TECHNICAL SPECIFICATIONS OF ENERGY PERFORMANCE CERTIFICATES DATA HANDLING: UNDERSTANDING THE VALUE OF DATA

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TABLE OF CONTENT

EXECUTIVE SUMMARY

The EPBD and its revisions in 2010 and 2018 strengthened the provisions relating to Energy Performance Certificates (EPCs) by setting out that the Member States have to provide information to owners and tenants on the purpose and objectives of EPCs, energy efficiency measures and supporting financial instruments through accessible and transparent advisory tools such as direct advice and one-stop-shops. The recent Renovation Wave Communication published by the European Commission in October 2020, suggested reinforcing existing EPC frameworks, including improving the data gathering, storage and overall quality.

This report outlines the user needs and technical specifications regarding features of EPC databases, building logbooks, tailored recommendations, financing options and one-stop shops. It comprises a description of the implementing partners' needs and potential usage of EPC data in the X-tendo target countries.

The set of EPC features discussed in this report do not involve additional building assessments tools, rather these are functions which can be built into certification regimes by better handling and using of EPC data. All these concepts and features will be further elaborated and tested during the forthcoming stages of the project.

Figure 1: X-tendo features

The main objectives of the features are given in Figure 2. Each chapter is dedicated to one specific feature, describing the status quo, end-users' needs, and the potential for this feature to be further developed and implemented within the certain implementing countries. The first chapter outlines the role of EPC databases (Chapter 2), followed by the logbook (Chapter 3) and tailored recommendations (Chapter 4). The following chapter examines the potential of EPC data in scaling up financing for renovation (Chapter 5), while the last chapter discusses how one-stop-shops (Chapter 6) powered by EPC data can make the renovation journey smoother for homeowners and investors.

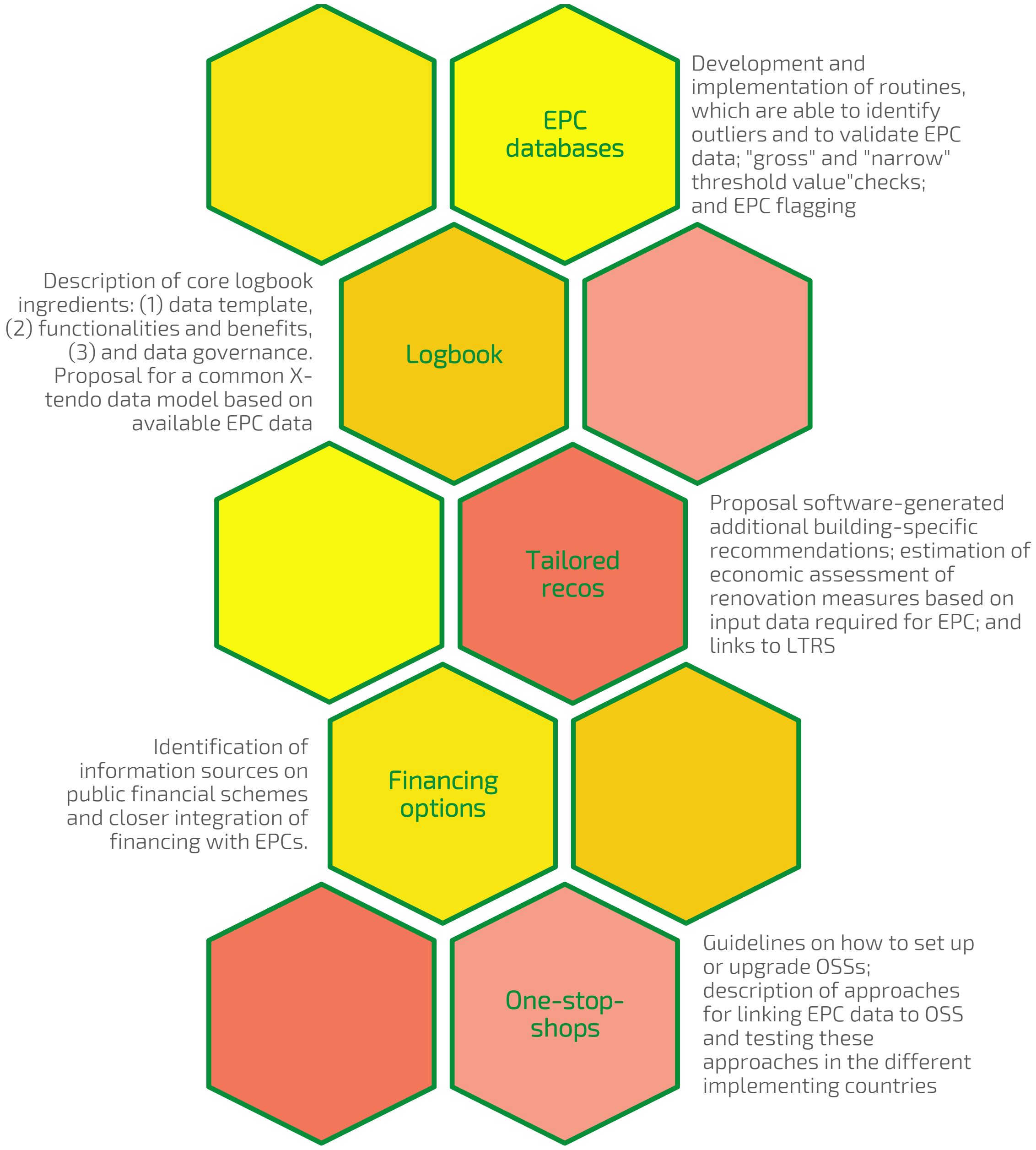

Figure 2: The five "innovative handling of EPC data" features

1 INTRODUCTION

Improving the energy performance of buildings is one of the major objectives of EU's energy and climate policy. The energy performance certificates (EPCs) were first introduced by the Energy Performance of Buildings Directive (EPBD) in 2002 to make the energy performance of individual buildings more transparent. The subsequent EPBD recast in 2010 reaffirmed and strengthened the existing legislation. It introduced independent quality control of EPCs and penalties for non-compliance; it addedthe obligation to display the energy label in advertisements and made it mandatory to hand out copies of the EPC in sale and rent transactions. The recast also introduced an improvement of featured recommendations.

The EPBD amendments of 2018 strengthened the provisions once again. According to the legislation, Member States have to provide information to owners and tenants on the purpose and objectives of EPCs, the energy efficiency measures as well as the supporting financial instruments. For this purpose, accessible and transparent advisory tools such as direct advice and one-stop-shops are recommended. The recent Renovation Wave Communication published by the European Commission in October 2020, suggested reinforcing existing EPC frameworks, by alsoimproving the data gathering, storage and overall quality of EPCs.

EPCs are the most widely available information documents on building energy performance across Europe. Despite their acknowledged limitation in terms of reliability, EPCs are an important measure providing market participants with relevant information to assess, benchmark and improve the energy performance of properties.

Underpinning the introduction of EPCs has been the belief that a property's energy profile is important to the property transaction process and will ultimately influence the behaviour by becoming a decision-making factor when comparing properties to buy or rent. Also, the intention was that this, in turn, will prompt decisions to renovate the property.

EPCs are more than just an information document and could become a powerful market tool to create demand for energy efficiency in buildings by providing recommendations for cost-effective and cost-optimal improvements. They can also become an effective instrument to map the energy performance of a country's building stock, create awareness about healthy buildings and monitor the impact of building policies or progress towards climate goals. Given their wide market penetration, they could likewise provide reliable benchmarks for originating preferential loans (both secured and non-secured) as well as to benchmark and tag existing real estate portfolios of banks for regulatory compliance (capital requirements) and green bond issuance.

EPCs thus promise to add value through multiple (innovative) uses. The main question out there is whether current EPCs are fulfilling these roles? X-tendo sets out to extend and improve current EPCs in order to fully bring to the front these additional functions.

This report outlines the user needs and technical specifications regarding features of EPC databases, building logbooks, tailored recommendations, financing options and one-stop shops. It comprises a description of the implementing partners' needs and potential usage of EPC data. The set of EPC features discussed in this report do not involve additional building assessments tools and data collection, rather these are functions which can be built into certification regimes by better handling and using of EPC data. All these concepts and features will be further elaborated and tested during the forthcoming stages of the project.

2 EPC DATABASES

The main function of EPC databases is the storage of EPCs and of the underpinning data which makes these a very important source of building stock information, especially if relevant parts of the information is made available to stakeholders such as building owners, construction companies, real estate actors, public authorities etc. When dealing with the question of how the performance of EPC databases may be improved, numerous topics can be highlighted. These usually include aspects such as how to set up an EPC database, how to gather the data, how to establish the interoperability of different databases, and how to use data and extract relevant insights from it. Last but not least, ensuring the reliability and accuracy of the information stored in the database through quality assurance processes and data verification remains a key requirement common to all EPC schemes. Current practices of setting up and operating EPC databases show significant differences among EU Member States in terms of the above requirements.

Exchanges with the X-tendo implementing countries of Denmark, Greece and Italy highlighted the need to develop a common method to help improve existing quality assurance processes in relation to EPCs and EPC databases. This chapter sets out the X-tendo methodology for improving the quality control of EPC databases.

A best practice example of quality control scheme of EPCs is shown Portugal. It consists of a nine-step approach, including quality assurance both pre-certification (as prevention) and post-certification (as correction).

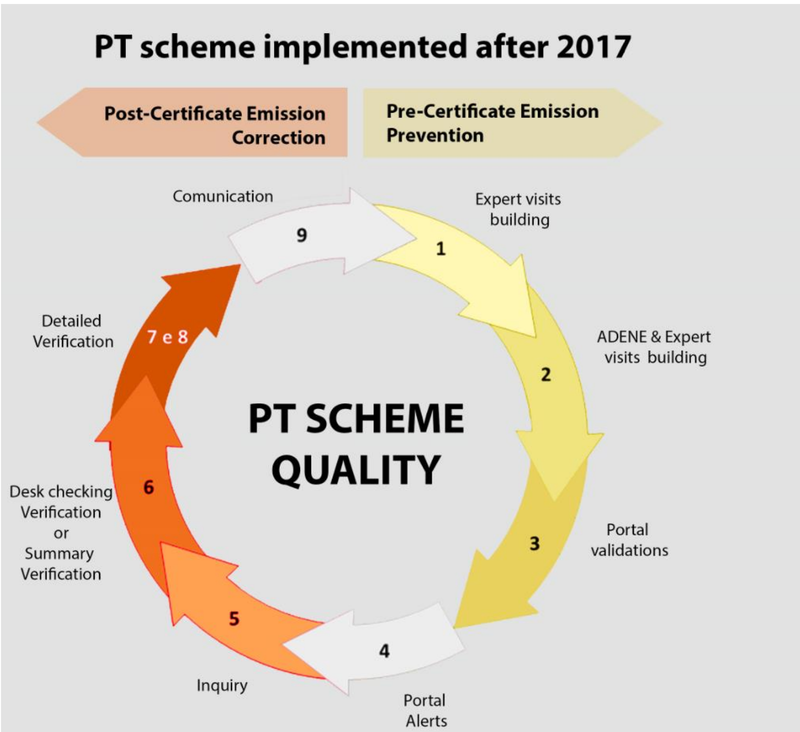

Figure 3: Quality assurance of EPCs in Portugal

In general, there are two approaches available to implement quality assurance routines, which can be implemented independently from each other.

In Figure 3 above these are shown as steps 3 to 7&8 . The first approach refers to the checking of input values entered in the calculation software or the platform used during the EPC issuance process. Its functionality is user-friendly as it immediately notifies the EPC issuer about any improper or missing data field. This approach is important as it prevents erroneous data from getting into the database. The second method involves the large-scale statistical analysis of EPC data, whereby inaccurate parameter values or values outside of range are flagged and referred to manual control. The X-tendo methodology is a four-step process which begins when EPCs have been logged in the database. It includes both “broad” and “narrow” band threshold value checks, as well as an automated EPC flagging mechanism.

The methodology will also contribute to the training curricula and upskilling of energy auditors. In addition to the four-step process described in detail below, it will deal with how to assess and present the outcomes from an EPC database quality control process. The main purpose is to improve the skillsets of building professionals: by highlighting commonly made mistakes, it will prevent them from being repeated.

2.1 Current state-of-the-art

EU legal provisions related to EPC databases

The recast of the Energy Performance of Buildings Directive (EPBD) – [Directive/2018/844/EU], Paragraph 10 – stipulates in the main functions of an EPC database that:

1- *“Databases for energy performance certificates shall allow* ***data to be gathered on the measured or calculated energy consumption*** *of the buildings covered (…)*
2- *“Least aggregated anonymised data compliant with Union and national data protection requirements shall be* ***made available on request for statistical and research purposes and to the building owner****.”*

In this context, the quality assurance of the EPC databases plays a major role. This is particularly important because if the data is made available for the public and/or used for other purposes (including policy design), it has to be reliable and trustworthy.

