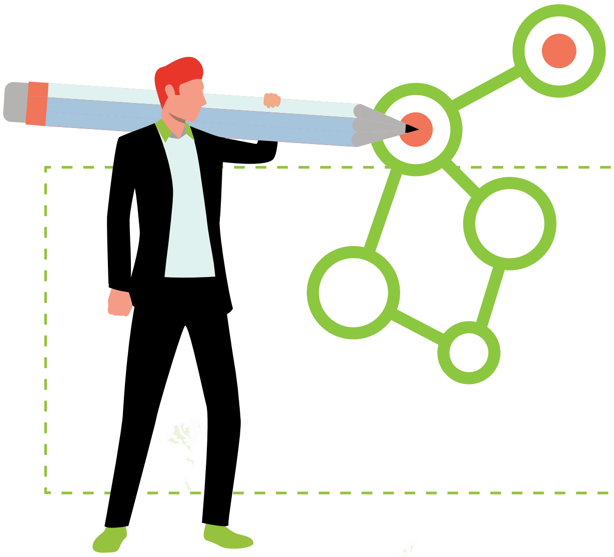
X-tendo



FEATURE 4: REAL ENERGY CONSUMPTION

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

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BPIE

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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

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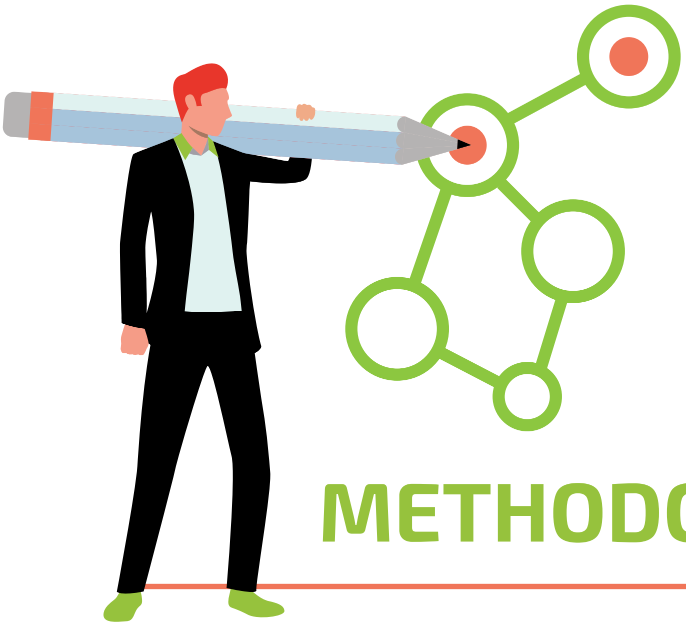
OBJECTIVE OF THE REPORT

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

Therefore, the objective of the report is twofold:

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

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



3 METHODOLOGY

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

These are briefly described below:

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

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

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

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

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

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

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

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

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

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

Methodology for estimation of quantitative impact due to wider implementation

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

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

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

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

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

4

FEATURE 4: REAL ENERGY CONSUMPTION

4.1 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).

4.2 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.

4.3 Drivers and barriers for a wide uptake of the feature

4.3.1 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.

4.3.2 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.

4.3.3 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.

4.3.4 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.

4.3.4 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.

4.4 Estimation of the quantitative replicability potential

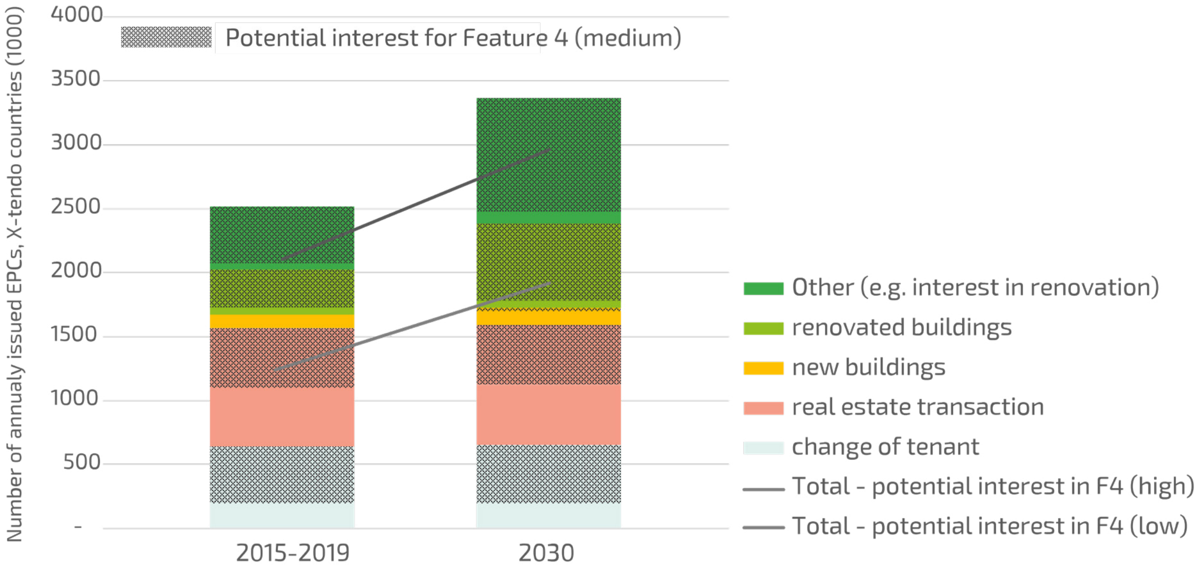
In this chapter, an estimation of the quantitative replicability potential of this feature is provided in the X-tendo countries. This follows the methodology described in section 3.
Figure 4 shows the number of annually issued EPCs, by the different trigger points in the total of X-tendo countries. In 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.



