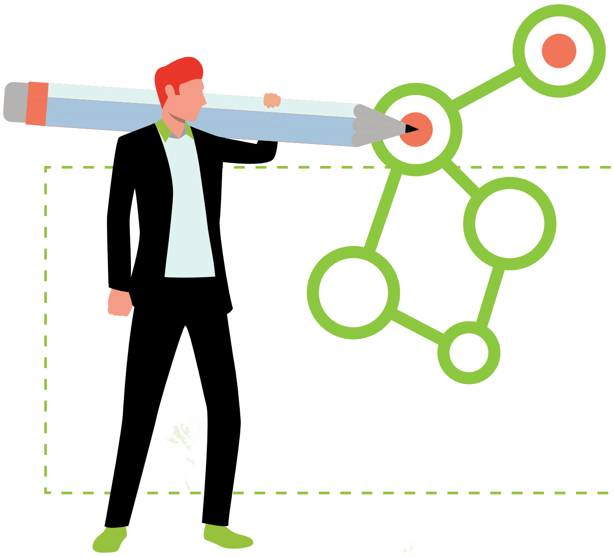
X-tendo



FEATURE 5: DISTRICT ENERGY

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

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

BPIE

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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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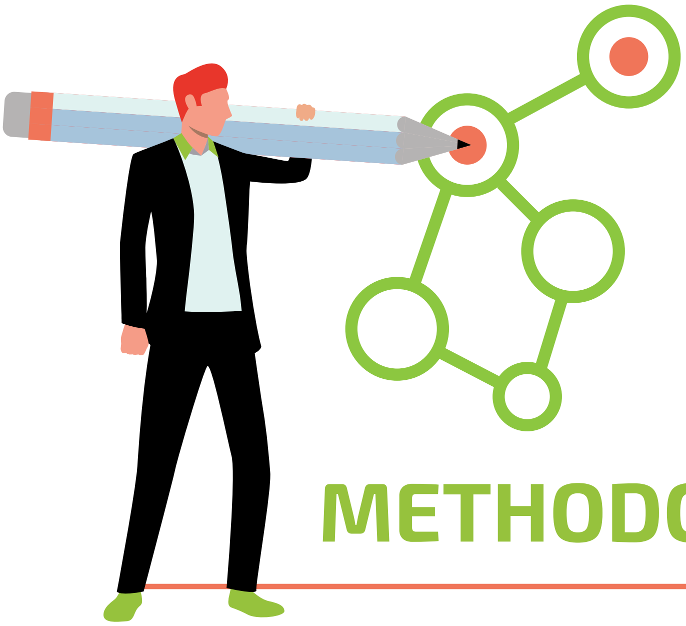
OBJECTIVE OF THE REPORT

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.



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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 5: DISTRICT ENERGY

4.1 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.

4.2 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.

4.3 Drivers and barriers for a wide uptake of the feature

4.3.1 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.

4.3.2 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.

4.3.3 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.

4.3.4 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.

4.3.5 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.

4.4 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.

