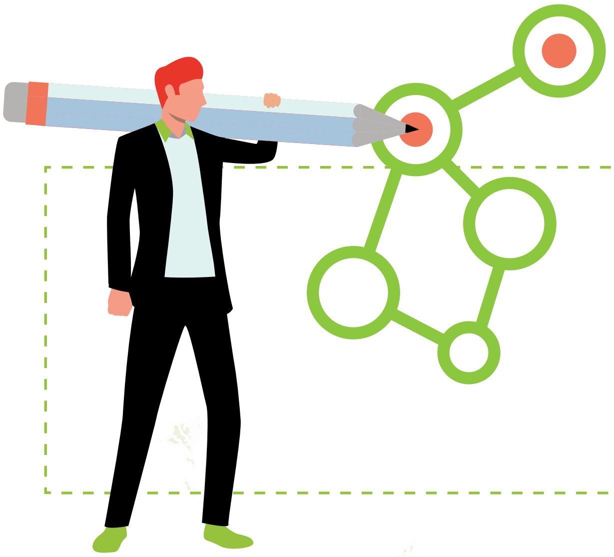

X-tendo

FEATURE 3:

OUTDOOR AIR POLLUTION INDICATOR

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

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

BPIE

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CONTENTS

EXECUTIVE SUMMARY

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

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

Some general conclusions derived for all features include:

- New or revised EPCs must not be burdened with a lot of new information for the end-user. Information on the first page must be prioritised for the end-user application. Thus, which information is presented on the EPC (on paper) and which on the digital EPC or digital building logbook (DBL) should be considered.
- Automation and simplification of procedures is necessary in overcoming major issues regarding interoperability and data exchange.
- User-friendliness of features is highlighted as one of the most important drivers during tests of all features and more research is needed in this regard, because so far, the features were tested with experts, not with end users.

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

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

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

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

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

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

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

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

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

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

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

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

1 INTRODUCTION

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

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

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

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

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

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

Table 1 - Overview of features and implementing partners

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

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

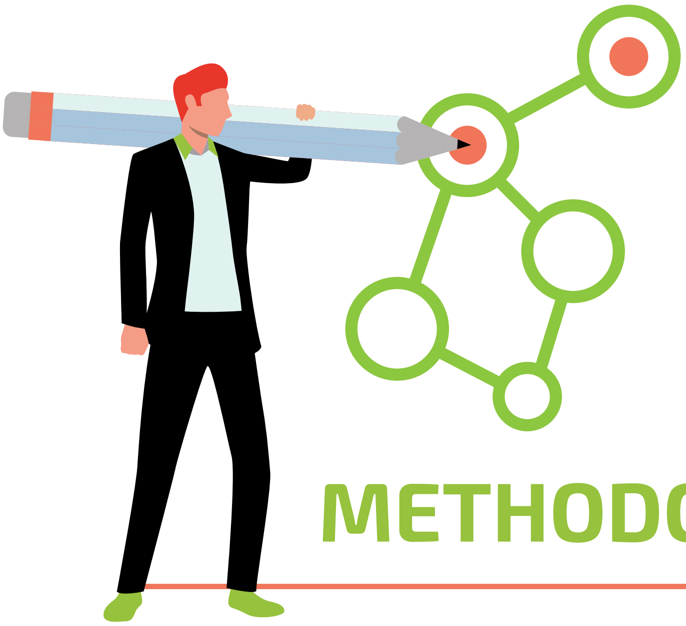
2 OBJECTIVE OF THE REPORT

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

Therefore, the objective of the report is twofold:

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

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



3 METHODOLOGY

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

These are briefly described below:

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

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

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

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

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

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

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

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

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

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

Methodology for estimation of quantitative impact due to wider implementation

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

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

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

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

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

FEATURE 3: OUTDOOR AIR POLLUTION INDICATOR

4.1 Overview

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

1. Local Air Pollution Contributor Index (LAPCI) which assesses potential building influence on local smog development.

2. Indoor Air Purity Index (IAPI) which assesses the efficiency of air filtration in the ventilation system of a building.

