock Observatory, building renovation passports, building logbooks, and also includes the Minimum Energy Performance Standards. All aspects are closely related to the question of quality checks which are foreseen in the EPBD. There is a further need to harmonise the quality assurance standards that should be applied in all the countries. With improved data quality, data can be better used for benchmarking or for the implementation of policies. For this purpose, the data should be more reliable and relevant to the building logbooks. To enable effective EPC databases, an interface between the national database and the developed code must be implemented. This interface would allow the inputting of EPC information into the core programming code. If needed, the code can be translated to other programming languages. However, the code may become obsolete if the necessary conditions are not met.

In some regions of Italy (e.g. Lombardia, Piemonte, Valle d'Aosta) EPCs are considered as support to plan local energy policies. While in Greece, the EPC databases are used in conjunction with other databases such as land registry, tax authority etc. Denmark considers that the quality of data is relevant for future policies, such as the building logbook. However, in their investigation with public stakeholders they identified that more data is required than the existing one in the EPCs for policy purposes. It is also important that all data collected during the issuing of the EPC is available as aggregated data. In Denmark some of the data is not made accessible in tables and this can make data extraction more complicated than necessary.

Compatibility with the EPC scheme

The principal method is replicable to any other country, but the concrete implementation is very much tailor-made. It is not possible to directly take the code as some effort is needed to tailor it to technical implementation:

- Providing an EPC quality control and assurance routine is important so that EPC data is readable for computer systems and accessible to users. Storing PDF documents is not sufficient.
- Public bodies in Member States need quality compliance methods and this feature would support this.

Italian experts found the code is fit for the structure of their national database. The EPC database feature is a good basis to start updating EPC systems. Every region in Italy has a regional database. The property of EPC data is regional and data in each regional database may be very specific; data processing for the whole country is based on a reduced dataset, common to all regional databases. Denmark already has a running risk-based control system thus, the feature was tested on enhancing the functionalities of their database. In Greece, the national database is under only one ministry and thus the algorithms were tested without any major issues.

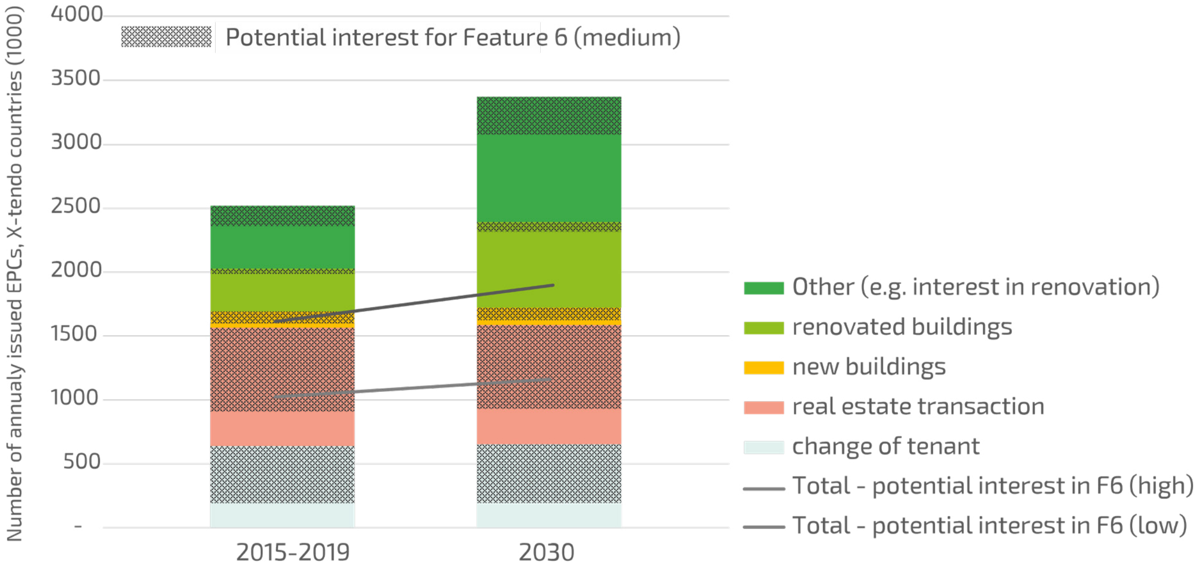
9.4 Estimation of the quantitative replicability potential

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. *Figure 7* shows the number of annually issued EPCs by the different trigger points in the X-tendo countries. In the period 2015-2019, about 2.5 million EPCs were issued annually. The largest part resulted from real estate transactions, followed by new building construction, while EPCs due to the change of tenant and building renovation according to available data and the chosen assumptions have lower relevance. In shaded colours, the figure shows the share of EPC end-users which potentially show special interest in this feature, according to the factors determined in *Table 13* and *Table 14*[7] in *Annex 1*. A high relevance is assumed in particular for 'new buildings', 'real estate transactions' and 'change of tenant', leading to a range of 44%-64% of all EPC-end-users showing potential interest in the results of the EPC databases feature. The total number of interested EPC end-users for all trigger points is estimated to about 1.11 – 1.62 million in the base year which may increase to 1.23 – 1.91 million EPC-end-users in the year 2030, as indicated by the grey lines. However, in contrast to other features, it should be noted that the quality assurance measures developed for EPC databases refer to indirect use for EPC-end-users.

The bandwidth (low-high) results from two factors: (1) The potential interest of EPC-end-users was assigned by categories, each representing a range, for example 20-40% of EPC-end-users are estimated to be interested. (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, a lower value of interest (typically the interest of the seller) is assumed, whereas for the "higher" case a higher value (typically representing the interest of the buyer) is considered. For Feature 6, no strong difference in the interest in the EPC databases is assumed for the buyer vs. the seller. Thus, the difference results only from the bandwidth of the estimation.

[7] The shaded areas (labelled as medium) in Figure 8 were derived as the average of the low/high range depicted in Table 14.

Figure 7 – Number of annually issued EPCs by trigger points and the estimated share of potentially interested EPC end-users, total of X-tendo countries (Feature 6). Historical data 2015-2019, projection until 2030.



9.5 Next steps for implementationl

9.5.1 Calculation method and quality assurance

Both in national and regional databases, EPCs are stored as machine readable data. Thus, Italian experts recommend that the EPC database must be set up in machine-readable formats. Danish experts advised that the next steps would need more focus on visualisations while making provisions for feedback. They also intend to make additional checks, for example, if an EPC assessor made several EPCs on the same date in various locations within long distances. It can also provide material for training or put a limit on the number of EPCs per day. Italy identified that the tool can be used at the regional level and in different Member States. Some parameters can be chosen to check, for example, not only to say that this EPC is wrong but to highlight outliers beyond the percentile. It is unlikely that all the regions will start using this tool, but it can be useful to harmonise the different databases. Greek experts consider it to be useful to notify the EPC assessor, as a warning, if a value is beyond a certain percentile. Such a system will have to identify common mistakes in data entry to provide information for the training sessions.

9.5.2 Capacity building for delivery bodies and training needs for assessors

It is important to clearly communicate the quality assurance results to energy auditors in a structured way, therefore contributing to their training and skills development. Concepts must be developed on how to apply the results from the EPC database quality control to educate energy auditors/consultants. Public authorities need a joint effort of professionals with IT (python) and engineering, data analysis and/or statistical knowledge skills and mixed teams are necessary to improve the existing EPC databases. The target group are the experts at the EPC database authority for the EPC database feature. In the long term, the easy use of the database will encourage all stakeholders to access the information, improving the quality of the construction sector.

9.5.3 Political discourse/ Market and end-user awareness

Researchers are interested in this database. For public authorities it is essentially important for policies. There is not much interested from the from the homeowner in the databases, rather only in their own EPCs. Since the trust on EPC quality is low, there is no interest at the moment from the market and they rely more on energy audits. The database does not contain data that is interesting for the SMEs, since there is no information on building components.

9.6 Conclusions

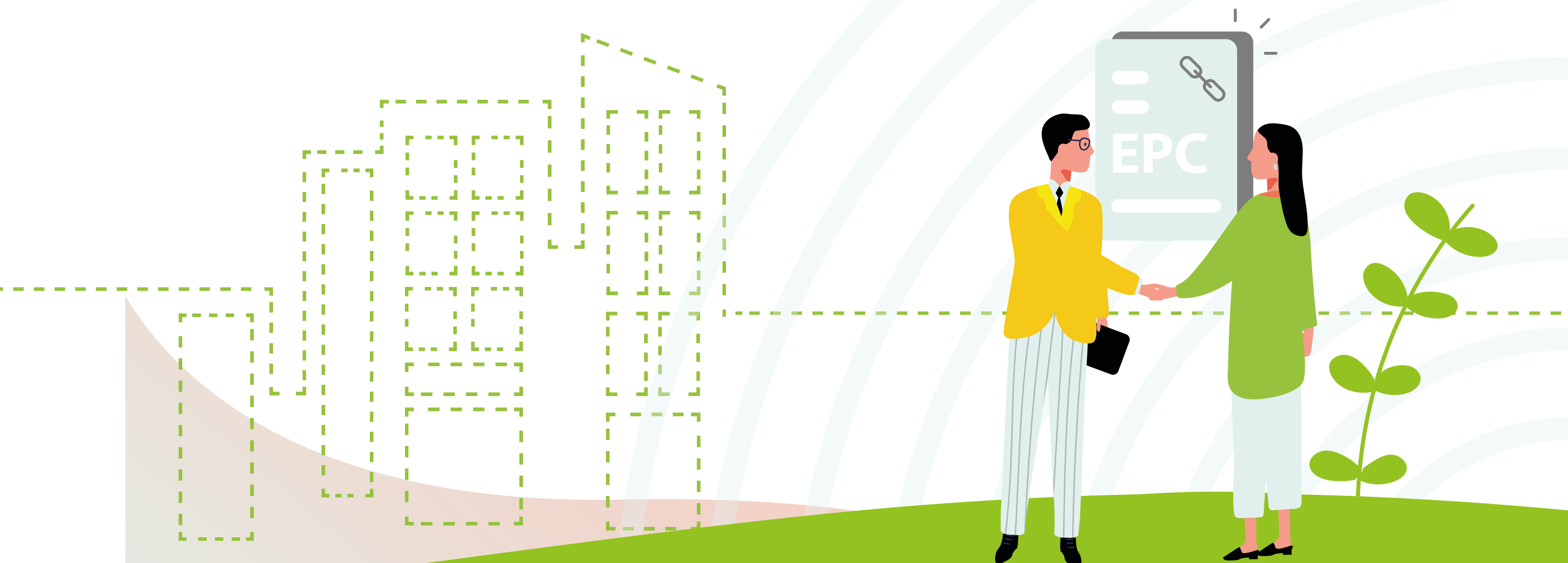
Article 19 in the proposed revision of EPBD 2021 [25] makes it mandatory for each Member State to set up a national database for the energy performance of buildings, to allow data to be gathered on the energy performance of the buildings and on the overall energy performance of the national building stock. There is more emphasis on making the database public in compliance with EU and national data protection rules. It is also expected that Member States exchange data with the Building Stock Observatory once a year. To ensure coherence and consistency of information, Member States are required to make their databases interoperable and integrated with other administrative databases containing information on buildings, such as the national building register and digital building logbooks. This X-tendo feature is directly linked to the Annex VI of the revised EPBD, where independent control systems for energy performance certificates are highlighted together with a validity check of inputs data including an on-site check, maximum deviations from energy performance of buildings and differing elements from defaults that should be evaluated for the issued EPCs. The X-tendo EPC database feature has developed robust quality check mechanisms that could support a systematic risk-based quality control of completed EPCs. The outcomes from the verifications can define the threshold values to be implemented on on-site checks for issuing EPCs and if integrated with a feedback loop to the energy auditors and EPC issues, can improve the EPC issuing practices. Based on the impact assessment for this feature, the total number of interested EPC end-users for all trigger points is estimated to about 1.11 -1.62 million in the base year which may increase to 1.23 -1.91 million EPC end-users in the year 2030. In contrast to other features, it should be noted that the quality assurance measures developed for EPC databases, are in any case, of indirect use for EPC-end-users. That is why there is not a significant increase in EPC end-users due to the implementation of this feature which is of higher interest and relevance to public authorities.