EPC databases in the X-tendo countries

This chapter focuses on quality control and quality assurance aspects of EPC databases. Other potential uses of EPC databases – such as data mining and interoperability with other external databases – are explored in the X-tendo report *Energy performance certificates – Assessing their status and potential*.[1]

[1] Online available under the link: https://x-tendo.eu/wp-content/uploads/2020/05/X-TENDO-REPORT_FINAL_pages.pdf

Although implementing an EPC database is voluntary, almost all Member States have done so. The approach for setting them up varies from country to country. While some only collect the input data about the building or EPC (in part extracted, for example, from an XML file[2]), others go further and perform the EPC calculation within the registry. Some Member States also store the detailed input data required to generate the EPC, while others only collect a PDF copy of the certificate but no data. In all cases, the EPC database should retain the underlying EPC data, making it easier to access the building information and to perform verification and quality checks.

Responsibility for storing the EPCs also varies across Europe. Some countries have centralised national databases, while others have regional databases (e.g. Italy, Austria), and/or additional national databases with more limited content than the regional ones.

To better understand the EPC databases in three of the X-tendo countries – Italy, Greece and Denmark – a survey was carried out with the country experts involved in this feature. Table 1 below summarises the key findings with a particular emphasis on quality assurance methods, consistency checks and administration of EPC databases.

	Denmark	Italy	Greece
Ownership of EPC database	National database owned and operated by Danish Energy Agency	Regions and autonomous provinces and national database operated by ENEA	National database owned by the Ministry of Environment and Energy and operated by CRES.
Validation process of EPC data and quality assurance	(1) On-site visits by certification bodies[3] (2) Random checks with full surveys on site by an assessor (3) Risk-based EPC validation; the inspection pool consists of EPCs with unrealistic input parameters	EPC data quality checks at regional level. At national level, validation of the input data format (string, numeric etc.) is conducted and some quality assurance checks are being implemented.	(1) Automatic validation of key input and output parameters (2) Periodic manual check by energy auditors, Ministry's assigned staff or external experts assigned by the Ministry; on-site inspections when needed (very rarely)
Choice of the EPC to be checked	Randomly, using a risk-based approach	Randomly	Randomly
Format of the EPC database	XML and PDF files. The data from the XML files can be extracted by a SQL-script without the need for complicated searches in the XML files	PostgreSQL extracted from XML file	Database containing administrative data and data printed in the EPC; repository of XML files containing all input and output EPC information

[2] "Certification, Control system and Quality – 2018", epbd-ca.eu. https://epbd-ca.eu/ca-outcomes/outcomes-2015-2018/book-2018/ct/certification-control-system-and-quality-update (accessed on 10.08.2020)

[3] On-site visits are made to check whether certified EPC companies are complying with the statutory requirements.

Input data features and auxiliary data	240 parameters divided into three main categories: building, climate shelter and technical installations. Energy prices are subcontracted to commercial providers and data for cost-benefit calculations are provided by the energy assessor	108 parameters with data about building geometry and building envelope, energy systems, building energy performance, calculated energy consumption, building cadastral data, recommendations, EPC expert	Geometry (possibly aggregated[4]), systems data, energy performance, improvement recommendations made by the energy expert (including estimation of costs). Around 140 parameters in the database and 300 more parameters in the XML files

Table 1: Overview of EPC databases in the three X-tendo countries

2.2 Quality control and assurance of EPC databases in the X-tendo countries

Data validation and quality control is one of the key issues impacting the credibility and market acceptance of EPCs. The X-tendo project will focus on this area by developing a methodology for quality control and quality assurance of EPC databases. In general, the validation of an EPC can be implemented in two stages. The first is when the EPC is being issued and the calculation software or the platform checks the validity of the input data by verifying if the ranges and types are in accordance with the previously set rules. The second stage consists of statistical checks of the EPC data already uploaded to the EPC database.

In Denmark, the validation checks are carried out in the first stage, as the EPC is being issued by the energy auditor. Checks are applied against approximately 100 predefined rules, and if values are found to be outside the set range, the auditor will not be able release the EPC unless the input values are corrected. The validation process has different levels of warning: (1) a yellow warning indicates that the entered value is outside the set range, and the energy auditor should provide documentation to prove the accuracy of the value (or correct the value); and (2) a red warning signals that the EPC assessment process cannot proceed further.

The second stage of the quality assessment involves risk-based monitoring which takes place when the EPC is already logged in the EPC database. This entails a risk assessment of the erroneous data, helping to identify the EPCs that should be manually checked – if no U-value has been inputted for the roof, for example, it would be considered very high risk. Figure 44 below gives a simplified overview of how the risk-based mechanism is embedded in the quality control process.

[4] The energy expert issuing the EPC may aggregate, e.g. sum the areas of all identical walls as if they were one wall.

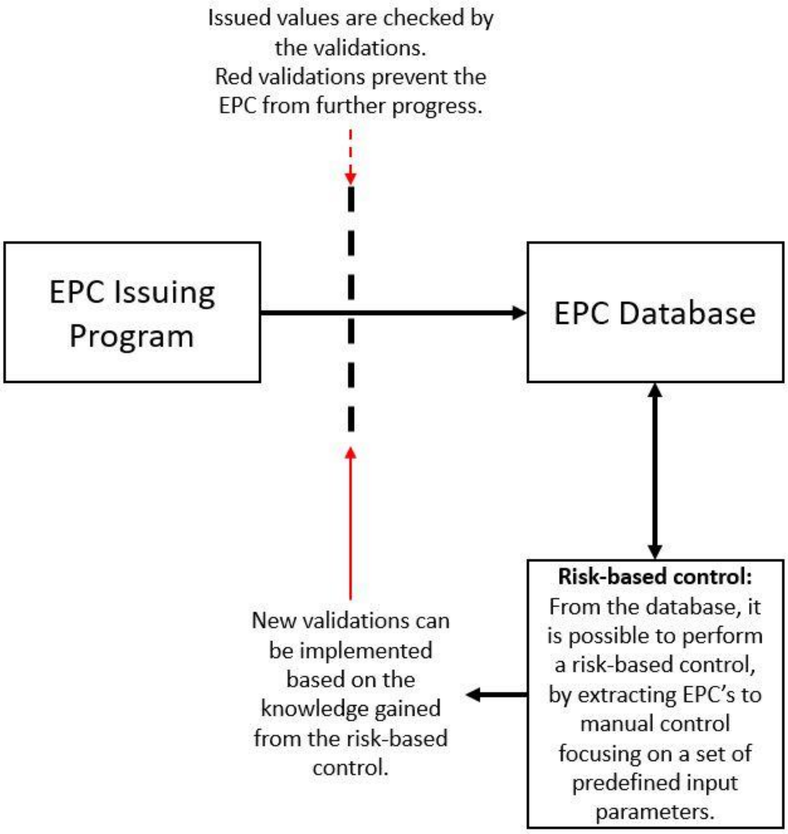

Figure 4: Overview of risk-based control of EPCs in Denmark. Source: own graph (from DEA)

In Italy, data validation and quality controls are mandatory in every region, including regions without a local EPC database. A sample of at least 2% of all newly issued EPCs have to be checked every year. Regions have autonomy over organising the quality assurance process, which has resulted in different quality control systems across the country. Regions without EPC databases only collect PDF files, but these are not uploaded to the national EPC database (SIAPE).

Lombardia (Annex I), which carries out quality controls at multiple levels, is an example of best practice in regional validation and control processes. A first-level control is carried out during the logging of the EPC in the regional EPC database. A second level of quality check (document control) is randomly performed on 2% of EPCs in the database: this is based on a comparison with cadastral plans, cadastral data and aerial photos. Finally, a third-level control consists of on-site inspections of a randomly selected share of the EPCs already subjected to a document control procedure where there had been a "doubtful outcome".

At the national level, SIAPE carries out an essential validation of data types (string, numeric etc.) including some other quality assurance checks. The implementation of a second-level quality assurance process at national level is considered to have been very useful for further improving the reliability of EPC databases.

In Greece, the first step of input data quality control is performed automatically on a web-based platform. A number of parameters are checked, including:

- Missing information on building identification (e.g. address, owner name, GIS data, national Land Registry number etc.)
- Missing audit fee deposit on the Tax Authority platform (linked platforms)
- Missing/faulty data or values in the following fields: building use, reason of issuance, renovation recommendations (at least one is required), primary energy for heating ≤ 0, primary energy for cooling ≤ 0, primary energy for lighting ≤ 0, total building surface ≤ 0, useful building surface ≤ 0, useful building surface > total building surface, primary energy consumption value > 5000, primary reference energy consumption value > 5000, annual CO_2 emissions < 0.

In addition, a sample of 5% of all EPCs are subjected to random desktop manual checks on data entry. Desktop checks are performed for all EPCs issued for the purposes of accessing preferential funding programmes. Random checks are also performed on-site, whenever required, depending on the outcome of the desktop checks and in case of complaints. On-site checks are conducted by the assigned staff of the responsible authority, i.e. Ministry – Energy Inspectorate.

2.3 Proposed X-tendo methodology

Figure below shows the proposed quality control method developed by the X-tendo project for EPC databases. The four-step process starts as soon as the new EPC has been logged in the EPC database, and consists of:

1) *First threshold value verification* requires all EPCs in the database to be automatically verified. At this stage, a **"gross" threshold value check** (broad range) is being performed for a series of EPC parameters, including for example U-values > 0.
2) *Second threshold value verification* of the EPCs which passed the first step verification is also done automatically. In this second stage, a more **"narrow" threshold value check** (narrow range) is being performed for previously defined building archetypes. Each *archetype* represents a cluster of buildings as defined by clustering different indicators (building type, building construction year, climate zone etc.).
3) *EPC flagging* according to the identified faults, notification of the inconsistencies, and indication of EPCs that will require manual checks. The manual check is however not covered by the scope of the X-tendo methodology.
4) *Professional development of energy auditors*: the methodology will also deal with how to assess and present the outcomes from a EPC database quality control process. The main purpose is to improve the skillsets of building professionals: by highlighting commonly made mistakes, it will prevent them from being repeated.

In general, for all EPCs verified, a verification protocol is generated with the warnings about the inconsistences. Therefore the methodology must clearly define the possible fault categories and, possibly also their different levels: very serious, serious or less serious faults.

In the long run, the feedback loop and close interaction with energy auditors are expected to greatly reduce recurring mistakes, increasing the quality of EPCs before they are logged in the database. For this reason, it is important to have clear and structured communications with energy auditors about the outcomes of the quality checks. This feedback mechanism can be part of the continuous professional development of energy assessors, who will also be educated on how to apply the results from the EPC database quality control process.

Any EPC flagged as faulty needs to be manually verified, possibly by the authority responsible for the EPC database. If the EPC is not valid, further steps should be taken, for example the notification of the energy auditor who issued the EPC. However, this is not part of the proposed X-tendo methodology.

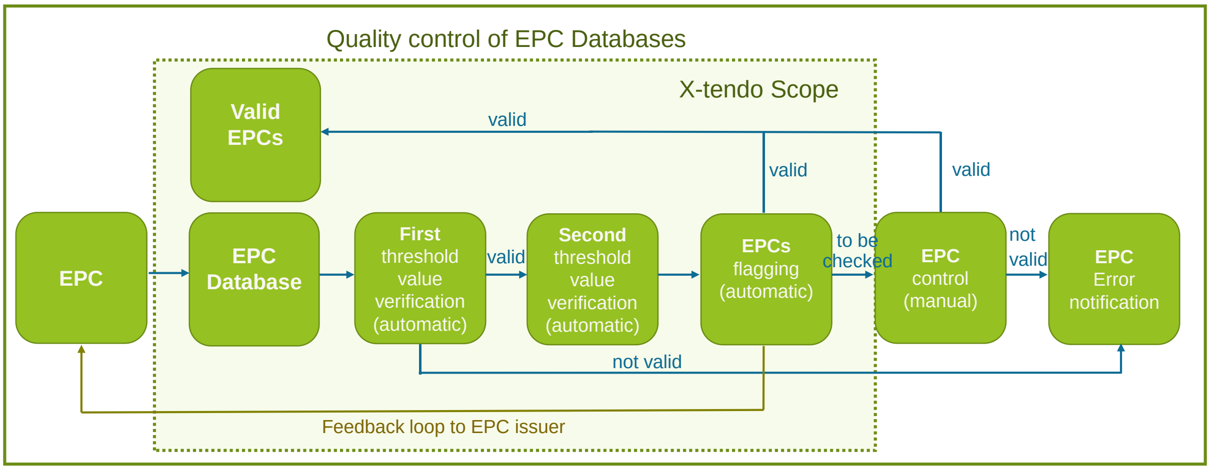

Figure 5 – *Outline of the proposed quality assurance method*

3 LOGBOOK

The construction, maintenance and operation of buildings from initial design through to use, refurbishment and disposal can only be managed with accurate data that sets a baseline and clear trajectory for improvement. Data is at the heart of decisions at all stages of the building lifecycle. The availability of reliable data can contribute to better design and management of buildings, improved market information and transparency, creation of innovative services and business models, as well as more effective policymaking. The accessibility and quality of data is a fundamental and common ingredient of all new EPC features being developed by X-tendo, being used either as an input in the calculation of new indicators or to enable innovative services such as tailored recommendations, financing options or one-stop-shops.