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

4.2 Key insights from testing

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

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

User testing

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

Local air pollution contributor index

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

Indoor Air Purity Index

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

In-building testing

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

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

4.3 Drivers and barriers for a wide uptake of the feature

4.3.1 Calculation method and quality assurance

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

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

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

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

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

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

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

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

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

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

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

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

4.3.4 Economic drivers and barriers

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

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

4.3.5 Consistency with existing policies and standards

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

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

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

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

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

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

Compatibility with the EPC scheme

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

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

4.4 Estimation of the quantitative replicability potential

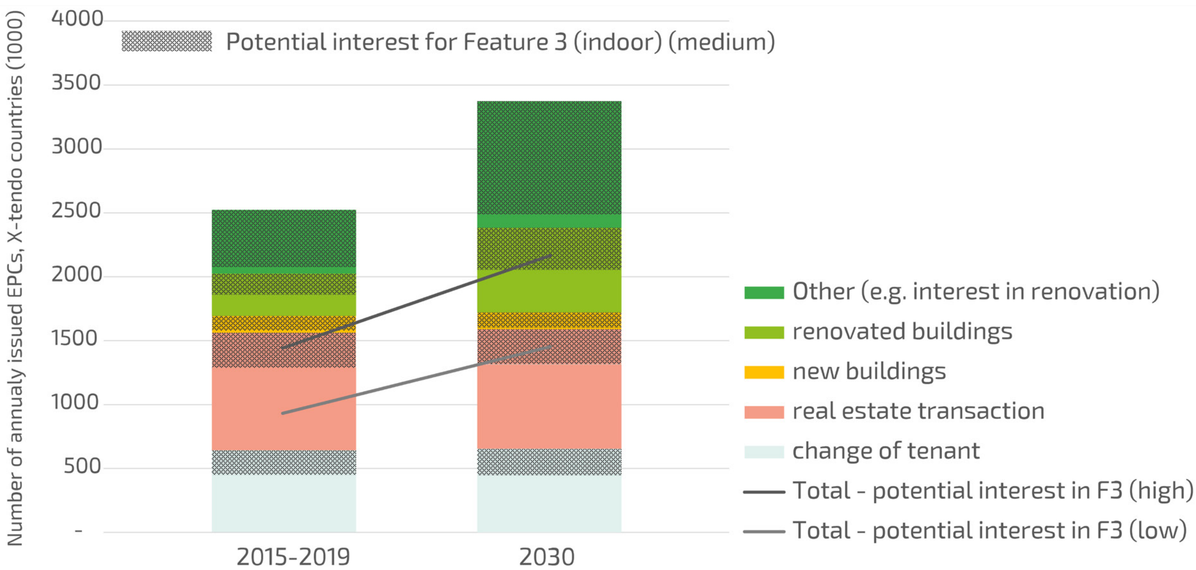
In this chapter, an estimation on the quantitative replicability potential of this feature is provided in the X-tendo countries. This follows the methodology described in section 3. *Figure 3* and *Figure 4* show the number of annually issued EPCs, by the different trigger points in the total of X-tendo countries. Due to the different characteristics of the two indicators (indoor air purity vs. contribution to outdoor air quality), separate analyses were carried out for these two cases. In the period 2015-2019, about 2.5 million EPCs were issued annually. The largest part results from real estate transactions, followed by new building construction, while EPCs due to change of tenant and building renovation according to the available data and the chosen assumptions have lower relevance. In shaded colours, the figure shows the share of EPC end-users which potentially show special interest in this feature, according to the factors determined in *Table 13* and *Table 14*[3] of *Annex 1*. A high relevance is assumed in particular for new buildings (outdoor) and building renovation (indoor), leading to a range of 38%-58% (indoor) and 22%-42% (outdoor) of all EPC-end-users showing potential interest in the results of the Outdoor Air Pollution feature. The total number of interested EPC end-users for all trigger points is estimated to about 0.95 -1.45 million (indoor) and 0.55 – 1.06 million (outdoor) in the base year which may increase to 1.48 – 2.16 million (indoor) and 1.08 – 1.76 million (outdoor) EPC end-users in the year 2030, which is indicated by the grey lines. The bandwidth (low-high) results from two factors: (1) The potential interest of EPC-end-users was assigned by categories, each representing a range, like 20-40% of EPC-end-users are estimated to be interested. (2) The interest may differ significantly between the buyer and the seller, in particular in the case where a building does not perform very well according to a certain indicator. Thus, for the "lower" case a lower value of interest (typically the interest of the seller) is assumed, whereas for the "higher" case a higher value (typically representing the interest of the buyer) is considered. For Feature 3 it is estimated that no strong difference in the interest is given for the buyer vs. the seller. Thus, the difference results only from the bandwidth of the estimation.

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

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

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

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



4.5 Next steps for implementation

4.5.1 Calculation method and quality assurance

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

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

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

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

4.5.2 Capacity building for delivery bodies and training needs for assessors

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

4.5.3 Political discourse/market or end-user awareness

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

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

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

4.6 Conclusions

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

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

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

Key takeaways:

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

Key action points:

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

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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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;
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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ENEA

BPIE

ΚΑΠΕ CRES

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