Key takeaways:

- The EPC database feature is directly linked to the Annex VI of the revised EPBD, where independent control systems for energy performance certificates are highlighted together with a validity check of inputs data.
- The feature has robust quality check mechanisms that could support a systematic risk-based quality control of completed EPCs.
- The feature includes a feedback loop to energy auditors and EPC issuers, to improve the EPC issuing practices.
- The feature is designed for public authorities and therefore, it is not of high direct relevance for EPC end-users.
- Application of the code structure does not entail additional investments to update EPC databases and can be easily adapted to specific countries.
- Expert programming knowledge is essential for database management and it is required to execute the code and provide quality assurance checks GDPR is highlighted as the main barrier in giving access to EPC data for end-users and other beneficiaries in most of the countries.
- The developed methodology can be applied to any EPC database, national or regional and is replicable in other countries.

Key action points:

- Develop useful visualizations while making provisions for feedback in databases.
- EPC databases must be set up in machine-readable formats



10

FEATURE 7: BUILDING LOGBOOKS

10.1 Overview

Digital Building Logbooks (DBLs) enable better decision-making throughout the building lifecycle, including management of technical and functional aspects, safety, conservation of economic value, certification, improved energy and environmental performance. DBLs are repositories for detailed building information. They act as a single point of input, access and visualisation of all the information associated with a building unit throughout its lifecycle.

Over the lifespan of buildings, data is routinely collected by multiple stakeholders for various reasons as many decisions rely on data availability. However, there is a lack of a common approach and structure among stakeholders which would make this wealth of information widely available, organised and easily accessible. Much of the data collected goes unused as it gets discarded, forgotten or is not compatible with other stakeholders' systems. The lack of an overarching structure shared across the built environment leads to information asymmetry, lack of transparency and higher risk for investment and renovation decisions.

Organised and shared data reduces uncertainty but also the time and cost needed for collecting missing information. Availability of granular performance and maintenance data in addition to the energy performance certificate (EPC) could provide a more robust and reliable indication of energy performance and reduce data gaps about the building's performance. Logbooks can enhance the overview of the entire building stock at all levels, allow public authorities to better tailor various measures, set benchmarks and strategies, as well as monitor progress toward climate goals (including through the national long-term renovation strategies). Equally, EPC data and databases are considered to be one of the most important sources of data for the initial population of logbooks. Establishing close links between EPC databases and building logbooks, could therefore mutually reinforce both tools.

The current feature developed three core aspects relevant to the building logbook: (1) a data template, (2) functionalities and benefits, and (3) data governance:

- Development of the logbook data model, including protocols for data capturing and data sharing (e.g. via a common web service).
- Stakeholder engagement over the use of data and access by third parties such as mapping of DBL-related benefits, costs, drivers and potential challenges, mapping of information flows, i.e. who needs what data, when, from what sources and in what form?
- Clarifications of data governance requirements (both legal and technical, such as GDPR, intellectual property rights, data access and storage).

10.2 Key insights from testing

Table 8 - Test projects summary in implementing countries for building logbooks

Country	PORTUGAL	GREECE	ESTONIA
Type of Testing	System & User Testing	System & User Testing	System Testing
Number of testing cases	2 functionalities and 15 beneficiaries	1 application and 10 stakeholders	1 application
Tool	Functionalities Development & User Questionnaire	Design of a Logbook Messaging Protocol - Development of a prototype of a logbook software system – User questionnaire	Desktop application test
Testing Period	06/2021 - 12/2021	07/2021 - 11/2021	08/2021 - 12/2022

System testing

System testing in evaluated different aspects of the DBL methodology developed in X-tendo. Portugal tested the two new functionalities within the casA+ platform and web service: (1) building components dashboard and (2) water & energy consumption monitoring. Estonia calculated and analysed renovation costs based on parameters derived from their building logbook application (Energiamonitor). In Greece a logbook messaging protocol was designed, and an application prototype was developed for the exchange of data between the EPC registry and a logbook:

- A building dashboard allowed the user to consult and edit some information about their home (e.g. walls, window glazing, lighting, appliances, equipment and renewable electricity).
- Water and energy consumption functionality allowed the user to monitor their consumption and compare them with others. It also gives their monthly bill for energy (€/kWh) and water (€/m^3).

User-testing

During the user testing in Portugal, the beneficiaries of the casA+ were invited to evaluate the new functionalities with the goal of collecting the homeowner's user experience. A questionnaire was prepared for this evaluation and completed by 15 registered homeowners in the casA+ portal. Most of the respondents were not aware of the building's dashboard functionality (79%). Considering the water and energy consumption functionality, 86% of the respondents were not aware of its availability in the DBL. They indicated that these functionalities will be very useful in both the context of the building logbook and a one-stop-shop. Most homeowners provided positive feedback and felt that the functionalities are fundamental to knowing more about their house and water/energy consumption. The tested DBL functionalities were considered to improve homeowners' understanding of the required improvement measures and behavioural change.

In the user testing in Greece, web meetings were held with the stakeholders in which the design elements of logbook and the design of a standard web-service providing interoperability between a building logbook and an EPC registry were discussed. The stakeholders were EPC registry administrators, energy experts, and engineering software developers. The respondents understood very well and were interested in the feature. They found that the feature would provide useful functionality for building owners and interoperability between relevant public sector applications. They also proposed that a central logbook should be implemented by a governmental agency but extensible by others; the RESTful-JSON architecture is best for the communication between the different logbook components. Thus, there is need for relevant legislation to enable these aspects at national level.

10.3 Drivers and barriers for a wide uptake of the feature

10.3.1 Calculation method and quality assurance

The DBL relies on existing databases, thus its quality assurance is highly linked to the trustworthiness of their data, as well as processes to enable interoperability, data consistency and information exchange. The member states are currently at different stages of digitalisation of the EPC database and the development of the DBL. A lack of digitalised EPC databases is a key barrier for automatised data transfer. The low quality of the EPCs, and thus of the EPC database is another important issue to be tackled. Experts consider that there are inconsistencies of the data within databases and between databases. The quality checks similar to those implemented by Feature 6 are being foreseen by the EPBD recast [25] and will continuously improve the quality and consistencies within the EPC database. It is not only an issue of errors but also of outdated data since the EPC is valid for 10 years and homeowners in this time can undertake light renovation measures, for example, changing windows. This data cannot be updated and overwritten unless a new EPC is issued. The DBL can further contribute to quality assurance if algorithms are set up to check the consistency between the databases. This can contribute to more frequent updates of the data compared to the EPC. Experts advise additional checks of the data by the PA before the information is introduced into the DBL.

The credibility of DBL is closely related to the quality of data and the reliability of sources. Data from public sources (e.g. EPC registries) is generally considered to be more reliable than information submitted by the owner for example. The data enclosed in the logbook will indicate the source and reliability of data, which can include:

- EPC data.
- General and administrative documentation for the identification of the building.
- Official documents related to building construction/renovation permits and real estate transaction contracts.
- Building plans and studies.
- Documentation on renovation works (invoices, materials certificates).
- Further documentation on energy performance, such as energy bills, as well as financial information on taxation, loans, market value etc. are considered to be of minor importance.

The mapping of different data sources will provide an overview of the different quality levels of the data.

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

The logbook is designed to bring a wide range of benefits to different actors involved in the building value chain, including non-professional users such as homeowners, tenants, public authorities or financial institutions. As such, the logbook must be user-friendly and easily accessible. Furthermore, the data should be linked to benefits and functionalities which enhances the value of the logbook and the buy-in from the homeowners (plus all other involved stakeholders).

Public awareness of DBLs is still relatively low due to the novelty of the scheme. Portuguese homeowners are not aware of the DBL as a standalone tool, they rather perceive it as part of the online services of the OSS. Similarly, the Greek public is not aware of the existence of the DBL, however, the associations of homeowners are. Some experts question the need for the general public to be aware of the DBL as a separate policy or that it is enough to be part of wider public services. Other experts consider it as a digital extension of the paper EPC, which can be consulted online for historical data. The divergence of views about the role of DBLs will hopefully be clarified in time as the tool becomes mainstream and additional (non-energy) modules and features will be incrementally added and enabled by logbooks.

Homeowners need to be incentivised to contribute data to the DBL (e.g. by uploading information from the building permit, project plans, BIM models, etc). They can be motivated by the convenience of having historical data on energy consumption in one place and easily at hand, instead of having different paper-based documents and bills laying around. This information can be presented in an attractive, user-friendly way. Digital logbooks can also provide alerts and reminders. However, split incentives concerning the collection and handling of data between tenants and owners will need to be addressed in due course.

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

Once the logbook platform is properly set up and operational, the end users will not require upskilling and training. By linking the logbook with other existing databases and tools such as building registries, environmental certification systems and BIM models, the logbook can act as a digital OSS and bring together building sector stakeholders, overcome value chain fragmentation and enable new/streamlined services. The data transfers and quality checks should be automatised. However, coordination between different departments of the public authorities will be necessary to set them up, as well as capacity to build IT public services.

10.3.4 Economic drivers and barriers

The main economic drivers for both public authorities and end users are cost savings and reduced red tape in accessing financial incentives. Attention must be paid to avoid potential confusion between various policies and public services, such as EPC, DBL, building passports, energy advice platforms or OSS. In Portugal, building experts play an important role as they are responsible for informing homeowners about the improvement measures recommended in the EPC and AQUA+ (Classificação de Eficiência Hídrica de Edifícios). Energy and Water efficiency companies are able to access parts of the DBL data (for example envelope or technical systems) and propose commercial offers on the execution of the improvement works. The DBL stores EPCs and will also store the AQUA+ data, making a historic overview of data from expired EPCs or retrofitted building components available.

The advancement of ICT technologies in the built environment opens up new opportunities to collect data (e.g. sensors, real-time energy use, IoT) but also brings further data privacy and security constraints: the DBL should be able to accommodate these to fully reap the benefits.

Even though business models based on data sharing are possible, experts consider that member states and the EU should implement DBLs based on the principle that data belongs to the homeowner. Currently, in Portugal and Greece, the DBL is managed by public authorities, however, the data is owned by the owner, who grants access to market actors. Besides a general consent on data handling, the homeowner is informed and has to provide consent every time a private actor needs to access a specific data. The PA does not own nor trade data, it is for DBL and OSS only a contact point between the homeowners and the private market actors.

Because of the new EU taxonomy framework, there is interest from financial institutions to access EPC data. The DBL, as well as the OSS, could provide additional information to homeowners compared to the EPC, such as financial products and tailored proposals for financing.

10.3.5 Consistency with existing policies and standards

The 2021 EPBD recast proposal introduces the definition of the 'digital building logbook' as 'a common repository for all relevant building data, including data related to energy performance such as energy performance certificates, renovation passports and smart readiness indicators, which facilitates informed decision making and information sharing within the construction sector, among building owners and occupants, financial institutions and public authorities;' [25]. **This definition is in line with the concept of the X-tendo feature.** At an early stage of implementation of several policies including DBL, building passport, renovation roadmap and SRI, clarity is needed to reduce market confusion. The DBL could be the common denominator and an information repository for the other tools introduced by the EPBD proposal.

The interoperability of the DBL with the EPC database and digital OSS depends on the maturity level of each member state. Digital EPC databases with quality checks are preconditions for the DBLs, which are required by the EPBD recast proposal but not yet implemented across Europe. Experts see the DBL as a first step in the implementation of building renovation passports, which will provide information on the phased renovation, such as the renovation roadmap. Given the overlap in the implementation of the DBL and building passports, there is an opportunity for Member States to implement them together in a way that the tools reinforce and complement each other.