Although data is routinely collected by multiple stakeholders for various reasons over the lifespan of a building, a common approach for organising building information is largely missing. Building-related data – such as EPC data, physical building characteristics data, environmental performance information and real estate transaction data – continues to be scarce, of unreliable quality and limited accessibility.[5] The lack of an overarching structure shared across the built environment leads to information asymmetries, inefficiencies and red tape, a lack of transparency and trust, a higher risk for investment – and, ultimately, a lack of uptake of energy efficiency improvements.

Tools for building information management have the potential to enable better decision-making throughout the building lifecycle, in areas including management of technical and functional aspects, safety, conservation of economic value, certification, improved energy and environmental performance. Organised and shared data that can be re-used would not only reduce uncertainty but also the time and cost needed for collecting missing information. In this sense, building logbooks can reinforce the successful implementation of other X-tendo features.

Building logbooks are a repository developed for the management of building information. The logbook can evolve both in terms of information stored and its functionalities, starting from EPC and building performance to gradually include other categories of data and services such as equipment maintenance, insurance, property plans and obligations, smart meter data and links to available financing options.

Several European countries have developed and implemented building logbooks or similar initiatives in recent years, including the EPC-oriented Woningpas in Flanders (Belgium), the private initiative BASTA in Sweden, the PTNB in France and the Portal casA+ in Portugal. These logbooks differ, however, in terms of focus (e.g. on energy efficiency or materials), data handling and digital solutions employed. A common European approach covering the

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[5] Hartenberger et al. (2019) The Building Passport as an enabler for market transformation and circular economy within the built environment: SBE19 Conference Series paper and RICS (2017) Global Trends in Data Capture and Management in Real Estate and Construction

entire lifecycle and comprising all relevant building information could enable synergies, interoperability, data consistency and information exchange. Several other Horizon projects have also explored the potential of building logbooks, including iBRoad and ALDREN.

This chapter introduces the three core ingredients of the logbook: (1) data template, (2) functionalities and benefits, and (3) data governance. The main focus of this section is on creating a core list of data points which are essential to the development of a logbook and, in parallel, reviewing the data points available in an EPC scheme to be linked to logbooks. The X-tendo logbook data template is based on a detailed country-specific scoping and review of the EPC data points that are relevant and reliable enough to be included in or linked to the logbook. The development of this table has been crosschecked with similar initiatives such as IBroad[6] logbook and the Global Alliance for Buildings and Construction.[7] The logbook's functionalities, its data and governance aspects are described briefly in the second part of this chapter.

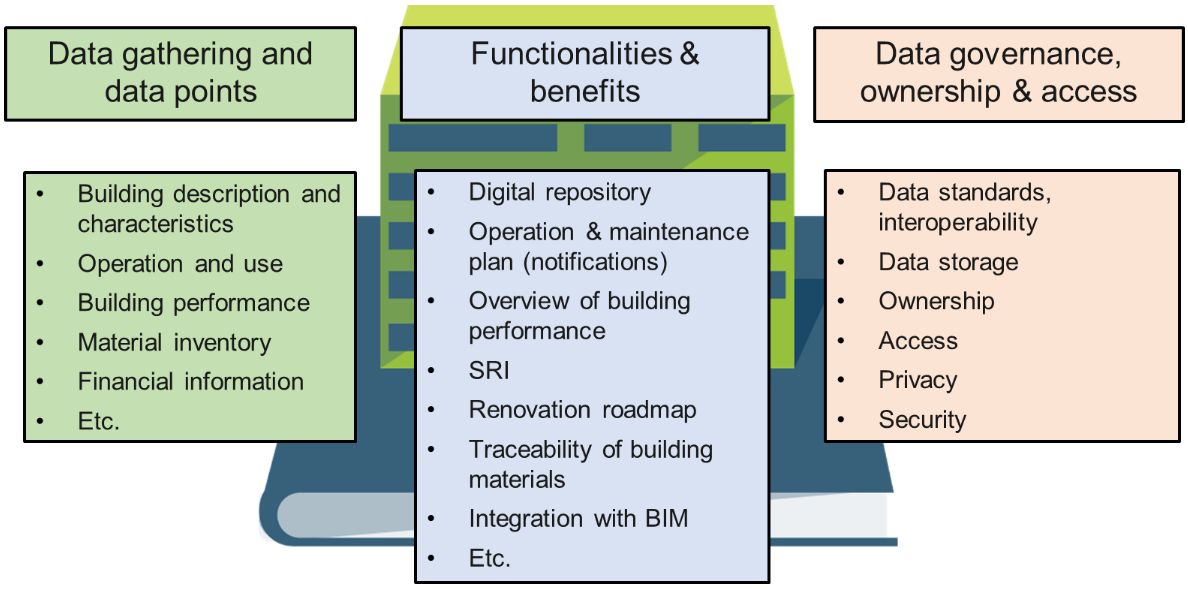

Figure 6 – The building blocks of a logbook

3.1 Data points in the building logbook – a common data template

The systematic collection and maintenance of data and information is the backbone of the logbook. The main purpose of the logbook data template is to provide a common set of data entry points that need to be captured. Adhering to a common standardised data template can remove the need for the additional mapping and transformation work that is currently required when collecting building information from various sources.

The data template should give guidance on how to organise the data according to categories, the importance of data, levels of granularity and frequency of update. It can also

[6] IBroad (2018) The logbook data quest

[7] Global Alliance for Buildings and Construction, Work Area 5, forthcoming, aiming to create a Building Passport Handbook with guidelines and good practice examples

indicate the data format, its level of importance (e.g. core or complementary data), its relevance for various building types and potential sources of data.

The organisation of logbook data needs to fulfil the following main requirements:

- The logbook should accommodate a wide range of data sources and data categories, including administrative data, building characteristics, energy performance data, operational, maintenance, and financial/legal information.
- The logbook should link with existing data sources and information tools, such as the Smart Readiness Indicator, Energy Performance Certificates, sustainability ratings and material passports.
- The advancement of ICT technologies in the built environment opens up new opportunities to collect data (e.g. sensors, real-time energy use, IoT) but also brings further data privacy and security constraints: the logbook should be able to accommodate these to fully reap the benefits.
- The logbook should be sufficiently flexible to serve both national/regional needs and also to integrate into a wider European approach.

The logbook as a dynamic tool: from EPC data to lifecycle data

The closer integration of EPC databases and building logbooks could be a promising first step for improving data availability, as EPCs already capture a wide range of information about buildings and their energy performance. The table below shows the range of information that is gathered and stored in national EPC databases. Currently, the databases store information about the building, some energy performance data, and the current EPC rating. Several countries also include information on the potential EPC ratings, which, for example, could be reached if the outlined recommendations in the EPC were followed. While just a couple of countries give a basic indication of the building's indoor environmental quality level, this can be seen as the first indication of Member States wanting to expand the scope of their EPC and the database (which this project also seeks to do).

	General information about the building	Energy performance data	Current EPC rating	Potential EPC rating	Indoor environmental quality indication
Austria	X	X	X		
Belgium Flanders	X	X	X	X	
Denmark	X	X	X	X	
Estonia	X	X	X		
Greece	X	X	X	X	X
Italy	X	X	X	X	
Poland	X	X	X		
Portugal	X	X	X	X	X
Romania	X	X	X	X	
Scotland	X	X	X		
Germany	X				
Ireland	X	X	X	X	
France	X	X	X		
England and Wales	X	X	X		
Spain	X	X	X		
Sweden	X	X	X		

Table 2 – Scope of building data in EPC databases across Europe

Organisation of data

The building logbook is intended to capture information of much wider scope than EPCs, including, *inter alia*, administrative data, building use, physical building characteristics, information regarding building materials and components used, building systems and financial data. The diversity of data raises a number of important questions about the structure of the logbook data template:

- How to organise data – e.g. across categories (administrative, construction information, energy, operation, maintenance etc.), types (numerical, descriptive, paper-format, machine-readable etc.) or velocity (static/dynamic)?
- How to prioritise among data points? What data points are more important or urgent (e.g. core and complementary) to better support the additional EPC features? What are the data points that should be included as a first step in developing a logbook?

- Who are the stakeholders that can contribute to or benefit from the logbook, who can provide/retrieve data and when?

The data captured by the logbook must be organised in a way that allows the registration of all types and categories of data related to the building and its environment. The data template must also be flexible enough to be easily adjusted to a specific country or regional needs.

In this sense, the X-tendo data template follows a similar structure to the IBroad logbook.[8] The data points are organised in eight categories as follows (vertical plane):

- Administrative information
- General information
- Building description and characteristics
- Building operation and use
- Building performance
- Building material inventory
- Smart readiness
- Finance

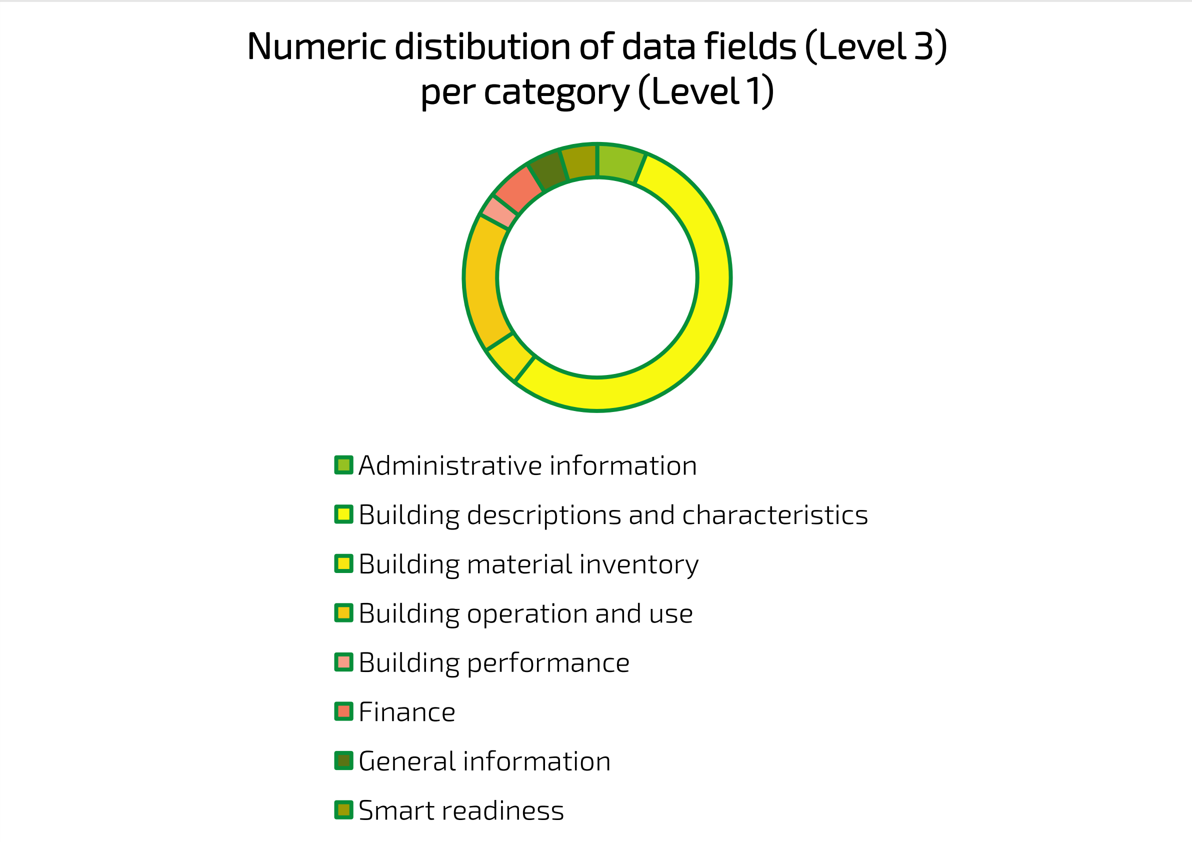

Figure 7 – Data categories in the X-tendo logbook

[8] IBroad (2018) The logbook data quest

The data is also organised according to levels of granularity to accommodate the European and national/regional levels of classification (horizontal plane). The higher levels 1-2 (i.e. data categories and data fields) are harmonised at European level, while the more granular levels 3 and above correspond to national/local categories of data. The more granular levels of categorisation are necessary to identify specific and disaggregated (raw) data and maintain the wealth of information.

Figure 8 – X-tendo logbook data structure

The majority of these data points are considered **core** information for the logbook as they represent the minimum set of data necessary for the basic logbook functionalities, including the data needs of the other X-tendo features. The logbook can also accommodate **complementary** information enabling a more robust database, enlarging the scope and functionalities of the logbook and potentially involving more stakeholders.