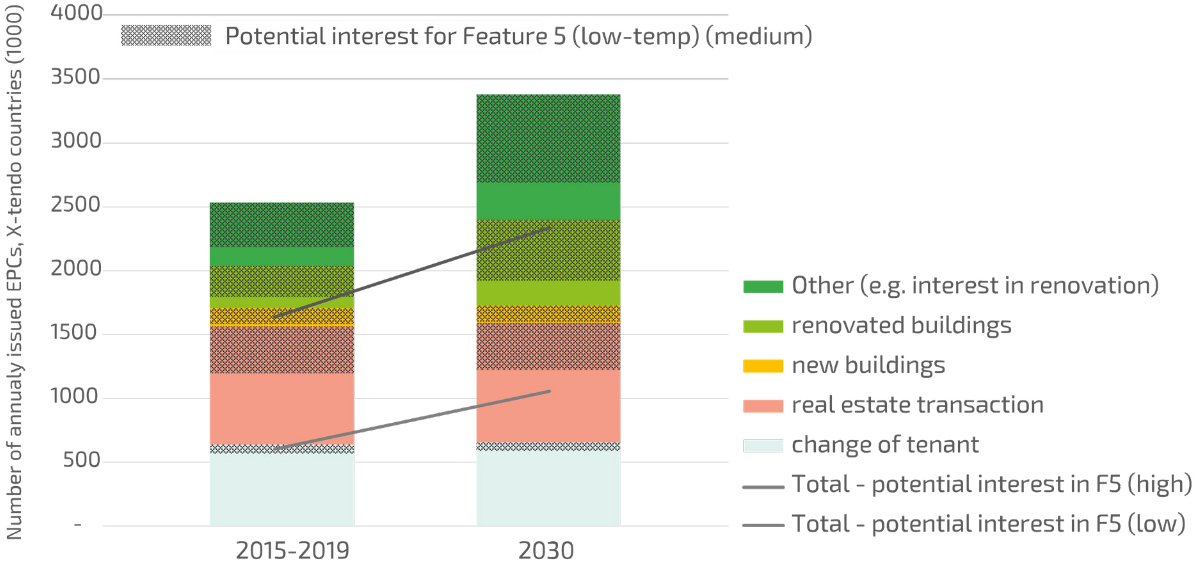
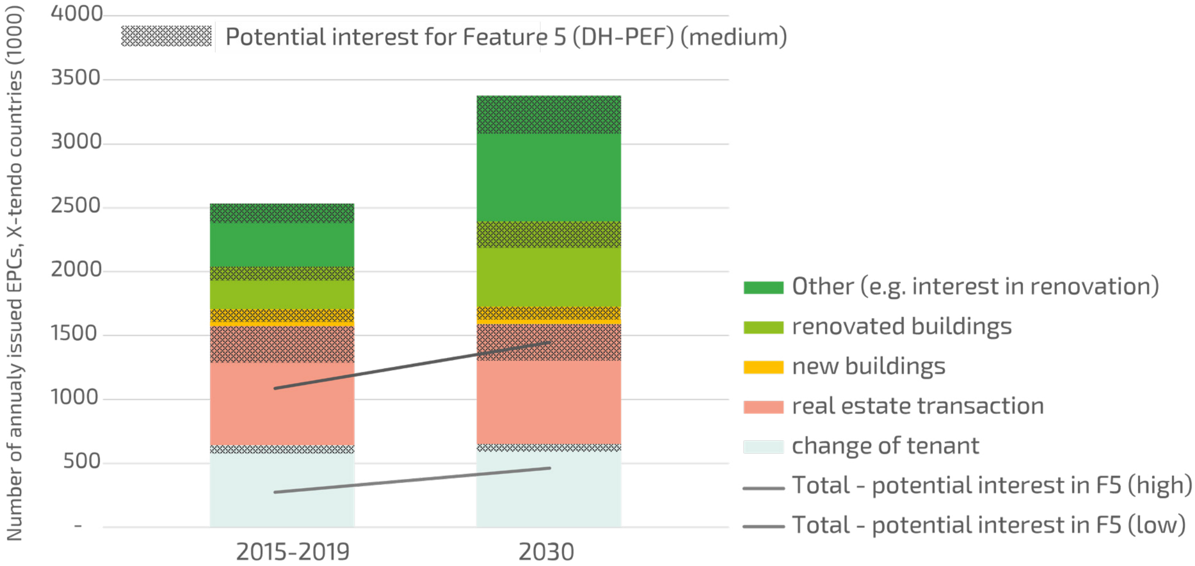


Figure 6 – Number of annually issued EPCs by trigger points and the estimated share of potentially interested EPC end-users, total of X-tendo countries (Feature 5 DH-PEF). Historical data 2015-2019, projection until 2030.



4.5 Next steps for implementation

4.5.1 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.

4.5.2 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.

4.5.3 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

4.6 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.

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.

EPC

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

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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;
Italy	Agenzia Entrate *https://www.agenziaentrate.gov.it/portale/documents/20143/264865/NON_RESIDENZIALE_2011_2020_definitiva.zip/edc366cf-1b6e-0255-f8ca-4c9e95482a90.* 05 April 2022; ENTRANZE. *www.entranze.eu*. 05 April 2022; European Central Bank - Statistical Data Warehouse. *https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=430.RESH.A.IT._T.N._TR.NTRA.IT2._Z.N._Z.* 24 Feb 2022; European Central Bank - Statistical Data Warehouse. *https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=430.RESH.A.IT._T.N._TR.NPRO.IT2._Z.N._Z.* 24 Feb 2022; European Central Bank - Statistical Data Warehouse. *https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=430.RESH.A.IT._T.N.NTR.HCOM.IT2._Z.N._Z.* 24 Feb 2022; Italian National Institute of Statistics. *http://dati.istat.it/Index.aspx?lang=en&SubSessionId=a3e8b60c-9cbd-4992-8941-b3847ef50c3d.* 02 March 2022; Osservatorio del mercato immobiliare, "RAPPORTO IMMOBILIARE 2021", Agenzia delle Entrate, 20/05/2021, Table 38, page 59; Osservatorio del mercato immobiliare, "RAPPORTO IMMOBILIARE 2018", Agenzia delle Entrate, 22/05/2018, Table 35, page 56; *https://www.agenziaentrate.gov.it/portale/web/guest/schede/fabbricatiterreni/omi/pubblicazioni/rapporti-immobiliari-residenziali.* 05 April 2020; Statista. *https://www.statista.com/statistics/677565/number-of-rental-agreements-registered-in-italy/#:~:text=The%20number%20of%20rental%20agreement,to%201.5%20million%20in%202020.* 03 Feb 2022;
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;
Scotland	Registers of Scotland. https://www.ros.gov.uk/data-and-statistics/house-price-statistics. 07 Feb 2022; Scottish Government. https://www.gov.scot/publications/housing-statistics-stock-by-tenure/. 07 Feb 2022; Scottish Government. https://www.gov.scot/publications/housing-statistics-for-scotland-new-house-building/. 07 Feb 2022;

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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