In the context of the Renovation Wave and Long-term renovation strategies (LTRS), there is high interest from policymakers for the DBL, with nearly 20 private and public initiatives in the EU. In some member states, the DBL is conceived as an extension of existing databases. For example, in Estonia, the existing National Building Registry includes mainly technical data on a building – permits, design drawings, technical and physical data, etc. It is planned to expand the database to include ownership (linked to real estate database), administrative and energy consumption data. This development aims to create a 'digital twin' of the building stock in Estonia, which would significantly reduce the administrative burden of the concerned agencies and the general public.

Another example of implementation of the DBL is linking it with the digital OSS, such as the casA+ portal in Portugal. The goal of casA+ is to act as a property ID, facilitating the access of the homeowner to building-related information while encouraging energy efficient home improvements. The portal also facilitates communication between the homeowner, the building expert and companies/service suppliers. The DBL is the digital repository on which the casA+ portal is based. Currently, the data can be uploaded into the portal in 2 different ways:

1. By the homeowner when the building does not have any EPC or when additional information - not available in the EPC - is required.
2. By the Portuguese EPC Registry Database - SCE (Sistema de Certificação Energética dos Edifícios) to upload energy related information. The homeowners can access the portal via their EPCs.

The information stored in the DBL is organised across 8 categories: Building Identification (EPC code, INSPIRE ID, etc.), Building Characterization (construction period, type of building, etc.), Envelope (walls, roof, etc.), Lighting & Appliances (light bulbs, washing machine, fridge, etc.), Technical Systems (heating, cooling, DHW, etc.), Energy Balance Indicators (heating, cooling, DHW energy needs), Improvement Measures (type of measure, cost, payback period, etc.) and Energy/Water Consumption.

The functionalities enabled by the building logbook which are currently available in casA+ are the following:

- Access to the building-related information and available financial incentives.
- Registration with associated EPC (not mandatory).
- Registration, use and interaction with both consumers and companies.
- Improvement measures proposals and access to a list of service suppliers to simplify the energy and water renovation of buildings.
- Energy and water efficiency guides and recommendations.
- Housing energy efficiency simulator.

Compatibility with the EPC scheme

Given that most data transfer processes are foreseen to be automatised, the impact of the DBL on EPC cost would be minimal and will not pose extended requirements and additional costs to the certification process. However, considerable effort from public authorities is required to upgrade the existing EPC databases and to link these with other databases. For example, in Greece the 'Electronic Identity of the building', a recently developed platform, can be linked with the EPC database for the purposes of facilitating the DBL roll out. Besides the Electronic Identity of the building and EPC, other databases such as Land Registry and the Taxisnet (tax authority) can provide other relevant information. Thus, the setup of DBLs require effective collaboration between various public agencies, otherwise it can cause legal and management challenges.

It is necessary to foresee a link between the paper EPC and the digital EPC and thus, the DBL. A QR code is already being implemented on the paper EPC in Norway, while in Portugal the DBL/OSS is advertised on the EPC platform. The PA should evaluate what information should be static, on paper, and what should be digital and dynamic. It should determine which online services could encourage the homeowners to access the DBL for example, simulations on financing information.

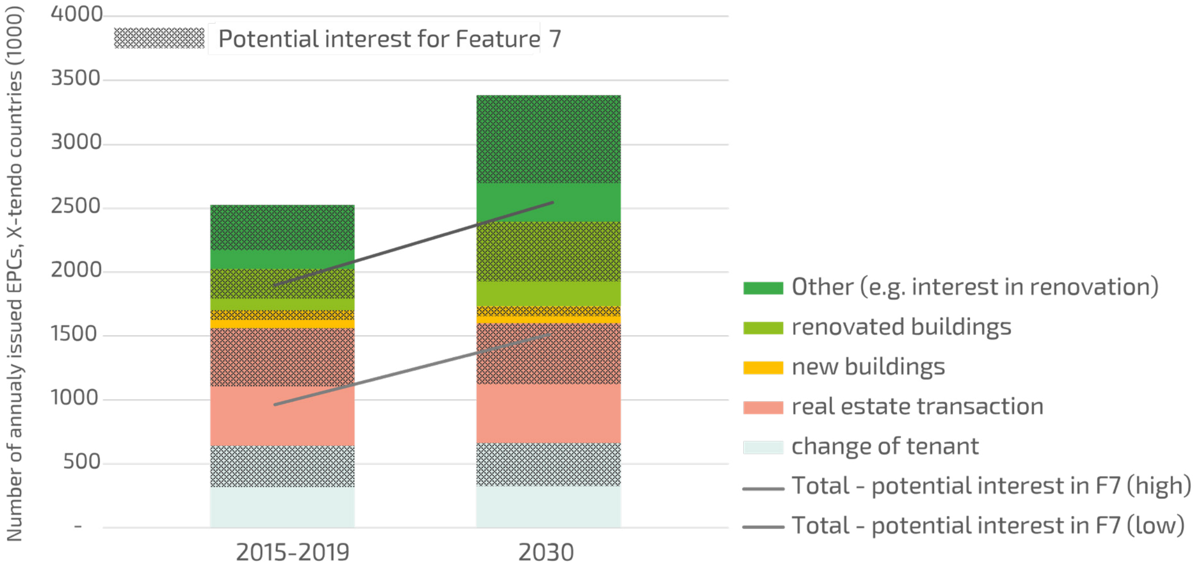
The information from the DBL could be used to prefill new EPC calculations, with consent from the homeowner. In case the EPC is already issued, the previous EPC data will be transferred to the reissued EPC. However, some EPC assessors are sceptical of the quality of the previous EPCs and consider that checking it is more work than filling it in from scratch. One issue is the data ownership of the inputs, which often belong to the EPC certifier. Meanwhile the homeowner only owns the output parameters, which are also present in the EPC database. In Estonia the input calculation values are also available. Another issue is how to store historical data of more EPCs in the DBL. For instance, in Portugal once a new EPC is issued, the previous data is kept in the EPC database (although the certificate is no longer valid), but in some countries the data may be overwritten.

10.4 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. *Figure 8* shows the total number of annually issued EPCs, by the different trigger points in the X-tendo countries. In the period 2015-2019, about 2.5 million EPCs were issued annually. The largest part resulted from real estate transactions, followed by new building construction, while EPCs due to the change of tenant and building renovation according to our data and the chosen assumptions have lower relevance. In shaded colours, the figure shows the share of EPC end-users which potentially show special interest in this feature, according to the factors determined in *Table 13* and *Table 14*[8] in *Annex 1*. A high relevance is assumed in particular for building renovation and real estate transactions (interest of the buyer), leading to a range of 39%-74% of all EPC end-users showing potential interest in the results of the Logbook feature. The total number of interested EPC-end-users for all trigger points is estimated to about 1.0 – 1.86 million in the base year which may increase to 1.50 – 2.55 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, for example, 20-40% of EPC-end-users are estimated to be interested. (2) The interest may differ significantly between the buyer and the seller, in particular in case that a building does not perform very well according to a certain indicator. Thus, for the "lower" case the lower value of interest (typically the interest of the seller) is assumed whereas for the "higher" case a higher value (typically representing the interest of the buyer) is considered.

The upper range of the results is similarly high for all X-tendo countries. However, there is also a high bandwidth between the lower and the upper boundary, resulting mainly from the perspective (seller perspective for the lower boundary, buyer perspective for the higher boundary). Thus, it means that the benefits of the DBL and of linking the logbook with EPCs is unevenly distributed between the buyer vs. the seller.

Figure 8 – Number of annually issued EPCs by trigger points and the estimated share of potentially interested EPC end-users, total of X-tendo countries (Feature 7). Historical data 2015-2019, projection until 2030.



[8] The shaded areas (labelled as medium) in Figure 1 were derived as the average of the low/high range depicted in Table 14.

10.5 Next steps for implementation

10.5.1 Calculation method and quality assurance

Many Member States are at an early stage of implementation of the DBLs; thus, they will benefit of implementation roadmaps, process flows, business models and good practices to successfully roll out logbooks. The following steps are considered to be necessary at the EU and national level:

- Provide clear scope of the logbook and clear legal framework.
- Include process for regular data validation updates.
- Develop a logbook data model.
- Design protocols for data capturing and data sharing.
- Engage stakeholders.

For countries at an early stage of implementing DBL the following stages are crucial:

- Develop a digital EPC database with quality checks.
- Mapping of other existing databases.
- Mapping of benefits and stakeholder interests.
- Mapping of information flows.
- Ensuring interoperability and data sharing, respecting GDPR.

10.5.2 Capacity building for delivery bodies and training needs for assessors

The main efforts in terms of capacity building within the public agencies involved in the DBL relate to the interoperability of databases, which includes issues with data protection and privacy. Experts consider that DBL data should be handled similarly to other public data such as the EPC database. The public agencies will have access based on a need-to-know basis, however, this could be a barrier in implementing cross-checks to validate inconsistencies between databases.

10.5.3 Political discourse/ market or end-user awareness

The logbook should be conceived in a modular fashion right from its conception. This is necessary not only due to cost but also because it needs to take into account available information, the state of development of real estate markets, market expectations and legal/regulatory circumstances.

Experts consider that it will be difficult to track the evolution of renovation rates with the building logbook, but it will be useful to track light renovation measures. It will be also possible to track the level of the investment because, since it is linked to the OSS, it will have information on the total surface of the renovated building stock, the total amount invested, as well as a percentage of public funding. The possibility to track and monitor renovation depths and rates will be highly relevant to develop and improve LTRSs. **An important** driver of DBL could be the integration of data regarding building performance, income and climatic conditions, which are relevant for the energy poverty indicator.

10.6 Conclusions

At this early stage of DBL implementation, Member States display different maturity levels of EPC databases, as well as different available databases to be integrated. Successful implementation of the DBL can bring multiple benefits to many stakeholders in terms of reducing administrative burdens and making processes more efficient and cost-effective. The homeowners can be encouraged to contribute to updating information by having access to additional services, subsidies as well as private and public funding. However, there is a risk of confusion between various innovative policies and instruments being currently introduced in parallel by the EPBD recast such as DBL, building renovation passport and SRI which should be addressed from an early stage of their implementation. The integration of socio-economic indicators into the DBL can help track and tackle energy poverty.

Key takeways:

- Lack of digitalised databases, low quality of data and inconsistencies between and within databases are important barriers to the successful implementation of the DBLs.
- Because of differences in maturity in digitalisation between Member States the DBL concept should be modular and adjustable to the local context. However, EU guidelines regarding the concept, principles related to data ownership and use, process flows, business models and good practices are necessary.
- Experts consider data protection a crucial aspect and encourage a public DBL based on the principle that the homeowner owns the data. General data handling consent is not enough, it is also necessary each time any part of data is shared with a public or private actor for a specific purpose.

Key action points:

- Setting up usable EPC databases shall enable the implementation of DBL in all Member States.
- EU guidelines for the concept and data interoperability are necessary to avoid market confusion between the EPC, BDL, EPC database, OSS and BRP.

11

FEATURE 8: ENHANCED RECOMMENDATIONS

11.1 Overview

For building owners undertaking deep renovation, individual building renovation roadmaps or end-user tailored recommendations become more adequate and to provide more accurate information. The latter is not part of the scope in this X-tendo feature.

EPC recommendations in many EU countries are not sufficiently informative to meet objectives. While reliable and usable indicative recommendations are sufficient for buying and selling houses, deep renovations require detailed recommendations. This feature demonstrates how to automatically provide enhanced recommendations in EPCs, mainly for building transactions (sell/ buy/ renovate), and how they can be linked to national long-term renovation and climate strategies for the building stock. The aim is not for the X-tendo feature to be stand-alone tool, but to demonstrate a method which could be later integrated into national software.

This approach could enhance the quality of recommendations by ensuring that they are not only in line with building requirements, but also in line with the national long-term energy and climate objectives. Therefore extending the recommendations currently provided in EPC schemes. Although the proposed recommendations will improve the status-quo, they cannot fully replace professional advice. For building owners undertaking deep renovation, an individual building renovation roadmap or end-user tailored recommendations become more appropriate to provide more accurate information.

The proposed method is built on three pillars:

1. Enhancing actual recommendations by demonstrating how building-specific recommendations could be automatically generated: this will comprise a discussion of how co-benefits resulting from these recommended measures can be included in the EPC recommendations.