The logbook data template

The table below represents an initial proposal for a core list of data points which are essential to the development of a logbook. It also identifies potential sources of information to populate the logbook. The table is based on a review of the EPC data points that are reliable and useful enough to be included in or linked to the logbook. The development of this table has been crosschecked with similar initiatives such as iBroad logbook and the Global Alliance for Buildings and Construction.

- X – data field exists already
- P – it is possible to get this data

- NA – not applicable
- NP – data is not public
- D – currently under development

Category (Level 1)	Data fields (Level 2)	Estonia (Tartu)	Greece	Portugal
Administrative information	Unique building identifier	X	X	X
	Address	X	X	X
	Building owner	NP	X	
	Logbook prepared by		NA	
	When was the logbook last edited	P	P	
	Building use		X	X
	Ownership type	P	P	X
	Tenancy agreement	NA	NP	NA
	Utility contract	P	NP	NA
	Service contract	P	NA	NA
	Insurance document	NA	NP	NA
	Maintenance log	P	P	P
	Licences		P	NA
General information	District heating access	X	P	NA
	Solar potential	P	NA	NA
	Soil/terrain	NA	NA	NA
	Climate data (zone)	P	X	X
	Altitude		NA	X
	Accessibility for people with disabilities	P	NA	NA
	Outdoor air quality		NA	
	Safety manual	P, D	NA	NA
	Primary energy conversion factor for energy carrier		NA	X
Building descriptions and characteristics	Design and plans of the building	P, D	P	X
	Building information modelling	P, D	NA	P, D
	Floor area	X	X	X
	Heated floor volume		X	
	Heated floor area	X	X	
	Number of floors	X	X	X
	Orientation		NA	X
	Building envelope construction	X	X	X
	Whole building solar absorption (g.A)	P	NA	P
	g-value		P	X
	Sun protection (shading)		P	X
	Surface area		P	X
	U-value (frame)		P	P, D
	U-value (glazing)		P	X
	Multiple glazed percentage		NA	P
	Windows orientation		P	X
	Yie-value periodic thermal transmittance		NA	
	Frame factor		P	X
	Number of sheltered sides (e.g. two)		P	X
	Factor for ambient on back side		NA	
	Insulation thermal conductivity		P	P, D
	Insulation thickness		P	P, D

Category (Level 1)	Data fields (Level 2)	Estonian (Tartu)	Greece	Portugal
Building descriptions and characteristics	Insulation type		P	P, D
	Layer material (for n layers)		P	P, D
	Layer thermal conductivity (for n layers)		P	P, D
	Layer thickness (for n layers)		P	P, D
	Overall flat thermal bridge U-value		P	X
	Surface area		P	X
	U-value		P	X
	Surface area		P	X
	U-value		P	X
	Surface area		P	X
	U-value		P	X
	Insulation thickness		P	P, D
	Appliances		X	
	DHW primary energy demand (not renewable)		P	P
	DHW primary energy demand (renewable)		P	P
	Construction year		NA	
	Expected lifetime		NA	
	DHW service present		NA	
	DHW manual		NA	P
	DHW certificate/warranty		P	
	DHW system efficiency		P	X
	Fuel type		P	X
	Storage		NA	
	Primary pipework insulation present		NA	
	Fuel type		P	X
	Heat emission control		NA	
	Heat generation		NA	
	Heat generator control (for combustion and district heating)		NA	
	Heat supply temperature		NA	
	Heated area		X	
	Heated gross-volume		NA	
	Heating days		NA	P
	Heating energy source		P	X
	Heating system efficiency		P	X
	Indoor temperature		NA	
	Main heat delivery system		P	P
	Net energy for space heating		NA	
	Nominal electrical power		P	P
	Nominal thermal power		P	X
	Norm outdoor temperature		NA	D
	Number of units installed		P	X
	Operational thermal efficiency of the space heating system		P	X
	Central heating pump age		P	
	Date of installation		P	P
	Date of last inspection		P	

Category (Level 1)	Data fields (Level 2)	Estonian (Tartu)	Greece	Portugal
Building descriptions and characteristics	Certificate/warranty		NA	
	Manual		P	P
	Cooled area		P	
	Cooled gross-volume		NA	
	Cooling emission control		NA	
	Cooling energy source		P	X
	Cooling system efficiency		P	X
	Energy delivered for space cooling by energy carrier		P	X
	Fuel type		P	X
	Storage		NA	
	Generator control for cooling		NA	
	Percentage from the total heat generation		NA	
	Nominal electrical power		P	P
	Nominal thermal power		P	X
	Number of units installed		P	X
	Date of installation		P	P
	Date of last inspection		P	
	Certificate/warranty		NA	
	Manual		P	P
	Control system		P	X
	Lamp type		P	X
	Lighting system efficiency		NA	
	Lighting is considered		P	
	Total power		P	X
	Interaction between TBS and/or BACS		NA	X
	Energy delivered for other purposes (excl. non-EPC uses) by energy carrier		NA	P
	Mech vent system efficiency		P	
	Mech vent system present		P	X
	Air flow control at room level		NA	
	Filter type/class		NA	
	Heat recovery efficiency		NA	
	Operational thermal efficiency of the heat recovery unit		NA	
	Temperature of ventilation return air		NA	
	Temperature of ventilation supply air		NA	
	Ventilation air flow rate		NA	X
	Ventilation rate		NA	
	Ventilation type		P	X
	Date of installation		P	
	Date of last inspection		P	
	Certificate/warranty		NA	
	Manual		P	
	Equivalent solar area/net heated area ratio		NA	
	Installed capacity		P	P
	Installed capacity		NA	
	Exported energy		P	X

Category (Level 1)	Data fields (Level 2)	Estonian (Tartu)	Greece	Portugal
Building descriptions and characteristics	Date of installation		P	P
	Date of latest inspection		P	
	Annual calculated production		P	X
	Annual measured production		P	
	Manual		P	P
	Certificate/warranty		NA	
Building operation and use	Number of occupants	P	P	P
	Main function	X	P	X
	Estimated heating consumption		P	X
	Estimated electricity consumption		P	P
	Estimated hot water consumption		P	X
	Estimated carbon emission use		P	X
	Cooling primary energy demand (not renewable)		NA	P, D
	Cooling primary energy demand (renewable)		NA	P, D
	Global CO2 emission (heating, cooling, domestic hot water etc.)		P	X
	Global primary energy demand (not renewable)		NA	P, D
	Global primary energy demand (renewable)		NA	P, D
	Heating primary energy demand (not renewable)		NA	P, D
	Heating primary energy demand (renewable)		NA	P, D
	Energy needs for cooling		P	X
	Energy needs for heating		P	X
	Lighting primary energy demand (not renewable)		NA	P, D
	Lighting primary energy demand (renewable)		NA	P, D
	Mechanical ventilation primary energy demand (not renewable)		NA	P, D
	Mechanical ventilation primary energy demand (renewable)		NA	P, D
	Transport primary energy demand (not renewable)		NA	
	Transport primary energy demand (renewable)		NA	
	Transport system efficiency		NA	
	Transport systems are considered/exist		NA	
	Useful electricity demand		NA	P
	Useful energy demand for heating		P	P
	Useful energy demand for domestic hot water		P	P
	Useful energy demand for cooling		P	P
	Useful energy demand for lighting		P	P
	Useful energy demand for mechanical ventilation		NA	P
	Primary energy conversion factor for energy carrier		NA	P
	Dynamic heating consumption		NA	NA
	Dynamic electricity consumption		NA	NA
	Renewable energy consumption		NA	NA
	Particular matter (2.5, 10)		NA	NA
	Radon		NA	NA
	Asbestos		NA	NA
	Behavioural insights		NA	NA

Category (Level 1)	Data fields (Level 2)	Estonian (Tartu)	Greece	Portugal
Building performance	EPC rating	X	P	X
	Air tightness		NA	P
	Building envelope (u-value of different components)	X	P	X
	Renovation recommendations		NA	X
	Tailored renovation recommendations	X	P	X
	Climate resilience potential		NA	
Building material inventory	Material 1 – Type		NA	NA
	Material 1 – Location		NA	NA
	Material 1 – Volume		NA	NA
	Material 1 – Weight		NA	NA
	Material 1 – Embodied carbon		NA	NA
	Material 1 – Life span		NA	NA
	Material 1 – Fire resistance class		NA	NA
	Material 1 – Waste category		NA	NA
	Material 1 – Certificate 1		NA	NA
	Material 1 – Chemical declaration		NA	NA
	Material 1 – Global Trade Item Number		NA	NA
Smart readiness	SRI result	P	NA	
	EV charging grid balancing		NA	NA
	EV charging information and connectivity		NA	P
	Storage of locally generated energy		NA	P
	Smart grid integration		NA	NA
	Cooling system storage and shifting of thermal energy		NA	NA
	Control of domestic hot water storage charging		NA	NA
	Heating system storage and shifting of thermal energy		NA	NA
	Smart district	P,D	NA	NA
	Demand response potential		NA	NA
Finance	Annual rent/property tax	NA	NP	NA
	Annual maintenance charges	NA	NP	NA
	Property value	NA	P	NA
	Valuation date	NA	NA	NA
	Valuation method	NA	NA	NA
	Valuation conducted by	NA	NA	NA
	Valuation document 1	NA	NA	NA
	Property yield	NA	NA	NA
	Building costs	NA	NP	NA
	Annual electricity cost	NA	NP	P
	Annual water cost	NA	NP	NA
	Annual gas cost	NA	NP	P

Table 3 – EPC data points and potential information sources for use in logbook development in X-tendo target countries

The table shows that many data fields are currently not available in the X-tendo project's three target countries. Some of these gaps are due to the fact that the data is not gathered, is not accessible or is with a private actor. On a more positive note, the table suggests that there is already a wealth of administrative and general information on building characteristics, operations, use and performance which could create real value when uploaded to the logbook. The data mapping above also suggests that it is not yet possible to obtain enough information on building materials or on a building's smart readiness level. These categories of data could come at the second stage of logbook implementation. Financial data, meanwhile, is perceived to be rather sensitive and the most difficult to gather.

3.2 Logbook functionalities, modules and benefits

The logbook gathers all building-related data and provides this through a smart and user-friendly interface, which can potentially be made available and accessible to different users. The more information that can be gathered and synced, the more benefits can be attained. The primary owner of the logbook should be the building owner and public authorities, but it could also be useful for the construction and real estate value chain and financial institutions. Permission should be granted under specific conditions, depending on who will be considered the 'owner' of the logbook or upon the consent of the owner.

This section outlines the possible main features, functionalities and benefits of the logbook. The **features** of the logbook are the intrinsic elements that make it work in a simple yet effective way for the users, while the **functionalities** are services built around the logbook. The **benefits**, in turn, are the added value gained from the new and improved functionalities. Some of the X-tendo EPC features could be linked to or integrated in the logbook as additional functionalities.

The most relevant **features** identified are: a) digital interface, b) interoperability, c) data syncing/matching, d) storage of data and information, and e) user-friendly navigation and visualisation.

- **Functionalities** refer to the services built around the logbook and the features mentioned above. Functionalities have corresponding benefits or sets of benefits for the user. The number and type of functionalities determine the scope, quality and type of information that the logbook covers. Examples could include building diagnosis and pre-emptive maintenance, tailored renovation recommendations and roadmaps, benchmarks, alerts and reminders etc. By linking the logbook with other existing databases and tools such as environmental certification systems and BIM models the logbook can act as a one-stop-shop portal and bring together building sector stakeholders, overcome value chain fragmentation and enable new/streamlined services.
- **Benefits** represent the additional value delivered to logbook users. Rather than being limited to specific types of features and areas, such as energy or administrative information, the logbook has the potential to bring a wide range of benefits to different actors. Clearly articulating these benefits is crucial to get the buy-in of all market actors involved. Focusing on the benefits – and the logbook functionalities

that help to realise the benefits – is key to build support, especially among building owners who would otherwise perceive the logbook as an additional administrative burden.

Figure 9 – Overview of benefits anticipated with the widespread introduction of logbooks

3.3 Data governance and data management

Data governance refers to the process, organisation and standards implemented to ensure the effective and efficient storage of and access to data. The development and proper implementation of logbooks require settling a series of questions around data ownership, access, storage, privacy and security. Below is an overview of the key challenges related to data governance, including legal aspects and technical matters such as data protection, privacy, data access and storage.

Legal aspects

It is essential that the logbook fully addresses data privacy and security. Finding the best arrangement for data privacy and security can however be difficult: EU data protection provisions are constantly being modernised and updated, and data-gathering technology is developing fast – this brings new data-gathering opportunities but also challenges. There must be active collaboration between the built environment value chain, operators, IT companies, public authorities and the public to ensure the security of the data in the logbook

i. GDPR

The main purpose of the logbook is to contain building-related data; but some of this could be personal data, which raises issues over confidentiality, integrity and data availability. Regardless of the format of the logbook and how it is implemented, it needs to be compliant with the General Data Protection Regulation (GDPR). Given that data processing will be one of the main logbook functionalities, it will need to ensure it embodies data privacy principles and to appoint a controller or Data Protection Officer (DPO).