4.5 Next steps for implementation

4.5.1 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.

4.5.2 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.

4.5.3 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.

4.6 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.

5

CONCLUSIONS AND POLICY RECOMMENDATIONS

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

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

Some key general conclusions derived for all the features are:

- An underlying need for all the features is the establishment of the right conditions and quality assurance of EPC databases at national level giving access to public and other relevant stakeholders.
- New or revised EPCs must not be burdened with a lot of new information for the end-user. Information on the first page must be prioritised for the end-user application. Thus, it should be considered which information is presented on the EPC (on paper) and which on the digital EPC or DBL.

- New features must not overload the assessor's work because it risks the quality, cost and reliability of EPCs.
- Automation and simplification of procedures are necessary for overcoming major issues regarding interoperability and data exchange.
- User-friendliness of features is highlighted as one of the most important drivers during tests of all features and more research is needed in this regard, because so far, most features were tested with experts, not with end users.
- EPCs must be coherently linked with other instruments such as DBL and building renovation passports to increase their impact.
- Training is required for some features to upskill and improve the competence of the workforce responsible for delivering EPCs. Some features do not require training at all, while others have methods, either simple or complex, with different training needs.
- New features must be voluntary in the initial stages of implementation and should be integrated once they showcase acceptance and demand in the building sector.
- All the features are compatible for different building typologies and construction periods. Some features have two calculation methods, one more simple and less reliable, while the other is more complex and reliable. Each method can fit different building typologies (e.g. a detailed SRI is needed for large commercial buildings, CARP and CORP of the comfort tool can be used for school, office and residential buildings).
- Calculation methods were adjusted for individual test countries. However, this presented challenges in different aspects such as missing databases to complete calculations, measurement issues, regional restrictions due to Covid-19, etc.
- All the features have the potential to increase the uptake of renovation if implemented, however, this varies for features that are more directed toward public authorities.
- Stakeholders consider GDPR to be a major barrier for many of the features. Therefore, it requires careful evaluation at Member State level for successful implementation, since it can be shown that the understanding of GDPR issues in the context of EPC data is very different in different EU Member States.
- It is important to establish partnerships and alliances between public and private stakeholders to overcome the market barriers and enable affordable solutions for the implementation of the features.
- Some features demonstrate a marginal increase in cost burden for the end-users of EPC, while some need specific mechanisms to be set up to function (e.g. enhanced recommendations, EPC databases).

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

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

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

Next steps for a successful implementation

- Plan and prepare mechanisms to link EPCs with new instruments such as Building Renovation Passports, DBL and SRI.
- Revise EPC calculation methodologies with a vision to integrate new features developed following the European Standards.
- Set up independent control systems to ensure data for EPCs is of high quality.
- Ensure that the EPC schemes are in line with more ambitious EU and national goals and targets.
- Promote the implementation of new features using market and non-market mechanisms to raise awareness among the public and other relevant stakeholders.
- The new features can help to track the progress on policies and support in enforcing mandatory standards by using EPCs for compliance.
- Conduct cost-benefit analysis at national level to determine the feasibility of features and their economic impact to build trust in markets.
- Selective implementation and independent pilot studies in national contexts would support in meeting MS individual policy goals.
- Evaluate national or regional building stock characteristics and estimate the need for new developed features.
- Incorporate medium and long-term horizons for the upgradation of the EPC system and on-set of new features.

Advancing comparability and consistency

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

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

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

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

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

Market, business models and training needs

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

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

GDPR

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

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

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

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

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ANNEX 1

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

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

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

with

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

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

Under the assumption that

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

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

Under the assumption that

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

with

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

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

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

with

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

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

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

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

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

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

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

[12] See Table 13 and Table 14

Table 12 – Data sources of trigger points

Country	Data sources
Austria	European Central Bank - Statistical Data Warehouse. *https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=430.RESH.A.AT._T.N._TR.NTRA.AT2._Z.N._Z*. 22 Feb 2022; Österreichische Nationalbank. *https://www.oenb.at/Publikationen/Volkswirtschaft/immobilien-aktuell.html.* 09 Feb 2022; Statistics Austria. *http://www.statistik.at/web_en/statistics/PeopleSociety/housing/housing_conditions/index.html.* 09 Feb 2022; Statistics Austria. *https://statcube.at/statistik.at/ext/statcube/jsf/tableView/tableView.xhtml.* 09 Feb 2022; Statistics Austria. *https://www.statistik.at/web_de/statistiken/menschen_und_gesellschaft/wohnen/wohnungs_und_gebaeudeerrichtung/fertigstellungen/026021.html.* 03 March 2022;
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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Portugal	Eurostat. http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do. 07 March 2022;
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Romania	European Central Bank - Statistical Data Warehouse. https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=430.RESH.A.RO._T.N._TR.NPRO.RO2._Z.N._Z. 15 Feb 2022;
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For the countries AT, DK, EE, PL, and PT it is considered that in case of apartment buildings, in most cases there is only one EPC issued for the whole building, not for each apartment. For the countries BE, GR, IT, RO and the UK (Scotland) it is considered that EPCs need to be issued for each apartment.

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

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

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

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

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

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

Note

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

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

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

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

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

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

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

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

GLOSSARY OF TERMS

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

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