2. Showing how the costs of recommended measures can be included in the EPC provision process, enabling calculation of the cost-effectiveness of the recommended measures.

3. Setting targeted values for recommendations to guarantee that they are in line with national long-term renovation and climate strategies for the building stock. In addition to the calculation methods, guidelines will also be provided on how to perform the calculations and assess the values, as a support handbook for energy auditors.

The method can be divided in three parts: providing measure-by-measure recommendations, assessing the whole building impact of all recommendations and providing an economic assessment. The third is optional, as it will depend on the availability and link to external databases, such as cost databases. Another aspect covered by the methodology is the definition of the target building, which can be set based on 1) actual building standards regulations, 2) energy auditors' expertise, or 3) national long-term renovation strategies or other climate plans.

11.1 Key insights from testing

Table 9 - Test projects summary in implementing countries for enhanced recommendations

Country	POLAND	SCOTLAND (UK)	DENMARK
Type of Testing	In-building Testing/ System Testing	In-building Testing	In-building Testing/ System Testing
Number of testing cases	10 residential multi-family buildings	8 single-family buildings and 2 single-family apartments	10 single-family buildings
Tool	Calculation tool	Calculation tool	Calculation tool
Testing Period	04/2021 - 11/2021	07/2021 - 11/2021	05/2021 - 11/2021

In-building testing

In-building testing was conducted by Poland, the UK and Denmark using the tool developed for enhanced recommendations. A calculation spreadsheet tool was provided with instructions and descriptions that forms a solid foundation to supplement EPC assessments. Based on a selected building, its documentation (audit report etc.) and additional external sources (prices of material, technical devices etc.) the calculation was done for providing recommended renovation measures.

- The results were mainly focused on building envelope, space heating system, renewable systems, air infiltration and MVHR.
- The calculations require lots of intricate construction data that is not immediately available e.g. the full breakdown of the wall construction in old buildings for thickness of elements.
- An extension of the tool to give an estimate of the energy demand for the recommended measures would be beneficial and practical.

System testing

In system testing the objective was to verify the functionality of the tool against the real energy audit documentation of the building. The outputs, time for calculation procedure, and accuracy were also assessed:

- The calculation time was shorter than a full energy analysis done for the energy audit.
- The tool is simplified but less accurate. The calculations are done for each building partition and recommendations are provided in contrast with the energy model analysis in the audit. This is more accurate. Polish experts understood that this tool can be used to support energy auditors by helping them to save time.
- The time needed to use the tool was around 0.5 hours for each building tested.

11.3 Drivers and barriers for a wide uptake of the feature

11.3.1 Calculation method and quality assurance

Polish and UK experts found that the enhanced recommendations feature generates results similar to energy audits. Austrian stakeholders indicated that higher quality of recommendations would be useful for meeting the criticalities of integrating increased costs. This could vary from region to region and would be valid only for the validity of EPCs (5-10 years). Experts from the UK also considered this aspect not just for costs but also material, fuel etc. As a solution to this it would be reasonable to provide ranges of cost instead of absolute costs that can vary based on regions. In Estonia, EPC recommendations are provided from a standardised list of recommendations and are not very detailed. Accurate gathering of building-related and end-user behaviour data helps in providing more accurate recommendations. One of the main barriers in providing these recommendations is that they are prone to differ based on specific conditions in buildings and the behaviour of occupants.

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

EPC recommendations are useful for homeowners to take key decisions on the renovation of their buildings or on the real estate transaction of buying a home. While these recommendations are made available in varied forms across different EPC schemes, they still lack clarity, accuracy and guidance for homeowners. Some drivers identified for the feature are that the outputs presented in a user-friendly manner, it highlights the type of recommended measure and consequent implication in terms of costs, emissions, energy demand and compliance with efficiency and decarbonising targets. A national cost database would enable the assessors to calculate and recommend the costs more efficiently. Some barriers from a social perspective are:

- Recommendations can have influence on the selling price of dwellings and the seller would have to pay for the EPC calculation.
- The potential of the building with all feasible building renovation measures would be useful for the homeowner, however, producing this information takes time.
- The split-incentive issue where the owner gets an EPC and the buyer sees what needs to be invested should be made transparent in real estate transactions.

Though Austria did not test this feature, the experts highlighted the need to focus on the presentation and illustration of the recommendations in the EPCs to make them more effective for owners and use marketing instruments to raise stronger awareness for recommendations. Denmark identified that digitalisation and standardisation in the new feature is a helpful and if implemented in the national software, it can support the energy auditors to provide EPC recommendations. Detailed and tailored recommendations inform real estate buyers or sellers during building transactions about the condition of the buildings and help them in taking appropriate measures for the building renovation.

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

There are many opportunities for the construction sector to give a push to the implementation of renovations through platforms such as one-stop-shops whilst enhanced recommendations are made available to the homeowner in EPCs. The feature developed shows what additional data is needed to provide enhanced recommendations and support energy auditors' work. Some of the drivers from the construction sector are:

- No additional expertise beyond an intermediate level of energy auditing practice is required to provide the "enhanced recommendations".
- Integration of enhanced recommendations with financing options and one-stop-shops are necessary to implement to increase their impact.
- Standardized checklists and calculations to support auditors and consultants would be useful to provide enhanced recommendations.
- An automated approach would provide more effective recommendations based on specific building type.

In Denmark, an EPC auditor gives recommendations based on their experience and use standardised defaults with mandatory consideration of renewables. Whereas UK experts advise that tailoring costs by selection of specific items would be very useful for the assessor and this functionality would improve how recommendations are provided.

11.3.4 Economic and market drivers and barriers

While for real estate transactions reliable, usable and indicative recommendations are sufficient, for the planning of deep renovations detailed and tailored recommendations are required. In the cases of deep renovation, recommendations are important for the owners undertaking and implementing them. Accuracy and detail are the key differences that consequently reflect on the amount of information needed and the adequate tool to generate the targeted recommendation:

- Accurate gathering of building-related and end-user behaviour data should be done in a way that keeps EPC costs affordable.
- Imbalance in the trade-off between accuracy and higher EPC prices against less accuracy and lower EPC prices.
- The assessment for providing recommendations is cheaper than the energy audit.

In the UK, EPCs give a current snapshot of the building performance but they are not used for stepwise renovation. So, including the enhanced recommendations would make the EPC richer and this would push the owners to go into more detailed analysis and also increase awareness. In Scotland, the government is mandating owners to get to a specific EPC class by a certain year under long term renovation and to encourage owners to learn more about recommendation information.

11.3.5 Consistency with existing policies and standards

In many countries, building codes for existing buildings are not as restrictive as for new buildings. This means that the energy performance achieved after the renovation might not be sufficient to achieve decarbonisation targets. Policies should consider long-term renovation and decarbonisation targets. A more ambitious integration in policies and standards could enhance EPC recommendations, by ensuring that they are not only in line with energy efficiency standards, but also with long-term low-carbon emissions targets and national policies. Among other drivers, across the EU, a variety of tools and methods are being used to provide detailed and tailored recommendations that could be utilised. Some major barriers regarding policies and standards are:

- Currently no clear definition of enhanced recommendations is available at EU level.
- Empowering the buyer through policies that focus on making suggestions more concrete would be important.
- The target values should be derived from the LTRS or a strategic document which has a policy agreement .
- There should be a link between the building stock data and how EPC data reflects the status so it would be easy to model for long term renovation strategies.
- The overall targets of building stock need to be broken down to each building. Using different bench marking or data modelling would impact the policy goals.

The Danish BetterHome/BetterHouses, a one-stop-shop solution, provides enhanced tailored recommendations for technical improvements and personalised recommendations based on the consultant's on-site visit. While in the UK, Energy Saving Trust's Portfolio Energy analysis Tool (PEAT) enables customers to build an energy efficiency package that meets their personal needs, budget, and objectives through tailored recommendations. In Austria, the recommendations need be related to the Austrian nZEB standard (which combination of measures must be taken to achieve nZEB standard) and it's already linked with national policies.

Compatibility with the EPC scheme

There is a window of opportunity to improve the EPCs and engage with policymakers. EPC recommendations still lack detail and in many countries are based on standardised lists. Enhanced EPC recommendations can be easily and automatically integrated into the existing EPC auditing processes. The developed feature will be incorporated in existing EPC calculation software to ensure long-term effectiveness. Long-term replicability will be assured if the provided methods are integrated into EPC calculation software or automatically integrated into energy auditors' practice. Calculation procedures are based on best practices that are nationally allowed and foreseen in existing standards and is therefore one of the main drivers for its use in the EPC scheme. There is no integration with available EPC calculation software but this feature can be used as a standalone method. Existing recommendations within the EPC are not displayed well, are low quality and are not individually tailored for end-users. Hence, there would need to be a comprehensive approach from the end user perspective.

Polish experts recommended that the feature should be linked to the software of each country to apply it. Most of the data should be taken from EPC calculation (parameters of building), thus it will be easier to implement. The feature could be used for providing recommendations for the building envelope, building systems and new systems such as MVHR etc. The UK has an existing system that is running and self-contained so it is difficult to move to a newer system. Denmark encountered some problems regarding compliance data where in their EPC system some values were difficult to manually calculate. The tool is not as precise as the recommendations made by an EPC consultant that are tailored to a specific house. Austria has a system to provide at least two recommendations in a given EPC for an existing building and how to reach nZEB standards whilst the on-site visit is not mandatory.

11.4 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. *Figure 9* shows the number of annually issued EPCs, by the different trigger points in the total of X-tendo countries. In the period 2015-2019, about 2.5 million EPCs were issued annually. The largest part resulted from real estate transactions, followed by new building construction, while EPCs due to the change of tenant and building renovation according to our data and the chosen assumptions have lower relevance.In shaded colours, the figure shows the share of EPC end-users which potentially show special interest in this feature, according to the factors determined in *Table 13* and *Table 14*[9] in *Annex 1*. A high relevance is assumed for real estate transactions (interest of the buyer) and general interest in the potential improvement of building energy performance, leading to a range of 24%-73% of all EPC end-users showing potential interest in the results of the Enhanced recommendations feature.

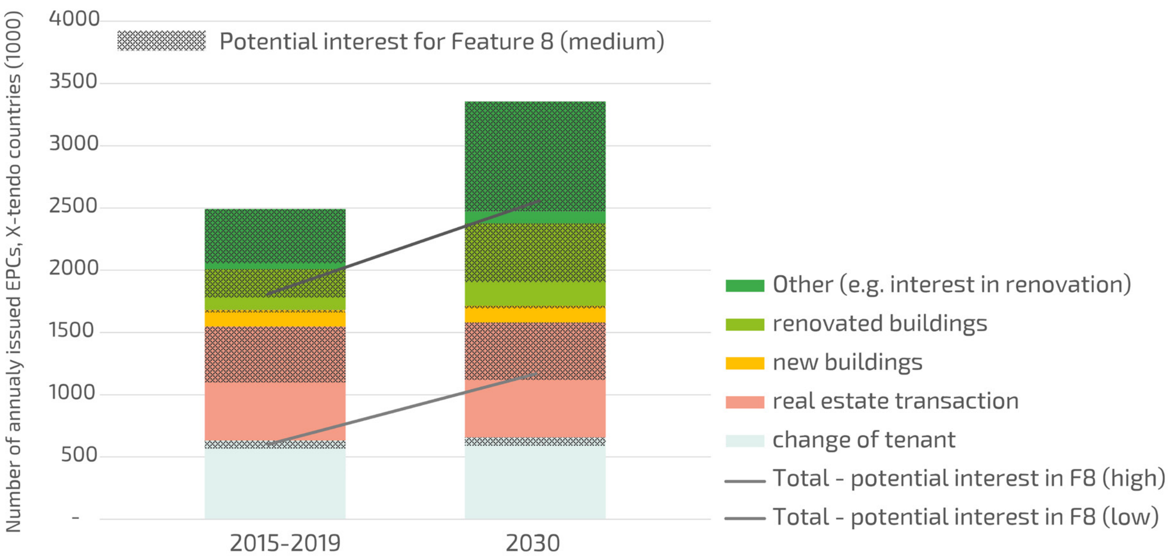
[9] The shaded areas (labelled as medium) in Figure 10 were derived as the average of the low/high range depicted in Table 14.