Figure 10 – Checklist for GDPR compliance

The security aspects that are relevant when setting up a logbook are as follows:

- Confidentiality: ensure that the information can be seen only by authorised people. Confidentiality requirements prevent unauthorised access to restricted data in a logbook. This can be achieved by implementing access controls, such as authentication and encryption.
- Integrity: ensure that the information cannot be changed or removed without authorisation. The logbook needs to validate that the data, while in transit or at rest, has not been modified from its original state. Digital signatures, blockchain and encryption may help maintain data integrity.
- Availability: ensure that only authorised people can access information when needed. Data and access to data must be easily available and resistant to single points of failure. Data backups, redundant storage and multiple network connections help ensure availability.

ii. Intellectual property rights

The logbook is all about information management and communication. The sharing of information among a large and diverse pool of stakeholders unavoidably raises questions around intellectual property rights regarding the work of e.g. the energy expert or other building professionals and service providers. There should be an agreement to allow the building owner to freely use and distribute the logbook data without formal approval procedures but with adjusted and 'contained' liability. Database and licensing rights could also be looked at in a similar fashion to maintain the full use of logbooks.

Technical matters

Similar to medical records or car maintenance logbook information, a building logbook would, in principle, stay with the building, meaning all the data concerning a building's design, construction and use life cycle phases would be easily available at all times. The logbook gathers different types of data from multiple sources. These can include utility companies, the construction industry, (smart) equipment in the building, third-party service providers, public authorities etc. Connecting all these data sources and users requires common 'languages' – interfaces and protocols – to enable interoperability, data consistency and information exchange, and therefore to realise the full potential of the logbook.

The data architecture underpinning the logbook will be described in the forthcoming X-tendo D4.4 and D4.6 reports. Three broad approaches are suggested below:

- The building logbook is a **database** which physically stores all the information related to the building.
- The building logbook is a **digital gateway** to data and information linked via a unique building ID (i.e. via data tagging). The main advantage of this approach is the automatic (dynamic) update of the data in the logbook whenever the information at the source is updated. However, this approach means that the logbook applications will have availability problems (will be partially 'down') every time the data/application at the source is unavailable.
- **Hybrid** versions, which are a combination of the first two approaches.

Regardless of the chosen approach, linking existing building information-related databases – such as public registries (e.g. information on administrative aspects, soil, cultural heritage), national EPC databases, energy or water consumption etc. – is vital for the success of logbook development and its implementation. Especially trustworthy data sources (e.g. originating from public authorities) increase the chances for a successful implementation.

The X-tendo logbook toolkit includes an overview of existing databases and the trustworthiness of their data, as well as guidelines to enable interoperability, data consistency and information exchange. The latter can be implemented, for example, via application programming interfaces (API): these are key tools in modern digital architecture, enabling third-party services and new business models to be linked to the logbook.

Finally, both the human interface and third-party applications may require user levels and access rights to be delimited. Both Portugal and Greece consider distinguishing different levels of data access for various stakeholder groups. For example, in Portugal, general and administrative information is owned by public authorities, energy suppliers, building owners, and actors from financial services and the construction industry. Building construction information and energy performance data is usually owned by qualified experts, energy auditors, and national public authorities. Operation and use data belong to owners, energy suppliers and national public authorities. Ownership of smart information is still to be defined.

3.4 Conclusion and next steps

The follow-up X-tendo reports will provide additional description and explanation of each data entry point of the proposed logbook data template. As described above, the data template will include both core-EU level data fields, as well as country-specific requirements. These will also establish the logbook data model, including guidelines for the organisation of logbook data and protocols for data capturing. Given that the logbook is a cross-cutting feature that could help the implementation of all the other X-tendo EPC features, further work will need to be done to set up the minimum required logbook modules concerning these X-tendo features.

The research on data availability gives a mixed picture. Many data points are currently not available due to reasons including, lack of data collection, limited access or disputed ownership. In the same time, there is a wealth of information, which could already be linked to the logbook, for example, administrative and general information, building description and characteristics, building's operation and use, as well as performance data. These data points can be a promising start for effective logbooks and the development of logbook modules that create real end-user value from the data. Financial and building material data, which is currently more difficult to attain, can come at the second stage of a logbook implementation and possibly beyond the duration of X-tendo.

Going forward, the X-tendo logbook toolkit will include an overview of existing databases and the trustworthiness of their data, as well as guidelines to enable interoperability, data consistency and information exchange. Documentation of the technical solutions and logbook concepts, e.g. stakeholder related benefits and relevant data governance issues will also be included. Visual guidelines for the design and implementation of logbooks, such as roadmaps, process flows, business models and good practice examples will further help the X-tendo implementing partners with the design and execution of their own logbooks.

4 TAILORED RECOMMENDATIONS

The recommendations provided by an EPC have different objectives: on one hand to provide the building owner/seller with recommendations on energy efficiency improvement measures, and on the other to provide detailed information about the proper implementation of these refurbishment measures. In the first case general information is sufficient, while in the second case the information needs to be more detailed and tailored to the specific context. Data of different quantities and quality is required to meet both these objectives, meaning a range of costs are involved in gathering the necessary data, tools and algorithms to calculate the recommendations and, finally, link with external databases, such as improvement measures and cost databases.

The ambition of the X-tendo project is to improve on the current state of generic recommendations, which often only provide limited value to homeowners. It will develop and demonstrate a method to extend recommendations provided in the actual EPC schemes with automatically generated targeted guidance. However, we do not yet believe that these advanced recommendations can fully replace the advice of a professional. A more detailed discussion on the term 'tailored recommendation' is provided later in this chapter.

4.1 Current state-of-the-art

EU legal provisions related to EPC recommendations

EPC recommendations play a key role in increasing renovation rates, and therefore in reducing the EU building stock's carbon emissions. Their main objective is to provide building owners with information regarding the implementation of energy efficiency measures. In practice, however, this is a complex challenge which touches upon a number of different areas: energy expert skills, available software and tools, gathering the necessary building-related information, linking to external databases (e.g. for material costs), consideration of real occupant behaviour data (i.e. real energy consumption), the accuracy level of the recommendations provided etc. Below we briefly describe the context of EPC recommendations, in terms of current EU policy requirements and how the current national EPC schemes in the X-tendo countries of Austria, Denmark, Poland and Scotland deal with this topic (see also the chapter 'EPC recommendations in X-tendo countries').

The recast of the Energy Performance of Buildings Directive EPBD – Directive (EU) 2018/844 (European Parliament, 2018) specifies, among other issues, requirements concerning recommendations provided in EPCs. Paragraph 11 sets out the following:

- Recommendations should indicate cost-optimal or cost-effective building improvements.
- Recommendations should cover measures which should be carried out in a major renovation of the building envelope or technical building system(s).
- Recommendations should cover individual measures for building elements independent of the major renovation.
- Recommendations should be technically feasible for the specific building.

- Recommendations may provide an estimation for the range of payback periods or cost-benefits over the building's economic lifecycle.
- Recommendations should provide indication about where the owner or tenant can receive more detailed information.
- The evaluation of cost-effectiveness should be based on a set of standard conditions, such as energy savings, underlying energy prices and preliminary cost forecasts.

Commonly used approaches for providing EPC recommendations are showed in Figure 11 below. In general, they can be divided into standardised lists (automatically filtered by software or selected by the expert), recommendations based on experts' experience, or different approaches (ADENE, 2016). The choice of approach is country-specific and is defined in the national EPC scheme. The quality of advice is usually directly related to the price to be paid for issuing an EPC. For example, to keep administrative costs low, the UK adopted the strategy of providing standardised EPC recommendations, which are more easily and cost-effectively implemented than complex/high cost measures. However, it is important to highlight that EPC recommendations are not a substitute for the detailed and specific retrofitting recommendations required in the EPBD. Irrespective of these indicative EPC recommendations, the EPC should also indicate where detailed recommendations for carrying out a retrofitting project can be gathered.

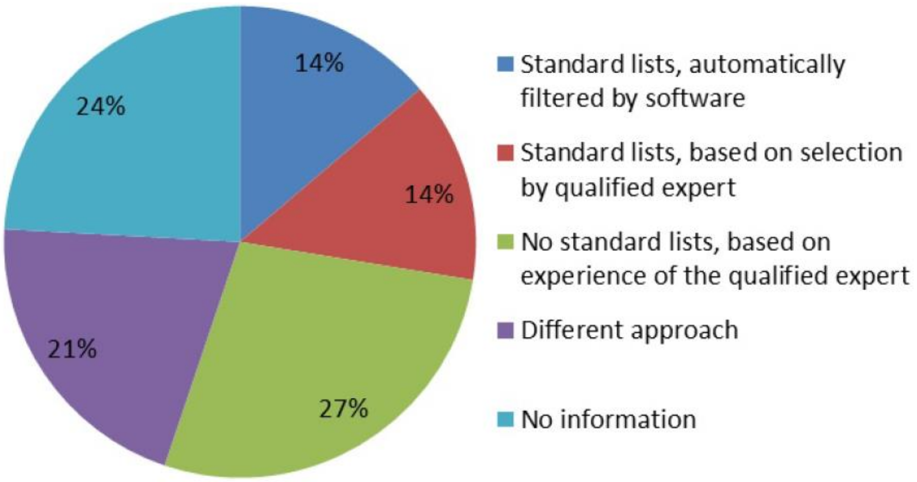

Figure 11 – Options for proving EPC recommendations. Source: Concerted Action EPBD, 2016

The report published by Concerted Action on implementing the Energy Performance of Buildings Directive (ADENE, 2016) suggests a clear typology of EPC recommendations: 1) EPC recommendations providing guidelines for potential energy savings, 2) EPC tailor-made recommendations, and 3) detailed and specific data for renovation planning of complex buildings.

The first type, EPC recommendations providing guidelines for potential energy savings, can be directly linked with the EPBD requirements listed above, with the aim of providing recommendations for a major renovation of the building envelope or technical building system. This type of recommendation is standardised to meet the EPBD requirements, and requires less detailed and building-specific information.

There is no specific definition in the EPBD or in (ADENE, 2016) for the second type of tailor-made recommendations. These require a more detailed understanding of the building, the occupants and its overall condition compared to the standardised recommendations. Tailored recommendations relate to specific buildings, although they can still be generated by software or developed by energy auditors based on their professional judgement. The provision of tailored recommendations requires non-standardised building inputs, site visits to collect specific building data, and the setting of minimum energy performance targets (Gonzalez-Caceres and Rammer Nielsen, 2020).

The third type of tailored recommendations presupposes granular building specific data and detailed planning of the activities. These recommendations rely on professional expertise from energy auditors and building planners, and cannot therefore be provided automatically.

Another possible interpretation of the term 'tailored recommendations' would refer to recommendations related to real occupant behaviour and real energy consumption data. These can be important elements for customising recommendations, especially in cases where the EPC is issued with renovation in mind. In this context, the building user becomes a relevant factor, as recommendations are made for a specific occupancy profile. If the building user changes, the recommendations should be reviewed and adapted to reflect the change. The X-tendo project explores the latter topic in more detail by developing a methodology for calculating real energy consumption. A description of the current state-of the-art of assessing real energy consumption in EPCs is presented in the report (Zuhaib *et al.*, 2020). Thus, the topic of user behaviour and its impact on recommendations is not the focus of this X-tendo feature. Nevertheless, we intend to describe which aspects should be considered if user behaviour and real, measured energy consumption need to be integrated into EPC recommendations.

In the methodology developed for the current 'tailored recommendations' X-tendo feature, the focus is on software generated targeted recommendations than is usual in current EPC practice, based on detailed building-related data. These recommendations could be useful, for example, to inform selling/buying transactions where user behaviour and actual real energy consumption play a secondary role, due to the likely change of the building user.

The methodology also proposes an approach to developing recommendations tailored to national renovation strategies. This approach could enhance the quality of recommendations by ensuring that they are not only in line with energy efficiency standards, but also with long-term low-carbon emissions targets and national policies.

EPC recommendations in X-tendo countries

To better understand how EPC recommendations are currently provided in the X-tendo countries of Denmark, Poland and Scotland, a survey was carried out among the experts involved with this feature. Table below summarises the key points, especially in regard to the development and type of recommendations.

	Denmark	Poland	Scotland
Provision of EPC recommendations	Physical survey by the energy consultant based on guidelines from the handbook for energy consultants and on-site audit	Choosing from the list of 'typical recommendations'	Based on the building survey and initial interview with the building occupant and application of EST software
Type of recommendations for renovation measures	Building envelope, building system (heating, cooling, lighting, ventilation etc.)	Building envelope, building system (heating, cooling, lighting, ventilation etc.)	Affordable heating solutions based on household's income
Economic assessment methods	Information is given on the investment's simple payback period. E.g. investment/lifetime = yearly savings	There is no obligation to provide any economic indicators in the EPC	Indicative cost of installation based on a typical property of that type
Criteria to prioritise the recommendations	Based on user needs, economy and rentability	EPC issuer or the software prioritises according to economic profitability. At least two measures should be chosen	Using software developed by EST to provide individual tailored recommendations based on needs
Behavioural adaptations	There are no behavioural adaptation recommendations in Danish EPCs	Energy auditors can individually decide if behavioural recommendations should be provided	There are no behavioural adaptation recommendations in Scottish EPCs
Link to the LTRS (Long-term renovation strategy)	Not directly linked, however EPCs in general do have a key role in the definition of the LTRS	Currently not considered	Currently not considered

Table 4 – Summary of EPC recommendation schemes in three countries

EPCs in Poland and Denmark provide mainly technical recommendations referring to the energy efficiency of the building envelope and technical system (heating, cooling, lighting, ventilation etc.) and an economic assessment. There is no direct link to external cost databases or energy prices in either country, and energy auditors are responsible for gathering the cost-related data. In Denmark, energy auditors are supported with guidelines showing typical lifetimes of different measures. In Poland, while there is no direct obligation to provide any economic indicators in the EPC, the most commonly used economic assessment method is the 'thermo-modernisation audit', which is based on the payback time. In Scotland, the focus is on providing recommendations about the affordability of heating systems according to a household's income. Each measure is given an indicative installation cost for a typical property of that type. This cost data comes from the Energy Saving Trust's (EST's) Housing Model. The typical annual fuel savings value for each measure is also provided. The savings presented can be actual or theoretical, depending on the specific information about the building and behaviours of the occupants. Examples of EPC recommendations in Poland and Scotland are presented in Annexes II and III.

Other policy measures on building renovation

Long-term renovation strategies

Based on the recast EPBD 2018/844/EU, in 2019 the EU Commission released guidelines on how Member States should develop long-term renovation strategies to achieve a highly energy efficient and decarbonised building stock by 2050. In the long-term renovation strategy, Member States are encouraged to include "*an overview of the national building stock, policies and actions to stimulate cost-effective deep renovation of buildings, policies and actions to target the worst performing buildings, split-incentive dilemmas, market failures, energy poverty and public buildings, an overview of national initiatives to promote smart technologies and skills and education in the construction and energy efficiency sectors*". Also, it suggested a roadmap should be developed with "*measures and measurable progress indicators, indicative milestones for 2030, 2040 and 2050 and an estimate of the expected energy savings and wider benefits and the contribution of the renovation of buildings to the Union's energy efficiency target*" (EU Commission, 2019). Although long-term renovation strategies are highly relevant for X-tendo, as of July 2020 only the Danish roadmap was publicly available, while those for Poland and Scotland were still awaiting publication.

The Danish long-term renovation strategy requires regulation of different areas within the building stock. Some of the regulations include:

- Energy renovations should be based on a cost-effective approach in connection with other renovations. This means that building owners should perform profitable energy renovations when renovating their building for necessary maintenance.
- Energy improvements will be made in government-owned buildings, where a commitment has been made to reduce energy consumption by 14%.

As well as the regulations, many economic incentives are also included in the long-term renovation strategy, such as financial support for energy renovations, reduced electricity fees, grants to move away from oil-based heating, etc.

National residential buildings regulations

A policy review in Scotland showed that regulations are set for different housing groups: 1) private rented sector (PRS), 2) social housing sector, 3) owner-occupied, and 4) fuel-poor households. All of these groups have targets to gradually improve their EPC ratings (i.e. A, B, C, D). Beyond that, the EPC's Environmental Impact Rating has been included as a target for Energy Efficiency Standard for Social Housing (EESSH) equal 2, and the focus is moving from carbon fuel sources to heat pumps (especially air source heat pumps (ASHPs)) to comply with this new, more ambitious standard (Scottish Government, 2018).

In Poland the regulations are defined by two sets of requirements: maximum value of the non-renewable primary energy indicator (EP) and maximum value of the thermal transmittance share (U-value) and insulation thickness of technical installation piping. The EP indicator is defined for six types of buildings: residential single and multi-family, collective residence, public health care and others and a group of production, warehouse and utility buildings. The U-values do not depend on the building type. For existing buildings undergoing renovation, only thermal transmittance and insulation thickness of piping requirements need to be fulfilled. The regulations for new buildings are stricter in respect to environmental impact by EP requirements.

In Denmark, the national regulations for buildings rely heavily on the long-term renovation strategy, explained above.

4.2 Existing initiatives and tools to provide enhanced building retrofitting recommendations

This section presents initiatives that give additional renovation recommendations which complement EPCs. These tools provide detailed recommendations either by looking at the technical performance of the building (building envelope and technical systems), or by taking into account real use information, such as real energy consumption and user behaviour profile. The term "real" in this context refers to measured consumption data. These software tools were developed by public authorities or private companies, and are briefly described below:

- EBECS tool (BE)

Objective: Provide tailor-made recommendations for residential buildings (user-related recommendations)

The Flemish research organisation VITO developed a tool which provides tailor-made recommendations based on the size of the house, family composition and the energy consumption of the residents.[9] Users enter data about the condition of their home and their real energy consumption, as well as other building-related information, and the tool gives them recommendations on how to save energy.

- Better Home (DK)

Objective: Enhanced tailored recommendations (building-related recommendations)

The Danish web platform Better Home, a one-stop-shop solution, provides enhanced tailored recommendations both on technical improvements and personalised recommendations (depending on the building owner's wishes). The Better Home consultant offers two different service packages: service package 1 has recommendations and a renovation plan, and service package 2 gathers offers and provides project management services. The Better Home software uses the same calculation procedures as the EPC scheme. The main outputs from the calculation are economic and CO_2 savings, as well as investment cost. Better Home provides even more accurate recommendations than EPCs do, especially from service package 2 – the difference is that input from the building owner is

[9] More information under: https://vito.be/en/tailor-made-recommendations-saving-energy

needed to provide these enhanced tailored recommendations. The main target groups are single family houses built between 1950 and 1990.

- Dynamic Engine tool (UK)

Objective: Enhanced recommendations (building-related recommendations)

The creation of Dynamic Engine (DE) was born out of the need to provide customers with the ability to build an energy efficiency package that meets their personal needs, budget and objectives, i.e. tailored recommendations.

The DE is a back-end calculation engine based on the Standard Assessment Procedure (SAP) – the UK government's official methodology for assessing the energy performance of a home. SAP (and RdSAP) are too rigid in themselves to provide flexible consumer advice, so EST, in collaboration with two partners, created the DE: this has SAP at its heart, but simplifies inputs and adds flexibility to recommendations and advice.

In a nutshell, DE models a property based on given data and output effective energy saving upgrades, estimated before and after renovation, including a SAP score and the potential savings in energy use and CO_2 production that can be made by installing the recommended measures.

Dynamic Engine is the calculation engine behind various digital tools EST offers to different types of clients depending on their scope and needs, such as the Home Energy Check (HEC) tool aimed at domestic customers who want a quick analysis of available upgrades, the Home Renewable Assessment (HRA) tool, which offers tailored recommendations focused on renewable upgrades, and the Portfolio Energy Analysis Tool (PEAT), which is used by public authorities to model and analyse many properties at once (EST, 2020b).

- GEQ von Zehentmayer Software (AT)

Objective: Enhanced recommendations based on cost-effectiveness (building-related recommendations)

In Austria, the state of Salzburg – together with software developers and other partners – has been adding additional features to the GEQ[10] software over many years (GEQ is one of the available tools for issuing an EPC). The software provides links with external tools and databases, such as regional EPC databases, cost-databases, geo information data, technical and environmental building material databases etc. The tool identifies cost-optimal levels of measures (e.g. insulation thickness) or cost-optimal heating systems. Figure 12 shows an optional feature, the cost comparison of different retrofitting variants. On the left, the different selected retrofitting packages are shown. On the right, the graph shows how the costs are split between investment costs, operation and maintenance costs, and energy saved.

[10] More information at https://www.geq.at/

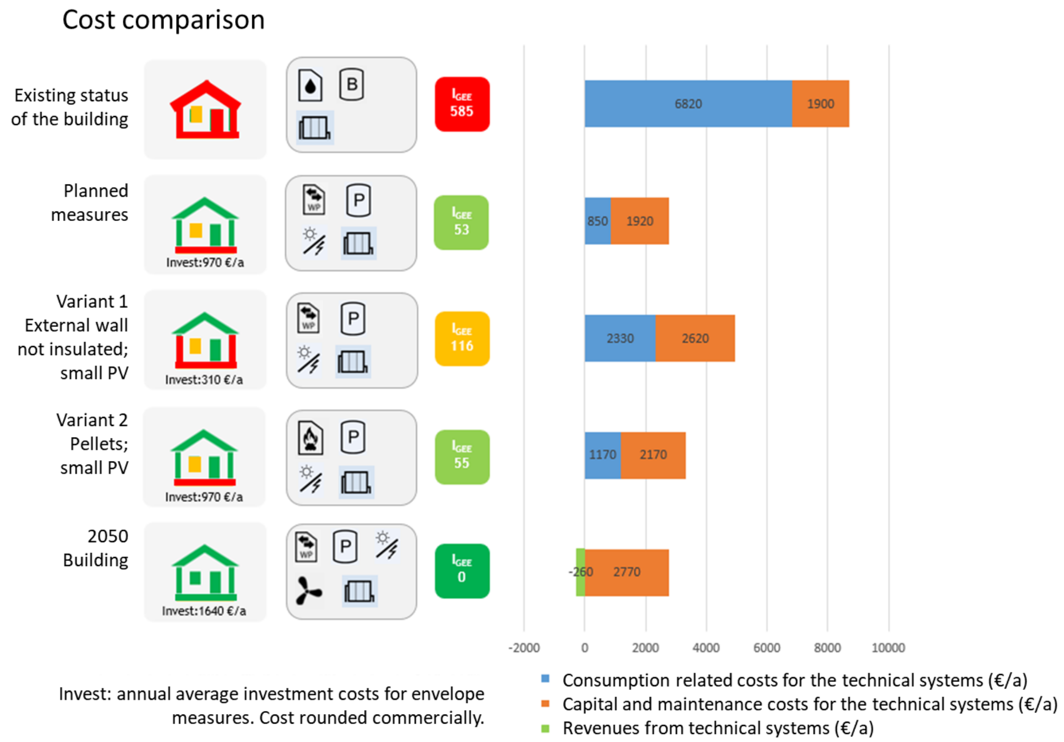

Figure 12: Cost comparison for different retrofitting variants (example from the EPC scheme in Salzburg, Austria)

4.3 Identifying EPC end-users' needs

X-tendo carried out a survey with EPC end-users in five countries to understand their needs and expectations about new EPC features, including tailored recommendations. The survey results and analysis are documented in the X-tendo project report *Understanding end-user needs and expectations of the next-generation energy performance certificates scheme.*[11]

Different types of information related to the recommendations were presented to end-users, covering aspects such as the timing and sequence of the measures, technical specifications, costs, comfort, and the expected impact on the energy and CO_2 indicators. The end-users were then asked which of the following options were of most interest to them:

1. Technical information for each renovation measure
2. Estimated cost for each renovation measure
3. Payback time of renovation
4. Expected impact of renovation on energy performance
5. Expected impact of renovation on energy costs
6. Expected benefit of the renovation on CO_2 emissions
7. Expected benefit of the renovation on indoor comfort
8. Time required to complete each renovation measure

[11] https://x-tendo.eu/wp-content/uploads/2020/10/X-tendo-D2.4-end-users-survey.pdf

9. How to prioritise the renovation measures
10. Recommended order in which to implement the renovation measures
11. Information on maintenance requirements for the renovation
12. Maintenance and operation costs linked to the renovation
13. None of these options

Figure 13 below presents the type of information end-users are most interested in, split by country. The highest ranked options were estimated renovation costs, impacts on the energy costs and maintenance costs. After those, the expected benefit for indoor comfort was of interest to interviewees in all countries.

Cost-related information is partly covered by current EPCs. In many EU countries, however, EPC software is not linked with cost databases.