The total number of interested EPC end-users for all trigger points is estimated to about 0.6 -1.83 million in the base year which may increase to 1.19 -2.62 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, for example, 20-40% of EPC end-users are estimated to be interested. (2) The interest may differ significantly between the buyer and the seller, in particular in case that a building does not perform very well according to a certain indicator. Thus, for the "lower" the lower value of interest (typically the interest of the seller) is assumed whereas for the "higher" higher value (typically representing the interest of the buyer) is considered.

For Feature 8, it is assumed that the interest of EPC end-users in receiving more reliable information on renovation recommendations strongly differs for the buyer vs. the seller. Thus, 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 can be observed that there is a high bandwidth between the lower and the upper boundary resulting mainly from the perspective (seller-perspective for the lower boundary, buyer perspective for the higher boundary). This indicates that there is a strong conflict of interest between the buyer showing a high interest in the information on expected, required and recommended building renovation and the seller, who orders the EPC. This calls for strong control, standards and guidance for EPC issuers when providing renovation recommendations.

Figure 9 – Number of annually issued EPCs by trigger points and the estimated share of potentially interested EPC end-users, total of X-tendo countries (Feature 8). Historical data 2015-2019, projection until 2030.



11.5 Next steps for implementation

11.5.1 Calculation method and quality assurance

For the successful implementation of this feature, stakeholders from Poland identified the need to establish a costs database in the future. Where there is no national software for providing enhanced recommendations, it would be beneficial in those contexts that private companies implement the new interface.

There is need for a method which does not use automatised and standardised recommendations and works in different urban contexts. These should be different and tailored to user needs. Another important aspect to enable this feature would be to integrate member state level databases into the third-party software used for the calculation of enhanced recommendations. The future versions of the tool can provide an energy and carbon emissions comparison for different recommendations. From the end-user perspective, it should be optimised based on costs and quality with details on the payback time. There should also be information on the lock-in effects of each recommended measure. Comparison of pre- and post-renovation works in results of the tool would merit the inputs/calculations.

11.5.2 Capacity building for delivery bodies and training needs for assessors

Polish experts advise that the authorities responsible for the EPC implementation should develop the cost database. Regarding the accuracy of the energy savings calculations, these must be manually inserted, not calculated by the tool. Austrian experts outline that it is critical to display the costs for renovation measures and that assessors need relatively less training to provide these to end-users. Other services by public bodies are important such as loans, grants and subsidies in collaboration with banks and other financial institutions. UK experts identified that no significant increase in time was required to do the EPC for enhanced recommendations since many inputs already exist.

11.5.3 Political discourse/ market or end-user awareness

In Poland, energy auditors who prepare EPCs do not provide recommendations. The feature being developed is promising to include some recommendations in the EPC. Experts from Denmark see this feature as very relevant as the existing recommendations are quite time and effort consuming, thus the new feature could make the work of the EPC assessors easier.

11.6 Conclusions

EPBD emphasises that the renovation measures must be technically, economically and functionally feasible for homeowners. Article 10 in the EPBD 2021 recast [25] focuses on Building Renovation Passports, where a qualified expert is required to make an on-site visit and advise on a roadmap to the owner. This feature is an important step towards the development of such roadmaps and advice on benefits in terms of energy savings, savings on bills, GHG emissions as well as other wider benefits. These recommendations would have a potential link to financial and technical support. However, there is no common definition of recommendations at the EU level, which provides an opportunity for impactful implementation of this feature. The revised EPBD has outlined that EPCs shall include recommendations for the cost-effective improvement of energy performance and reduction of GHG. There is a specific focus on measures carried out in connection to a major renovation or elements independent of building envelope or systems. The enhanced recommendations feature tool is designed to augment these aspects while also displaying the co-benefits that the end-user will get from renovation measures. However, an extension of the developed methodology is required in order to provide a potential indication of payback over the lifecycle. The recommendations are provided for building envelope, space heating system, renewable systems, air infiltration and MVHR.

The quantitative estimations on the impact of the uptake of this feature in X-tendo countries indicate that there is a strong conflict of interest between the buyer, showing a high interest in the information on expected, required and recommended building renovation, and the seller who orders the EPC. This calls for strong control with standards and guidance for EPC issuers when providing renovation recommendations. The total number of interested EPC end-users for all trigger points is estimated to about 0.6 – 1.83 million in the base year which may increase to 1.19 – 2.62 million EPC end-users in the year 2030.

Key takeways:

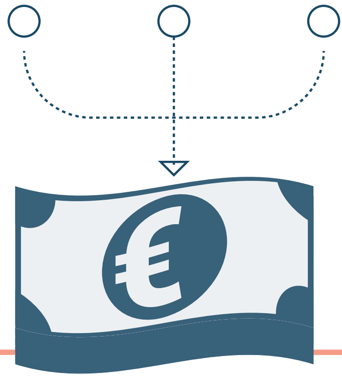
- This enhanced recommendation feature is an important step towards developing roadmaps and giving advice on benefits in terms of energy savings, savings on bills, GHG emissions as well as other wider benefits.
- The methodology has a specific focus on measures carried out in connection to a major renovation or elements independent of building envelope or systems.
- The feature demonstrates how to automatically provide enhanced recommendations in EPCs, mainly for building transactions (sell/ buy/rent).
- The developed feature has the capability to be incorporated in existing EPC calculat ion software to ensure long-term effectiveness.
- No additional expertise beyond an intermediate level of energy auditing practice is required to provide the "enhanced recommendations".

Key action points:

- An extension of the developed methodology is required in order to provide a potential indication of payback over the lifecycle.
- A strong control with standards and guidance for EPC issuers when providing renovation recommendations is required in order to ensure that recommendations are in line with long-term climate and energy targets.
- A clear definition of enhanced recommendations is required at the EU level to harmonise the approach.
- Display of cost of renovation measures and services for loans, grants and subsidies should be integrated with enhanced recommendations (see also feature 9 in the next Chapter).

12

FEATURE 9: FINANCING OPTIONS



12.1 Overview

Integrating information on financial support in the EPC and its specific recommendations can help to persuade building owners to undertake an energy renovation and steer investments toward deep renovations. There is a need to unlock further public and private financing for energy renovations of buildings to achieve the long-term climate and energy objectives of the EU. The EPC provides renovation recommendations to the end-user making it a logical entry point to increased awareness of various financial options, including the availability of subsidies, low-interest loans, as well as innovative financial solutions (e.g. energy performance contracting, on-bill financing).

EPCs can provide a market benchmark and clear eligibility criteria for public authorities, as well as guide policymaking and the introduction of new financial support schemes. Furthermore, integrating financial support alongside the EPC recommendations can help to persuade building users to undertake an energy renovation. This feature is exploring how the integration of financing options can boost the perceived usefulness of the EPC, increase its impact on renovation decisions and help public authorities to develop more effective financial support schemes.

The current feature identifies and assesses which financial sources can be linked and integrated with the EPC. This includes the identification of available financing options, linking EPC data with the underwriting of finance, as well as effective communication with building owners/users.

12.2 Key insights from testing

Table 10 - Test projects summary in implementing countries for financing options

Country	ROMANIA	PORTUGAL	DENMARK
Type of Testing	User Testing	User and System Testing	User Testing
Number of testing cases	29 (homeowners), 15 (public authority), 37 (qualified experts), 3 (bankers)	133 (qualified experts), 1 (interview), 56 (workshop participants)	8 (homeowners)
Tool	Interview questionnaire	Interview questionnaire	Interview questionnaire
Testing Period	06/2021 - 12/2021	06/2021 - 12/2021	11/2021 - 12/2021

The user-testing was conducted with different stakeholders in Romania, Portugal and Denmark mainly using interview questionnaires as a study method. The aim was to assess the individual country context regarding the types of financing schemes and role of EPC as a facilitator for financing. Also, how owners finance their energy renovation should be identified. Some key findings regarding the financing option feature are given below:

- A clear communication strategy is required for financing options and an interconnection to communicate the existing benefits available at national and regional level, namely through digital platforms linked to EPCs (e.g. OSS).
- EPCs should be used to access financing for energy renovation with clear indication of detailed eligibility criteria. A connection is required between the level of energy performance improvement, including emission reduction and the promised financing amount.
- Instruments with special focus on families, loan offers, low interest rates on funding, and better return on investment (ROI) analysis should be looked at to encourage homeowners for energy renovation.
- Prioritisation of worst performing building stock is necessary for subsidies and incentives.
- Discounts should be made possible to the owner when updating the EPC and financing advice should be made available without a fee (e.g. on OSS).
- Amendments in national legislation are important regarding the financing of energy renovation.
- Banks are interested in providing financing solutions and guidance to the public sector.
- Experts are interested in accessing the financing options' data for providing consultancy services to the beneficiaries.

12.3 Drivers and barriers for a wide uptake of the feature

12.3.1 Calculation method and quality assurance

The financing options methodology intends to identify information sources on public financial schemes that can be provided alongside the EPCs and explore how financing schemes can be more closely integrated with these, providing guidelines on approaches and mechanisms to achieve this goal. The outcome dedicated to public authorities will be guidance on how to link EPC schemes with financial instruments, which could be easily applied by the countries involved. To achieve the expected output the following tasks were developed:

- Evaluate the types of mechanisms and available financing, including descriptions and classification of financing schemes.
- Assess the focus of these mechanisms and their target audience.
- Evaluate financing conditions and the type of data used to underwrite and monitor the financing mechanisms.
- Map the needs and barriers faced by financial institutions.
- Analyse the compatibility of existing financing schemes based on EPCs.
- Identify existing best practices in the use of financing related to EPCs.

Renovation of buildings and its financing tend to have many similarities among Member States; however, it is necessary to adapt the feature to the local conditions, needs, socio-economic and market conditions. The tool supports overall good quality EPCs and regular quality assessment procedures. The use of transparent methods, data and results improves the relevance and acceptance of EPCs and assures access to adequate data. Expert assessors must prepare the EPC so it can be used to apply for specific financing mechanisms and comply with their requirements, leaving the beneficiary the freedom to choose among the existing options. Assessors must be aware of available financing options that could be applied for the building typology and/or improvement measure under evaluation. Financing schemes could be adapted to different building typologies and tailored around the EPC.

Currently, there are several barriers to estimating prices and the percentage covered by grants/subsidies/funding for each EPC recommendation. The eligibility criteria are different for each measure and they depend on the socio-economic situation of the dwellers. Thus, experts from Romania and Denmark find these estimations difficult to calculate during the EPC certification, however, they could be possible during the energy audit. Another option would be an online platform such as digital building logbook (DBL) or digital one-stop-shop (OSS) which allow simulations of different scenarios. Specific guidance must be developed for different building types.

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

Experts consider the maturity of the developed feature for system testing low but for user testing high. The users are willing to find information on financing, however, experts do not find the EPC to be the right policy tool. Providing information about financing and incentives would need a platform where all the financial suppliers are present including public and private institutions. This platform should be updated, and allow simulations. Specifying the validity of information is necessary and a link to the platform is easier to administrate at the national level.

Testing showed that worst performing buildings must be prioritised, which is in line with the introduction of minimum energy performance standards (MEPS) by the EPBD recast. Member States offer subsidies and funding which are tailored for low-income households to encourage renovation instead of subsidising energy bills. In Poland, some grants for low-income groups cover most of the expenses to change the heating system if it is highly polluting. However, the issue is often not in lack of funding, but in the cost of the fuel after replacing the heating system, since the fuel price for coal is lower than for gas or electricity.

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

Early involvement of all stakeholders is necessary for the successful implementation of the instrument. Setting up an effective financing mechanism is challenging, requiring multi-stakeholder engagement, including building owners, experts and financing institutions. In a first step to set up this new financing option, other stakeholders from the construction value chain and public authorities ought to be involved.