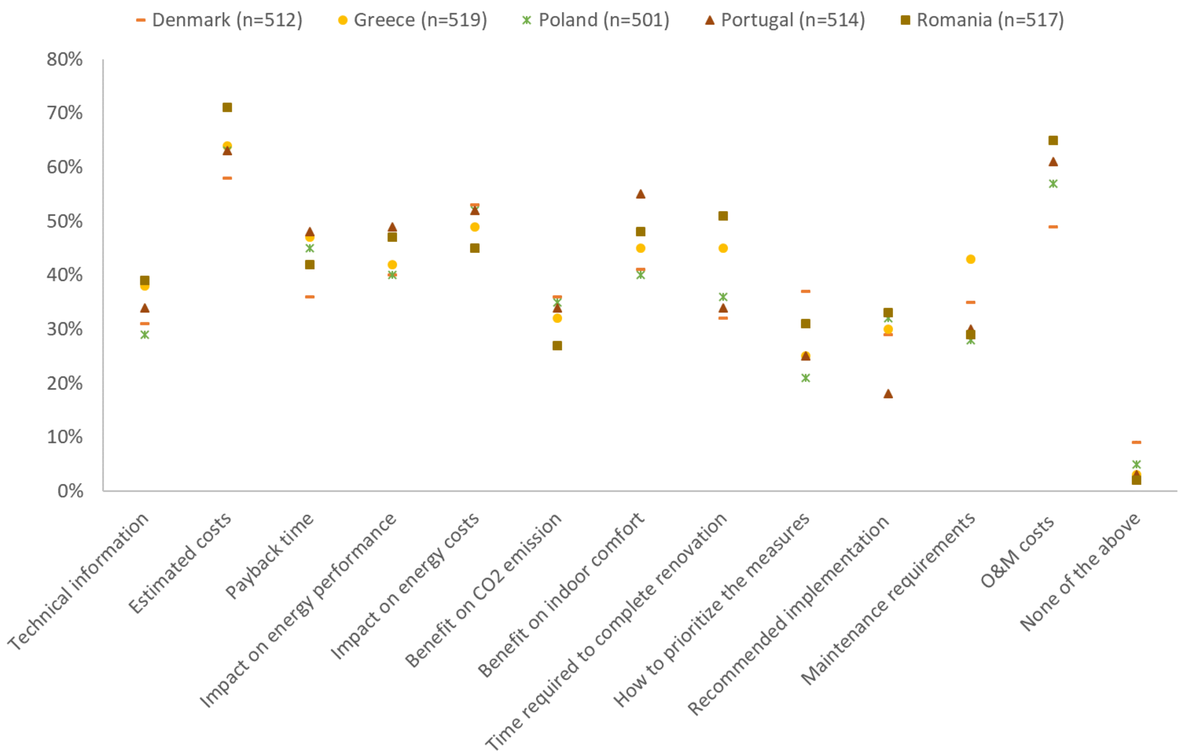

Figure 13 – Interest in types of EPC information by country

4.4 Proposed X-tendo methodology

Building on the review of the current state of EPC recommendations across the three X-tendo countries of Denmark, Poland and Scotland, the next section presents the proposed methodology to be developed in the X-tendo project. The main objective is to support public authorities in improving the quality of EPC recommendations.

The proposed method is built on three pillars:

1) Enhancing actual recommendations, by software-generated additional building-specific recommendations: this will comprise a discussion of how co-benefits

resulting from these recommended measures can be included in the EPC recommendations.

2) Showing how the costs of recommended measures can be included in the EPC provision process, enabling calculation of the cost-effectiveness of the recommended measures.
3) Setting targeted values for recommendations in order to guarantee that they are in line with national long-term and climate strategies for the building stock. In addition to the calculation methods, guidelines will also be provided on how to perform the calculations and assess the values, as a support handbook for energy auditors.

Enhanced measure-by-measure recommendations

To define the measure-by-measure recommendations, we closely analysed the recommendations provided in the EPC schemes of the three countries. This time the country experts were asked to identify a list of possible recommendations which can be provided in their EPC schemes. These recommendations were clustered in the following eight groups, with measures to be defined for each one:

1. Improve the thermal quality of the envelope
2. Improve the energy efficiency of heating technology systems
3. Improve the energy efficiency of cooling technology systems
4. Improve the energy efficiency of ventilation technology systems
5. Improve the energy efficiency of domestic hot water production systems
6. Improve the energy efficiency of lighting technology systems
7. Increase the use of renewable energy sources and reduce CO_2 emissions
8. Indicate the optimum sequence for implementation of the measures.

Interface with cost databases

In addition to the technical measure-by-measure recommendations, in the countries where a cost database will be available, the X-tendo methodology will also provide cost information on each measure. Therefore the project will demonstrate how measure-by-measure costs and other possible economic assessments (e.g. the calculation of the net present value) can be integrated into the EPC schemes.

Setting whole-building target values for EPC recommendations

The provision of tailored recommendations requires target values, which represent a specific energy efficiency standard. Depending on the country, these values are determined in the building codes or by the energy auditors based on their expertise (but not necessarily in line with regulations in force or with long-term renovation targets or decarbonisation targets).

In many countries, building codes for existing buildings are not as restrictive as for new buildings, which means that the energy performance achieved after the renovation might not be sufficient to achieve decarbonisation targets. In the short term, if a high number of buildings perform less efficient renovations, the decarbonisation target (e.g. set for the year 2025) can still be met. However, in the long term – and given the need to move towards a fully decarbonised building stock – shallow-level renovations will not provide enough savings and carbon reductions to meet the target.

This kind of trade-off analysis can be realised by building stock models, which study different pathways to achieve a set goal. For this purpose, the use of building stock model analysis is proposed as a relevant instrument to help set ambitious whole-building renovation target values for several specific building types, taking into account policies and specifications in, for example, long-term renovation strategies or decarbonisation scenarios and targets. This could also enhance EPC recommendations, by ensuring that they are not only in line with energy efficiency standards, but also with long-term low-carbon emissions targets and national policies. Setting target values for 'whole-building' indicators can be done with a building stock model. However, determining target values for particular building elements requires specific building energy performance models, such as thermal simulation models or thermal-dynamic software tools.

Summary of X-tendo activity per country

Table 5 below summarises how the proposed X-tendo methodology will be applied and tested in the implementing countries:

	Denmark	Poland	Scotland
(Technical) enhanced measure-by-measure recommendations		Target building standards will be set according to Polish building regulations	
Technical and economic enhanced measure-by-measure recommendations	Target building standards will be set according to Danish building regulations. Cost data will be defined according to actual market values		Target building standards will be set according to UK building regulations. Cost data will be gathered from internal tools, such as Insight & Analytics

Table 5: Summary of X-tendo activity per implementing country

5 FINANCING SCHEMES

To meet the climate objectives of the European Union and support the transition to a clean energy system, there is a need to further unlock public and private financing and boost energy renovations in buildings. According to article 10 of the amended Energy Performance of Buildings Directive (EPBD) [Directive/2018/844/EU], all Member States should link their financial measures for energy efficiency improvements in buildings to the targeted or achieved energy savings. Likewise, the Energy Efficiency Directive (EED) [Directive 2018/2002/EU] establishes a common framework of measures, including financial incentives, for the promotion of energy efficiency to ensure the achievement of the targets and to pave the way for further improvements.

EPCs and related buildings data are important for accessing preferential financial instruments. EPCs can provide a market benchmark and clear eligibility criteria, as well as support finance decision-making and risk assessments. Furthermore, the provision of information on financial support alongside the EPC recommendations can help to persuade building users to undertake a renovation; and it will boost the energy efficiency renovation market by facilitating interaction between building owners/users and the construction and finance sectors.

5.1 Current state-of-the-art

Available and accessible financial instruments can provide a strong impetus for the wider uptake of building renovations. Financing schemes will however need to be embedded in a broader policy framework, including other supporting mechanisms such as training, quality assurance, awareness-raising and communication campaigns. Stakeholder collaboration and engagement with financial institutions, public authorities and end-users are also needed to better integrate the value chain, streamline the financing process and reduce red tape.

Several barriers persist, including (i) the size of projects, (ii) the lack of standardisation of energy savings measurement and verification methods, (iii) the long pay-back periods for certain measures, and (iv) the high transaction costs and the risks associated with end-users' credit. Overcoming these barriers will require the right policy tools and financial instruments to be put in place.

The type of financial instruments in the EU range from conventional ones such as (i) subsidised loans, to (ii) emerging products, and finally to (iii) innovative instruments such as energy efficiency mortgages, crowdfunding and on-bill financing. The most common instruments under the three main categories are:

1. Traditional well-established:

- Grants and subsidies
- Tax incentives
- (Preferential) Loans

2. Tested and growing in the market:
- Energy efficiency obligations
- Energy Services Companies (ESCO) model and Energy Performance Contracts
- Energy Services Agreement (ESA)

3. New and innovative:
- On-bill finance (OBF)
- Property assessed clean energy (PACE) financing
- Energy efficiency mortgages (EEM)
- Feed-in tariffs
- Property taxation and property purchase taxation
- Crowdfunding

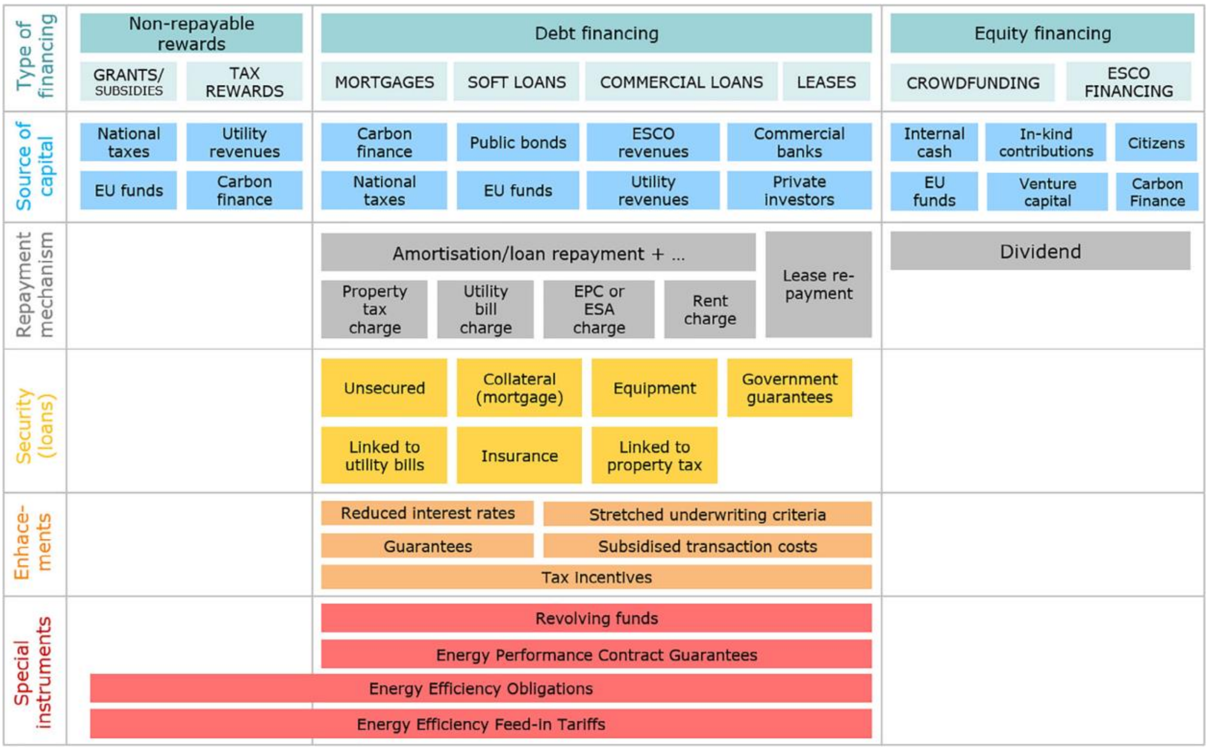

Figure 14 – Summary of key characteristics of financial instruments for energy renovations in buildings[12]

The figure above summarises the various design and implementation elements of the instruments, such as the source of capital, repayment mechanism, types of enhancements etc. Debt financing is typically linked to traditional amortisation arrangements, but given the nature of energy efficiency investments, more innovative repayment channels can be available, including property tax and utility bills.

[12] P. Bertoli, M. Economidou, V. Palermo, B. Boza-Kiss, V. Todeschi, 'How to finance energy renovation of residential buildings: Review of current and emerging financing instruments in the EU', May 2020, doi: 10.1002/wene.384

Annex IV includes a summary of the main financial instruments available for energy renovations of residential buildings, including adoption rates, main advantages, and implementation challenges.

According to the review of EPC schemes across Europe (X-tendo deliverable 2.1), countries including Bulgaria, Portugal[13] and Scotland use the EPC as a loan prerequisite. Scottish homeowners can, for example, access an interest-free loan for energy improvements if they apply for improvements recommended in 'an acceptable energy report', such as an EPC. In addition, there is a requirement for another EPC assessment after the renovation works have been completed in order to demonstrate improvements in the building's energy performance. Another example is the JESSICA programme in Lithuania, which offered low-interest and long-term loans, over 10 and 20 years, on the condition that the building owner provided proof through an EPC that the renovated property had reached at least energy class C.

Financing options in X-tendo countries

The X-tendo project aims to use EPCs to better link financial instruments to residential home improvements.

The tables below provide an overview of public financing schemes in X-tendo target countries (Denmark, Portugal and Romania). This mapping was carried out with the support of the X-tendo national partners DEA, ADENE and AAECR.