The implementation of a financing option involves several different actors and sectors, which demands a certain level of skill and expertise, supported with training and communication activities. Good advice and technical assistance from an EPC assessor, who can evaluate building performance and identify the best measures to implement, is needed to convince the building owner. Currently, most assessors lack any deeper knowledge about the available and applicable financing options, including where and how they could be attained. For this feature, an intermediate level of expertise would be enough for the EPC assessor, which could be supported by digital instruments. Specific training sessions for experts would enable them to provide more attractive advice to building owners. To encourage deep, staged renovation instead of single measures, homeowners must be provided with continuous support to guarantee success during the whole process.

12.3.4 Economic drivers and barriers

Financing institutions traditionally view energy renovations as a rather risky investment due to a lack of knowledge and follow-up, and because many renovations are based on questionable advice. Increased confidence in the EPC data and related experts would help decrease the perceived risk and could facilitate better financing conditions for the end user. Private Banks are particularly interested in the link to the EPC and interoperability between the EPC database and their systems considering the new regulatory framework (the EU Taxonomy). In Portugal, families are indebted and have low incomes which has an impact on the rate of green loans. Commercial banks or ESCOs could take the risk of these investments and offer affordable interest rates. In Denmark, the EPCs are crucial for financing since most financial institutes want to evaluate the recommendations from the EPCs before providing loan opportunities. Other important factors are the payback time and debt factor. Sometimes it is not possible to pay back the investment for buildings in rural areas due to the house valuation. It is important to evaluate and inform about the state of the building to visualise the potential for the building and convince financial institutes to engage in the renovation.

12.3.5 Consistency with existing policies and standards

Current development and implementation of the Renovation Wave and LTRS, along with recovery and resilience plans which provide considerable public and private funding make this feature very timely and convenient. Various business models already exist for energy audits and in Romania, where OSS are not yet in place, intermediaries provide support in applying for financing.

In Portugal the current mechanism (IFFRU) is a good example of a financial mechanism which enables the energy rehabilitation of the entire building. The model used by IFFRU, namely regarding the link to EPCs and the technical advisory support were very important for the success of this mechanism and have potential of replication to other Member States.

Member States implement various concepts of the DBL, OSS which include EPC certifications or energy advice, thus at this stage it can generate confusion in the market. At this stage, it is important to provide EU guidelines regarding concepts and lessons learned from front runners. The current feature was developed in consistency with CEN/ ISO standards. The determination procedure is developed taking into account the relevant standards, starting from the EPBD overarching standard EN 52000-1: 2017 and the underlying set of standards, along with other standards related to finance or similar, e.g. those provided by the Energy Efficiency Financial Institutions Group (EEFIG) and its toolkit.

The following aspects in the implementation of the LTRS must be considered:

- The role that real state evaluation can have in changing the paradigm of energy renovations contributing to the achievement of the ambitious renovation rates proposed.
- The opportunity the LTRS brings to define the initiatives that will support the policies and actions.
- Which entities will negotiate with the financial entities regarding the mechanisms of operationalisation.

Compatibility with the EPC scheme

Linking this feature to the existing EPC frameworks will help to overcome some of the main barriers to renovations. It can achieve this by engaging various stakeholders including financing institutions and by reducing the risk of investments. The existing paper EPC should be linked to online services and where homeowners receive the EPC recommendations, they should receive an offer from the online platform for financing. The energy audits often include information on financing however, these are rather costly compared to the EPCs. Thus, additional digital tools and services should be provided. It is important to make EPCs more dynamic for integrating financing information with the inclusion of digital formats such as QR codes linking EPC to a platform where information is updated periodically. It is crucial to initiate a partnership with financial and other private actors in the setup of online services of the DBL, building renovation passport or the OSS and the update of the information. Adding detailed financing options within the EPC scheme would considerably increase the cost of it. Another barrier is the detail of the information regarding requirements to access various products for different socio-economic profiles. The online platform, on the other hand, offers the possibility of simulations of scenarios and a continuous update of the information. The EPC recommendations could provide generic information such as whether funding or incentives are available and a link to the online platform.

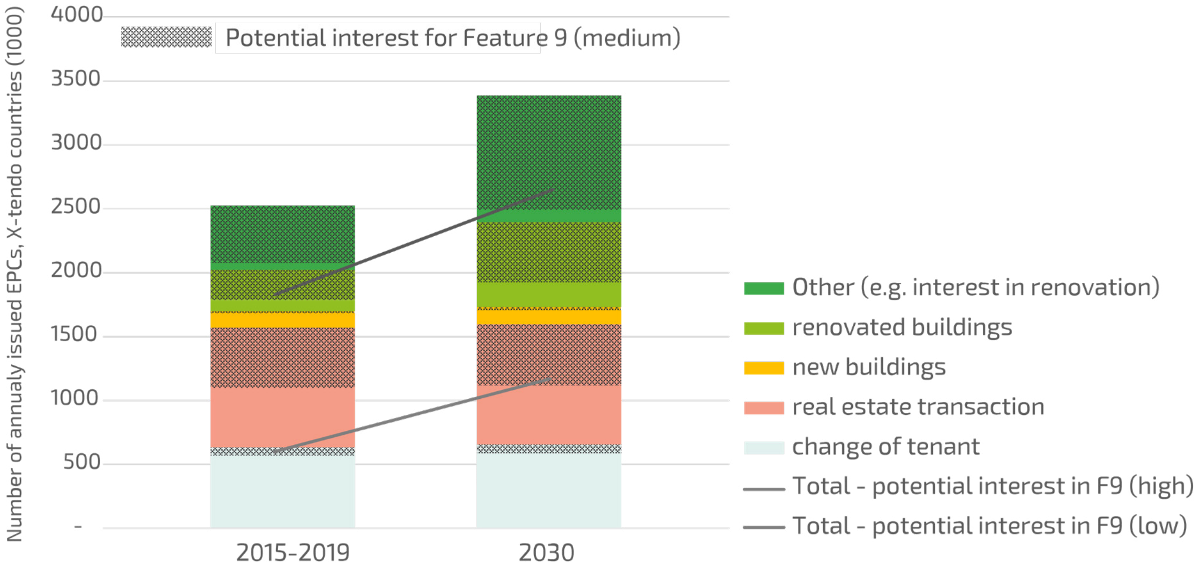
12.4 Estimation of the quantitative replicability potential

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. *Figure 10* shows the number of annually issued EPCs, by the different trigger points in the total of X-tendo countries. In the historical period 2015-2019, about 2.5 million EPCs were issued annually. The largest part resulted from real estate transactions, followed by new building construction, while EPCs due to the change of tenant and building renovation according to our data and the chosen assumptions have lower relevance. In shaded colours, the figure shows the share of EPC end-users which potentially show special interest in this feature, according to the factors determined in *Table 13* and *Table 14*[10] in *Annex 1*. A high relevance is assumed in particular for real estate transactions (interest of the buyer) and general interest in the potential improvement of building energy performance, leading to a range of 24%-73% of all EPC-end-users showing potential interest in the results of the financing schemes feature. The total number of interested EPC end-users for all trigger points is estimated to about 0.6 – 1.83 million in the base year which may increase to 1.19 – 2.62 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, for example, 20-40% of EPC-end-users are estimated to be interested. (2) The interest may differ significantly between the buyer and the seller, in particular in case that a building does not perform very well according to a certain indicator. Thus, for the "lower" case a lower value of interest (typically the interest of the seller) is assumed whereas for the "higher" case a higher value (typically representing the interest of the buyer) is considered.

For Feature 9 it is assumed that the interest of EPC end-users in receiving more reliable information on financing strongly differs for the buyer vs. the seller. Thus, 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 can be observed that there is a high bandwidth between the lower and the upper boundary, resulting mainly from the perspective (seller-perspective for the lower boundary, buyer perspective for the higher boundary), since for the seller the financing of possibly required renovation measures is not relevant, whereas for the buyer this is of high interest.

Figure 10 – Number of annually issued EPCs by trigger points and the estimated share of potentially interested EPC end-users, total of X-tendo countries (Feature 9). Historical data 2015-2019, projection until 2030.



[9] The shaded areas (labelled as medium) in Figure 11 were derived as the average of the low/high range depicted in Table 14.

12.5 Next steps for implementation

12.5.1 Calculation method and quality assurance

Similar to other features, the implementation of this tool depends on the maturity level of the EPC databases and the level of interoperability between data sources in various Member States. First of all, it is necessary to identify what information is available from EPCs and which are necessary to support the financial instruments. However, the mapping of existing financial instruments and their requirements in the implementing countries may also be replicated for other building types such as public, commercial and office buildings along with residential.

12.5.2 Capacity building for delivery bodies and training needs for assessors

The success of the implementation of the current feature relies on the ability to engage public and private stakeholders. Thus, communication and training campaigns for stakeholders and experts may include training on financing, technical and IT skills. Experts involved in the energy audit may require minimum training because they already perform cost/benefit and payback calculations. Currently, energy auditors in Romania are familiar with eligibility criteria for funding schemes and incentives and provide financial advice. However, the OSS in Denmark which offers integrated financial solutions resulted mainly in shallow renovation. For encouraging deep, staged renovation, the energy audit must be complemented with online services and sustained financial advice.

12.5.3 Political discourse/market or end-user awareness

Based on the testing some recommendations for the design of future financing mechanisms for were highlighted:

- Prioritize the worst-performing buildings, reinforced by the introduction of the MEPS in the EPBD recast proposal.
- Define the entities that will negotiate with the financing sector.
- Have a clear communication strategy for the energy renovation financing initiatives.
- Design instruments with a special focus on the low-income support: the low-interest rates financing mechanism.
- Non-refundable support should be avoided or limited for resource efficiency and the risk assessment analysis should be reconsidered because of the return on investment.
- Important to articulate the subsidies/incentives for financing the energy renovation.
- Link different entities, promoting the skills and knowledge of stakeholders towards a common goal.
- Improvement of evaluation criteria of economic activities (taxonomy).

12.6 Conclusions

The current feature is highly relevant in the view of the Renovation Wave, LTRS, Recovery and Resilience plans and thus, available public and private funding. Besides the EPC scheme, various online tools such as DBL, building passport or digital OSS can provide additional advice on financing. A clear communication strategy is required for financing options and an interconnection to communicate the existing benefits available at national and regional level, namely through digital platforms linked to EPCs (e.g. OSS). For successful implementation of the feature, various public and private stakeholders must be involved in setting up and updating the information. The available funding should also be tailored to target low-income families and worst-performing buildings that must be prioritised. The introduction of MEPS by the EPBD 2021 recast proposal, as well as policies to tackle fuel poverty are in line with prioritising funding for renovating worst-performing buildings. However, homeowners may be reluctant to replace the heating system if the electricity prices are higher than gas and coal. To encourage deep, staged renovation instead of single measures, homeowners must be provided with continuous support to guarantee success during the whole process. It is essential to link different entities and promote the skills and knowledge of stakeholders towards a common goal. The total number of interested EPC end-users for all trigger points evaluated for OSS feature is estimated to about 0.6 – 1.83 million in the base year which may increase to 1.19 – 2.62 million EPC end-users in the year 2030.

Key takeways:

- OSS feature is highly relevant in the view of the Renovation Wave, LTRS, Recovery and Resilience plans and thus, available public and private funding.
- Experts must be aware of available financing options that could be applied for the building typology and/or improvement measure under evaluation.
- Existing paper EPCs should be linked to online services where homeowners receive the recommendations and an offer from the online platform for financing.
- For successful implementation of the feature, various public and private stakeholders must be involved in setting up and updating the information.
- There are methodological barriers to estimate prices and the percentage covered by grants/subsidies/funding for each EPC recommendation.
- It is key to increase the confidence of financing institutions to reduce perceived risk of investment in renovation

Key action points:

- A clear communication strategy is required for financing options and an interconnection to communicate the existing benefits available at national and regional level.
- To encourage deep, staged renovation instead of single measures, homeowners must be provided with continuous support to guarantee success during the whole process.
- Assessors involved in the energy audit may require minimum training because they already perform cost/benefit and payback calculations.

13

FEATURE 10: ONE-STOP SHOP

13.1 Overview

One-stop shops (OSS) can be defined as advisory tools to facilitate access to financial mechanisms, benefits and support schemes, assist consumers concerning technical and financial issues and to guide them through their building renovation process. Therefore, to provide these functionalities and valuable building information, the data coming from the EPC plays a special role and should be linked to the OSS (among other sources of data). OSS are transparent and integrated advisory tools/venues which will accelerate energy renovations by informing, motivating and assisting building owners throughout the renovation journey, from beginning to end.

The key benefit of setting up an OSS is the possibility to overcome the many and simultaneous barriers related to residential building renovation. The OSS acts as an intermediary that simplifies the fragmented offer of renovation suppliers, for example by aggregating designers, suppliers, installers and financiers into a single package for the homeowners. An OSS also supports the supply side of building renovation by mediating with potential clients, using techniques such as organising offer packages, pooling the projects and managing the project implementation. The OSS is well placed to facilitate the implementation of locally developed projects with strong and trustworthy partnerships between homeowners, local actors and local governments.

OSS can be defined as advisory tools that facilitate access to financial support schemes, assist building owners with technical and financial issues and guide them through their renovation process. To provide these functionalities and valuable building information, the data coming from the EPC plays a special role and could be linked to the OSS (among other sources of data).

This feature links EPC data to OSS and assesses the applicability of the approaches for the different implementing countries, taking account of their corresponding existing EPC data, activities and needs.

The expected outcomes to include in the X-tendo toolbox are guidelines on how to set up or upgrade OSS and link EPC data in order to boost the market. Overall, the guidelines could:

- Explain how to reduce barriers and transaction costs for finding information regarding support schemes, tradespeople and public authorities.
- Describe OSS functionalities that can be adopted partially or completely.
- Provide detailed information to homeowners about their homes and monitor the uptake of improvement measures.
- Facilitate communication between homeowners and experts.

13.2 Key insights from testing

Table 11 - Test projects summary in implementing countries for one-stop-shops

Country	ROMANIA	PORTUGAL	PORTUGAL	Denmark	UK - SCOTLAND
Type of Testing	User Testing	System Testing	User Testing	User Testing	User Testing
Number of testing cases	29 (homeowners), 15 (public authority), 37 (qualified experts), 3 (bankers)	2 functionalities	463 beneficiaries	8 (homeowners)	3 (focus groups)
Tool	Interview questionnaire	CasA+ application	Survey	Interview questionnaire	Interview questionnaire
Testing Period	06/2021 – 12/2021	06/2021 – 12/2021	06/2021 – 12/2021	11/2021 – 12/2021	09/2021 – 01/2022

User testing

The main objective of user testing was to investigate the awareness among stakeholders about the need and usefulness of having OSSs for boosting the renovation rate of buildings. Romania, Portugal, Denmark and the UK conducted user testing with multiple stakeholders. The key results of the user-testing are given below:

- Several stakeholders (owners, assessors, suppliers, companies, financial institutions, utilities and local authorities) are highly interested in OSS.
- Linking of EPC and OSS is essential for the success of the feature.
- Older, inaccurate and poor quality EPCs may pose a challenge to OSS.
- The administration of OSS for renovation must be done by local authorities connecting the local web-portals with local/national databases.

- Setting up of pricing strategy is necessary to ensure optimal marketing and operational plans (e.g. membership for companies).

- Self-service functionalities would be relevant with the options to register and create accounts to directly connect construction and installation companies and end-users.

- User stories and successful cases should be promoted and advertised.

- A database of works subject to verification of compliance and quality would be useful for assessors.

- Strategies for effective public and private collaboration are required between several stakeholders for the success of OSS.

- Multi-channel support (phone, email, online tools etc.) would be useful for personalization of OSS.

- Improved consent process from homeowners is necessary to provide feasible solutions.

- Awareness must be raised about OSS to extend the services and benefits available to homeowners.

System testing

Two new functionalities were tested by Portugal related to OSS on their existing platform for EPCs i.e. casA+. These were (i) automatic proposal for improvement measures, (ii) information on financing and incentives. Some key findings from system testing are given below:

- Both new functionalities are very useful in the context of one-stop-shops and are fundamental for the homeowner.

- The functionalities give the homeowner a better understanding of the possible improvement measures.

- Improvement of the energy performance has been achieved after renovation works supported by casA+ for some homeowners.

- The homeowners are now more aware of the functionality benefits and are interested in using some incentives or support programs.

- Customer led engagement and flexible support to end-users reflecting their interests is necessary.

- Companies are interested in different membership plans offered, however, with more clarity on products and services to homeowners.

13.3 Drivers and barriers for a wide uptake of the feature

13.3.1 Calculation method and quality assurance

This feature explores how to link EPC data to OSS considering existing EPC data, building stock renovation activities and the needs of various countries. Guidelines on how to set up or upgrade OSSs are developed with descriptions of approaches for linking EPC data to OSS. Several barriers and drivers were identified for the one-stop-shop feature:

- The existence of significant differences in providing renovation services between Member States demands a high degree of flexibility when it comes to implementation rules and approaches.
- OSS can be developed around EPC schemes that have common points (recommendations, costs etc.).
- Access to EPC data is one of the major drivers that could enable effective renovation advice to homeowners.
- Financing instruments, renovation works and audits typically are not very linear.
- Centralizing several functionalities in a single place and providing a more effective, efficient service to all stakeholders could benefit greatly from the tool and provide high quality service.
- Protection of the homeowner from fraudulent offers is important.
- Verification methods on OSS are key to establish trust for suppliers and homeowners.
- Public ratings are useful for homeowners to select relevant suppliers.

Denmark outlines that OSS should be simple to use for the end-user. In Portugal, the public authority manages both the EPC database, as well as the OSS, thus the interoperability between platforms makes it easy to implement the OSS services. A company directory was made available for suppliers where they agree on terms and conditions on data usage, which is not used for other purposes. The homeowners have access to suppliers and their offers then further exchange of information takes place outside OSS. In the UK, the focus is on providing impartial advice, which is set aside to support the renovation journey. A list of potential installers and services is available on the existing portal for homeowners; however, the systems are not automated and relies mostly on the end-user to find the relevant suppliers and get offers from them.

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

OSS feature provides a better way to analyse data and EPC information, increasing EPC owners' awareness of EPC relevance and needed improvement/implementation actions. OSS can provide a trusted link between end-users and qualified energy experts, financial institutions and companies that have good feedback from clients:

- OSS adds an additional layer of data assessment, especially when linked with building logbook.

- Feedback from clients (end-users) will increase the level of confidence of end-users in the advice/help that they may receive.

- One of the main issues raised concerning processing and sharing of personal data is the GDPR.

- OSS that provide easy access to reduce the burden on end-users by developing platforms with good user experience and communicating in persuasive, non-technical language is more likely to be successful.

The feature focuses on developing guidelines and tools for Denmark, Portugal, Romania and the UK for homeowners to explore the benefits of renovations and of implementing them via OSS, with links to the EPC, focusing on energy and economic savings among others.

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

The existing OSS have very different approaches and types of stakeholders involved, which requires different levels of expertise, skills and training:

- Despite the approach taken, an OSS dedicated to energy renovation can involve aspects throughout the whole customer journey from capturing the attention of the homeowner to access the OSS to the implementation of measures and taking advantage of their benefits. It therefore requires a wide range of skills and considerations.

- OSS are typically digital platforms and require a certain level of IT skills to set up and run. Also, information provided to/by the OSS via other platforms (links with EPCs databases or others) requires a robust level of interoperability.

- Communication expertise, guidance and instructions are also required to target and support the different stakeholders interacting with the OSS: homeowners, energy auditors, suppliers of building components and contractors, financial institutions, real estate market, insurance companies or public authorities.

- Several stakeholders in the construction industry have shown interest in OSS and would like to get involved in national OSS models.

- Increasing trustworthiness by accrediting and quality control of local partners.

All these requirements are influenced by the functionalities of an OSS, which can range from simple marketing, communication and awareness, to providing technical assistance and financial advice, supporting access to products and financial instruments, coordination of works or assurance of performance. In Romania, different priorities were observed for OSS, where public authorities prefer it at municipal level while other actors emphasise the need for physical space. There is a need to provide training for professional advice and provide additional information at no cost. If the services are commercial, then it could entail additional costs. The trust expected in developing OSS could benefit if linked to a public service.

13.3.4 Economic and market drivers and barriers

Different policy and market backgrounds and potentials exist in Member States for considering the future implementation of OSS.

In Romania, there is no OSS and so it needs to be designed from the beginning. In the UK, the current OSS is based on a consultancy approach making the available data accessible online to possibly create better links with funding schemes and installers. The more-developed OSS in Portugal and Denmark still has potential for improvements.

- Definition of the OSS functionalities and a viable business model supporting different stakeholders involved.
- Evaluate existing models already implemented and study the market acceptance.
- A major barrier is the cost that would be required to support OSS and its services, especially if they are provided for free to the homeowners.
- To overcome existing market barriers between service providers and beneficiaries it is important to establish stable partnerships and cheaper solutions.
- Ensuring technical support to manage the OSS.
- Information on green mortgages by collaborating with financial institutions.

Economic feasibility is to be evaluated but OSS may be organised in the energy efficiency departments of public authorities, with well-trained employees, implying no additional costs for end-users. Alternatively, distinct state/private OSS may be financed by the companies involved in construction sectors, with small fees for being on the information platform. Potential financial constraints linked to the business model are the costs of set-up, maintenance, and system interoperability. The OSS business model in the UK (Scotland) is publicly funded. The automation of the data flows between the EPCs and OSS reduces costs when high quality data is imported automatically. In Romania the focus is also on private actors in the market who could benefit from the OSS. Portugal has a mixed model that is funded partly by the public from EPC revenue and funds are from membership plans for companies. Denmark's OSS is market driven, assessors pay to get the training, the services of energy audit are also paid but this has a negative impact on its popularity for renovation advice.

13.3.5 Consistency with existing policies and standards

Accelerating energy renovations faces multiple barriers including social (e.g. lack of awareness, low trust), technical (e.g. inadequate advice, incoherent renovation measures), financial (e.g. high investment costs) and market related (e.g. lack of reliable experts and tradespeople, split-incentive dilemma). To overcome these barriers, the EPBD 2021 recast proposal calls upon Member States to consider transparent advisory tools to inform and assist consumers in energy efficiency renovations and related financial instruments. The concept of OSS has gained traction as a solution to overcome market fragmentation on both the demand and supply side by offering holistic, whole-value-chain renovation solutions.

- The OSS feature and roll-out procedures for future deployment are developed in good consistency with CEN/ISO standards. The determination procedure is developed considering the relevant standards, starting from the EPBD overarching standard EN 52000-1: 2017 and the underlying set of standards for evaluating the performance of buildings and links to EPCs.
- Integration of OSS with building logbooks, building renovation passports, finance options, etc. is important.

- OSS should support and monitor the whole renovation journey with the end-user following all national and regional standards.
- Can implement and monitor policies at national or local level to the building stock.

In the UK (Scotland), it is strategically important to address energy poverty issues. It is about integrating EPC better in the system and how potential measures can be delivered to homeowners. To tackle fuel poverty, it can be used to provide better funding support. Denmark also shows that getting information to homeowners is a priority and it should be easy to access to comply with national instruments. This would make measures and services more accessible to homeowners.

Compatibility with the EPC scheme

In Denmark, the same calculation tool of software is employed to serve their OSS and EPCs which is an extension to the EPC scheme and can be based on an existing EPC for a building. There are a lot of similarities between the two processes. The OSS report can import EPC data and it is also available to the consultant. However, there is room for improvement where the main requirement is to digitally link between EPCs and OSS, in order to make it more flexible, update certain inputs and make it more reliable so it can be used in a longer perspective. In Romania, since there is no OSS, it's mainly the energy auditors who give advice to the beneficiaries regarding renovation and also concerning the costs. Also, due to unavailability of a functional EPC database, it is not possible to process this information and give advice for OSS. In the UK (Scotland), the national OSS is delivered by local advising agencies, whose service was mainly phone-based advice and is now being transformed into online advice. The advisors have access to the EPC database and can give advice to owners using the online tools. Existing EPCs are being used for advice up to 50% of the time but there is scope for much more. There are quality issues that must be overcome as the advisors don't feel confident using the data.

13.4 Estimation of the quantitative replicability potential

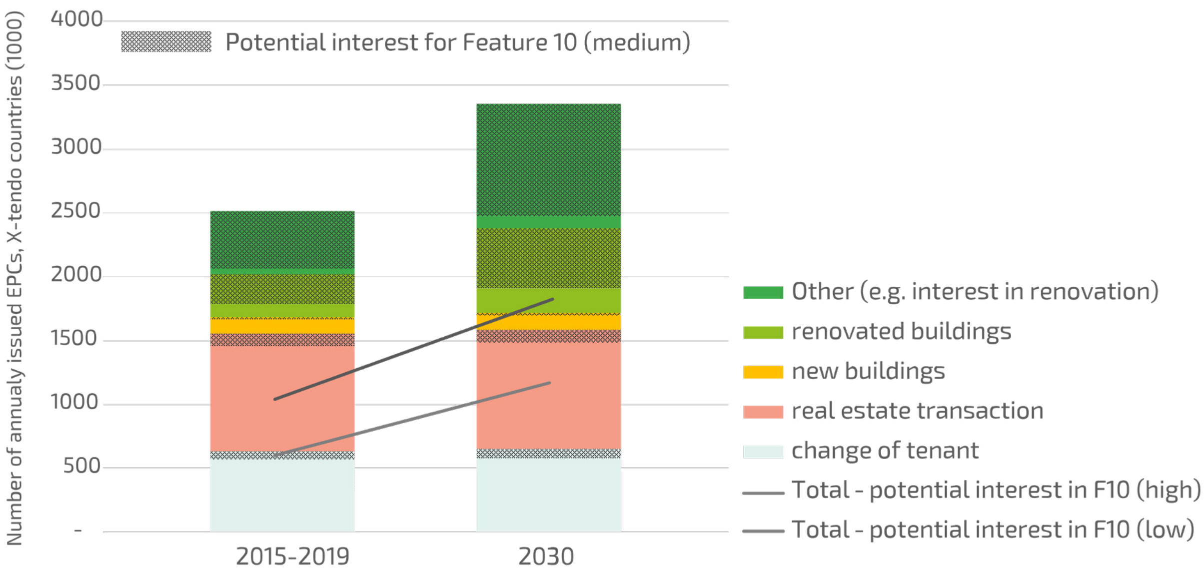
In this chapter, an estimation on the quantitative replicability potential of this feature is provided in the X-tendo countries. This follows the methodology described in section 3. *Figure 11* shows the number of annually issued EPCs, by the different trigger points in the total of X-tendo countries. In the period 2015-2019, about 2.5 million EPCs were issued annually. The largest part resulted from real estate transactions, followed by new building construction, while EPCs due to the change of tenant and building renovation according to our data and the chosen assumptions have lower relevance. In shaded colours, the figure shows the share of EPC-end-users which potentially show special interest in this feature, according to the factors determined in *Table 13* and *Table 14*[11] in *Annex 1*.

[11] The shaded areas (labelled as medium) in Figure 11 were derived as the average of the low/high range depicted in Table 14.

A high relevance is assumed in particular for general interest in the potential improvement of building energy performance, leading to a range of 24%-44% of all EPC end-users showing potential interest in the results of the one stop shop feature. The total number of interested EPC-end-users for all trigger points is estimated to about 0.6 – 1.10 million in the base year which may increase to 1.19 – 1.87 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, for example, 20-40% of EPC-end-users are estimated to be interested. (2) The interest may differ significantly between the buyer and the seller, in particular in case that a building does not perform very well according to a certain indicator. Thus, for the "lower" case a lower value of interest (typically the interest of the seller) is assumed whereas for the "higher" a higher value (typically representing the interest of the buyer) is considered. For Feature 10, it is estimated that no strong difference in the interest in the One stop shop is given for the buyer vs. the seller. Thus, the difference results only from the bandwidth of the estimation.

While the one-stop-shop is very relevant for EPC-end-users planning a renovation, it is not so relevant for most other trigger points.

Figure 11 – Number of annually issued EPCs by trigger points and the estimated share of potentially interested EPC end-users, total of X-tendo countries (Feature 10). Historical data 2015-2019, projection until 2030.



13.5 Next steps for implementation

13.5.1 Calculation method and quality assurance

Denmark outlines that the appetite for OSS depends a lot on the market structure and their link to the EPC database. An attempt must be made to remove barriers and have a single point of information, but it is a costly service and should be made affordable for the future. Another strategy that can be used by the Member States is to provide a free public service so that it becomes affordable. In the UK (Scotland), there are different levels of administration and it is a top-down model, therefore, the first step would be to communicate the benefits across all levels.

As a next step, Portugal sees using an integrated building logbook to improve the information available and after cross-examining they can provide individual measures or packages of measures to homeowners. These are being delivered to the homeowner, which help them to carry out more measures at once achieving deeper renovation. The Danish approach is also to encourage deep renovation which is an initial goal of the OSS. The Danish OSS model needs more specific, digital, connected services.

13.5.2 Capacity building for delivery bodies and training needs for assessors

In general, it would be easier for public authorities to fund the OSS. It is important that an EPC database is connected to this service by the public actors and the subsequent step should be to involve private actors. In the UK (Scotland), the first most important step would be to ensure quality assurance for the EPCs. Another key step would be to link it with the building logbooks. Denmark emphasises that in future OSS should be more flexible and digital. Their current EPC system is well developed and thus meets most of the needs to set up an OSS. They envision making the OSS a unique product that is more digital and tailor-made.

In the UK (Scotland), there is a need to increase the training level, the advisors should compare the data set from the EPC with the one from smart meters and provide different advice to different cases, including behavioural change. Now it is only a list of measures and funding schemes, in the future it should start a more sophisticated discussion with the homeowner. The OSS should also have a different purpose compared to the EPC and focus more on the funding schemes and financing options for homeowners.

13.5.3 Political discourse/ market or end-user awareness

To be able to establish the need for OSS it is essential to identify in Member States what information is needed using detailed market surveys and to establish which stakeholders are interested. For structuring different business models and to increase their effectiveness, it would be important to detail how the improvement measures are evaluated and documented, including what type of data is recorded and integrated in the OSS. End-users can be made aware of OSS using national information campaigns to promote potential benefits to them under the national funding schemes and grants available for renovation. Competition in the market should drive the prices for services down.

13.6 Conclusions

The one-stop-shop feature for existing buildings sets out to facilitate access to financial mechanisms, benefits and support schemes, assist consumers concerning technical and financial issues, and to guide them through their building renovation process. Article 8-10 and 15 on existing buildings in the revised EPBD 2021 proposal [25], outline the need for stronger provisions to overcome the barriers to renovation and mobilisation of financial incentives with one-stop-shops accessible to all building ecosystem stakeholders. A stronger emphasis is seen on deeper renovations supported with higher financial incentives and technical support via one-stop-shops. The one-stop-shop feature is addressing these points very closely and aims to overcome the barriers to residential renovation. There is a high degree of flexibility in this feature to implement in different Member States. This feature enables transparent advisory tools and assistance to homeowners providing integrated renovation services which is very much aligned with the regulations outlined in the revised EPBD. However, awareness regarding one-stop-shops needs to increase so that tailor made information is made available to vulnerable households. It emerges from this research that the social and economic drivers have the capacity to increase the uptake. Meanwhile, there is significant work required to build the capacity of Member States in making provisions for setting up the one-stop-shops. Since the one-stop-shop feature is very relevant for EPC end-users planning a renovation, the impact assessment shows that the total number of interested EPC end-users for all trigger points is estimated to about 595-1,099 thousand in the base year which may increase to 1,190-1,866 thousand EPC end-users in the year 2030 due to implementation of this feature.

Key takeaways:

- The one-stop-shop feature is designed to facilitate access to financial mechanisms, benefits and support schemes, assist consumers concerning technical and financial issues, and to guide them through their building renovation process.
- There is a high degree of flexibility in this feature to implement in different Member States.
- Access to a functional EPC database is a major driver to process the information and give advice to homeowners.
- Verification methods on OSS are key to establish trust for suppliers and homeowners.
- One of the main issues concerning processing information and sharing of personal data is the GDPR.
- Several stakeholders in the construction industry have shown interest in OSS and would like to get involved in national OSS models.
- Integration of OSS with building logbooks, building renovation passports, finance options, etc. is important.
- To overcome existing market barriers between service providers and beneficiaries it is important to establish stable partnerships and cheaper solutions.

Key action points:

- Awareness regarding one-stop-shops needs to increase so that tailor made information is made available to vulnerable households.
- There is significant work required to build the capacity of Member States in making provisions for setting up the one-stop-shops.
- Ensure the quality assurance of EPCs so that reliable advice can be provided to beneficiaries (see also feature 6: EPC databases).
- Identify in Member States what information is needed using detailed market surveys and establishing which stakeholders are interested.

14 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

16.1 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;
Belgium	Eurostat. *http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do.* 02 March 2022; Statbel (Directorate General Statistics - Statistics Belgium). *https://statbel.fgov.be/en/open-data/sales-real-estate-belgium-according-nature-property-land-register.* 01 Feb 2022; Statbel (Directorate General Statistics - Statistics Belgium). *https://statbel.fgov.be/en/themes/housing/building-stock#figures.* 03 Feb 2022; Statbel (Directorate General Statistics - Statistics Belgium). *https://statbel.fgov.be/en/themes/housing/building-permits#figures.* 14 Feb 2022;
Denmark	Statistics Denmark. *https://www.statbank.dk/EJEN88.* 02 Feb 2022; Statistics Denmark. *https://www.statbank.dk/statbank5a/selectvarval/saveselections.asp.* 02 Feb 2022; Statistics Denmark. *https://www.statbank.dk/statbank5a/SelectTable/Omrade0.asp?SubjectCode=6&ShowNews=OFF&PLanguage=1.* 15 Feb 2022;
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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Poland	European Central Bank - Statistical Data Warehouse. *https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=430.RESH.A.PL._T.N._TR.NPRO.PL2._Z.N._Z*. 16 Feb 2022; European Central Bank - Statistical Data Warehouse. *https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=430.RESH.A.PL._T.N._TR.TRAT.PL2._Z.N.RO.* 16 Feb 2022. Statistics Poland. *https://stat.gov.pl/en/topics/municipal-infrastructure/municipal-infrastructure/real-estate-sales-in-2020,2,13.html.* 08 Feb 2022; Statistics Poland. *https://stat.gov.pl/en/topics/industry-construction-fixed-assets/construction/construction-results-in-2020,1,14.html.* 28 Feb 2022;

Country	Data sources
Portugal	Eurostat. *http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do.* 07 March 2022; Statistics Portugal. *https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0008330&contexto=pi&selTab=tab0&xlang=en.* 10 Feb 2022; Statistics Portugal. *https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0007838&contexto=bd&selTab=tab2.* 10 Feb 2022; Statistics Portugal. *https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_publicacoes&PUBLICACOESpagenumber=1&PUBLICACOEStema=55534.* 10 Feb 2022; Statistics Portugal. *https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0009632&contexto=bd&selTab=tab2.* 10 Feb 2022; Statistics Portugal. *https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0008329&contexto=bd&selTab=tab2.* 10 Feb 2022; Statistics Portugal. *https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0008320&contexto=bd&selTab=tab2.* 17 Feb 2022; Statistics Portugal. *https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0008335&contexto=bd&selTab=tab2.* 17 Feb 2022; Statistics Portugal. *https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0008334&contexto=bd&selTab=tab2.* 17 Feb 2022; Statistics Portugal. *https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0008330&contexto=bd&selTab=tab2&xlang=en.* 17 Feb 2022;
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

X-tendo

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ENEA

BPIE

ΚΑΠΕ CRES

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