Denmark

Name of measure	Grants for New Business Concepts for Heat Pumps (HO-6)
Policy type	Grants/subsidies
Targeted sector	Residential and industrial buildings
Targeted actor	Owner-occupiers
Implementation period	2016-2019
Implementation body	Government, Danish Energy Agency
Supported interventions	Conversion from oil and natural gas to heat pumps in existing buildings
Budget	EUR 3.33 million for residential houses and EUR 1.43 million for industrial buildings
Link with EPC	No
Name of measure	Green BoligJobordning household employment scheme
Policy type	Tax incentives

[13] Annex V – Portuguese case study: EPC integrated into financial instrument

Targeted sector	Residential, commercial, public
Targeted actor	Owner-occupiers
Implementation period	Since 2011
Implementation body	Government
Supported interventions	Insulation of roofs, cavity wall insulation, window replacement etc.
Budget	A maximum deduction from taxable income of EUR 1 607 per year is given for each person in the household
Link with EPC	No

Portugal

Name of measure	Energy Efficiency National Fund
Policy type	Grants/subsidies
Targeted sector	Residential, commercial, public
Targeted actor	General public, landlords, owner-occupiers
Implementation period	Since 2010
Implementation body	Government
Supported interventions	Predominantly technology-oriented projects in transport, residential and services, industry and public sector; action-oriented cross-inducing energy efficiency in the areas of behaviour, taxation and incentives and financing; projects not covered by the National Energy Efficiency Action Plan but which demonstrably contribute to energy efficiency
Budget	Initial allocation of EUR 1.5 million
Link with EPC	Yes
Name of measure	Financial Instrument for Urban Rehabilitation and Revitalisation (IFRUU 2020)
Policy type	Soft loans
Targeted sector(s)	Residential, commercial, public (and urban area)
Targeted actor(s)	Enterprises, public entities, social sector entities, general public, landlords, low-income households
Implementation period	2017-2023
Implementation body	Central public administration, financial institutions
Supported interventions	Renovation of entire buildings and promotion of their energy efficiency. To ensure that the financing is focused on real needs, the buildings must be aged 30 years or more, or present a very bad state of

	conservation, and be located in urban rehabilitation areas locally defined by each municipality
Budget	IFRRU 2020 has a financing capacity of EUR 1 400 million, generating an investment of around EUR 2 000 million.
Link with EPC	Yes[14]
Name of measure	**Casa Eficiente 2020**
Policy type	Soft loans
Targeted sector	Residential (buildings or part-owners, condominiums)
Targeted actor	General public – building owners, tenants, condominium associations, other actors that have the legal right to execute the interventions
Implementation period	2018-2021
Implementation body	Promoted by the Portuguese state and executed by CPCI – Portuguese Confederation for Construction and Real Estate Technical support from the Portuguese Environmental Agency (APA), Portuguese Water Company (EPAL) and Portuguese Energy Agency (ADENE)
Supported interventions	Interventions on energy efficiency, renewable energy sources, hydric efficiency, urban waste management projects. Intervention can be on envelope (walls, roofs, windows) and energy systems (lighting systems, ventilation, solar water heater, sanitary and water systems)
Budget	EUR 200 million: EUR 100 million from the EIB and EUR 100 million from commercial banks
Link with EPC	No
Name of measure	**Fundo Nacional de Reabilitação do Edificado (FNRE)**
Policy type	Fund; tax exemptions
Targeted sector	Residential, commercial, public
Targeted actor	State, municipal and other public entities, private sector
Implementation period	Since 2016
Implementation body	Fundiestamo – Real Estate Investment and Funds Management Society
Supported interventions	Depends on intervention type needed in the building

[14] Annex V – Portuguese case study: EPC integrated into financial instrument

Budget	n/a
Link with EPC	No
Name of measure	1º Direito
Policy type	Soft loans; tax exemptions
Targeted sector	Residential (in precarious condition)
Targeted actor	Families, municipalities, building owners
Implementation period	2019-2024
Implementation body	IHRU – Institute for Housing and Urban Renovation
Supported interventions	Full renovation works, supporting works, safety and construction management services during the works, legal expenses. Renovation works are only eligible for soft loans if the energy efficiency measures bring an increase of two levels in the EPC in comparison with the baseline
Budget	EUR 700 million
Link with EPC	Yes
Name of measure	
Policy type	Soft loans
Targeted sector	Residential
Targeted actor	Individual or collective agents that own a building needing to be renovated
Implementation period	Since 2015
Implementation body	IHRU – Institute for Housing and Urban Renovation
Supported interventions	Designs and other works including project management, technical assistance; energy efficiency solutions including certification and studies; preparatory studies; works in the common building areas including envelope and water, electricity, gas, stairs and elevators; works on the inside of the buildings
Budget	EUR 50 million total (EUR 25 million from BEI)
Link with EPC	No
Name of measure	Programa de Apoio a Edifícios mais Sustentáveis
Policy type	Fund, subsidies/incentives
Targeted sector	Residential
Targeted actor	Single and multifamily building owners; buildings built by the end of 2006
Implementation period	2020-2021

Implementation body	Government, Environmental Fund
Supported interventions	Renovations to improve energy and water efficiency, including measures such as windows, thermal insulation, renewable energy sources, domestic hot water systems
Budget	EUR 4.5 million
Link with EPC	Yes

Romania

Name of measure	National Programme for Improvement of Energy Performance in Apartment Blocks
Policy type	Grants/subsidies
Targeted sector(s)	Residential
Targeted actor(s)	Owners and occupiers
Implementation period	Since 2009
Implementation body	Central government, associations
Supported interventions	n/a
Budget	Total annual investment: EUR 60 million (EUR 50 million public; EUR 10 million private)
Link with EPC	No
Name of measure	Thermal rehabilitation of residential buildings financed by bank loans with government guarantee
Policy type	Loans
Targeted sector(s)	Residential
Targeted actor(s)	General public, housing associations, owners and occupiers
Implementation period	Since 2010
Implementation body	Associations, financial institutions
Supported interventions	Thermal insulation of the building envelope; repair/replacement of the heating and hot water systems; repair, replacement/purchase of the boiler and the related facilities; introduction of alternative systems for providing partial/total energy for hot water, lighting and/or heating
Budget	n/a
Link with EPC	No

Name of measure	Prima Casa (First Home Programme)
Policy type	Loans
Targeted sector	Residential
Targeted actor	Owners
Implementation period	Since 2009
Implementation body	Government, National Guarantee Fund for SME Loans
Supported interventions	Measures to increase energy efficiency of buildings
Budget	For 2020: EUR 415 million
Link with EPC	Yes
Name of measure	**Casa Verde (The Green House Programme)**
Policy type	Green taxes
Targeted sector	Residential, public and religious buildings
Targeted actor	Owners and tenants
Implementation period	Since 2011
Implementation body	Government, Environmental Fund Administration
Supported interventions	Renewable energy sources (solar) and heat pumps
Budget	EUR 25 million
Link with EPC	No

5.2 Identifying EPC end-users' needs

The X-tendo project carried out an end-user survey in five countries[15] – Denmark, Greece, Poland, Portugal and Romania – with the aim of gaining a better understanding of homeowners' perceptions, needs and expectations regarding the new EPC features, including financing options. The survey also provided an opportunity to evaluate the needs of the implementing countries (Denmark, Portugal and Romania) regarding Feature 9.

The majority of the end-users in the surveyed countries would like to perform energy renovations in their homes, and available financing was flagged up as one of the key support measures needed in order to get them to proceed. In all the surveyed countries, a majority of respondents are comfortable with sharing energy consumption data with different stakeholders. Access to consumption and EPC data is needed to assess and choose the right

[15] X-tendo deliverable 2.4 "Understanding end-user needs and expectations of the next-generation EPC-scheme", September 2020

financing measure and to evaluate the risks. It can also be used for performance monitoring purposes.

Alongside information about the available financing schemes, homeowners from Portugal and Greece would like to receive cost estimates of renovation measures (>45% of responses). Portugal is the country with the highest interest (>48%) in receiving information on the payback time for a certain renovation measure. Greece and Romania showed the highest interest (~65%) in the maintenance and operation costs linked to renovations.

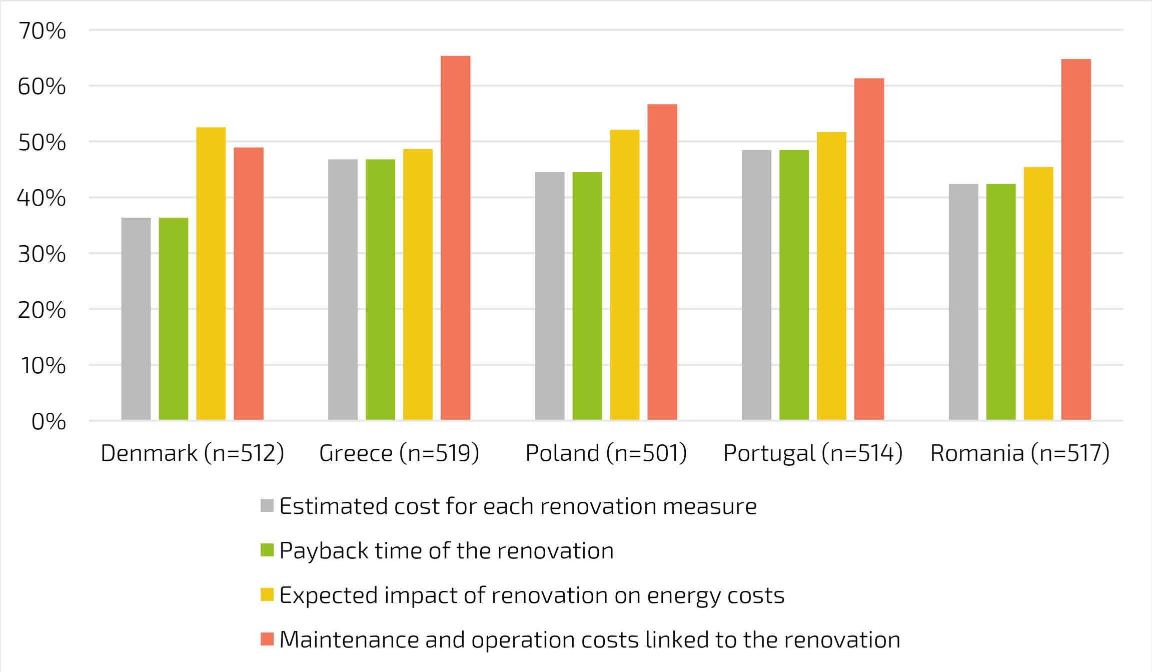

Figure 15 – Most useful information on financing options, by country

Greece and Portugal are the countries with the highest overall interest in additional information regarding financing options. Despite showing interest in financing information Denmark is the country with the lowest relative rate of interest. One possible explanation is that Danish EPCs already include cost information about the various renovation measures.

Respondents from all the countries would like to receive specific financial information and to be aware of the different options offered by the market. These results thus represent a high potential for replicability in other Member States, with the available options as a baseline to present the financing options to building owners/tenants.

The survey also shows that end-users want to be able to find links to potential financial options in the EPC. Information on financial support alongside the EPC recommendations can help persuade building users to undertake energy-saving measures. The impact would be even stronger if the hassle of applying for a renovation loan was reduced by including an automatic link to financial support schemes. [16]

Conversations with the implementing partners revealed the need to bridge the gap between the energy certification schemes and the financial sector. The following action items were identified:

Denmark

- Current EPCs do not include links to financing options; the new EPC layout forthcoming in 2021 will include a link.
- Although the national one-stop-shop BedreBolig provides detailed information on building renovations and financing options, the new EPC layout will provide tailored, end-user-oriented financial information.
- The government is assessing the possibility of setting up new public support schemes and subsidies.

Portugal

- Maintain the link between the EPC and both existing and new financial options.
- Explore the possibility of setting up similar links with the new instruments not yet linked to EPCs.
- The future EPC layout should include the available financing options for each proposed energy efficiency measure and add a direct link to financing options in the electronic EPC.
- Create a single and dedicated database for existing finance options.
- Evaluate setting up other attractive public support scheme options.
- Evaluate the possibility of including different aspects related to demographics and financing support.
- Within the national one-stop-shop casA+, a direct link will be created from the EPC to the available financing instruments and tax benefits.

Romania

- Links between the EPC (and underlying data) and a few financial instruments already exist; these should be maintained and potentially extended to other financial schemes.
- Other financing options could be linked to the EPC with an economic indicator as a specific investment, in EUR saved/kWh which could be compared to the cost of energy units.
- The new EPC layout will include payback times for various energy recommendations.
- Set up a database for all available financing options, and the EPC may provide a link to this platform.

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[16] X-tendo deliverable 2.1 “Energy Performance Certificates, Assessing their status and potential”, February 2020

- Set up public support schemes and information points targeting single-family homeowners, retired people and owners who are planning major renovations (nZEB level).
- Provide support to large projects in proportion to the impact and visibility of achieved results.
- Improve communication and awareness-raising actions with end-users.

To realise the full potential of EPCs for financial institutions along with the availability of dedicated financial products, the following core actions should be considered:

- Align financial data and indicators with the available EPC data.
- Make the existence of a valid EPC an eligibility condition for both public and private schemes.
- Make relevant EPC data available to financial institutions; improve data flows across the value chain in order to better link financial information, property and energy efficiency characteristics in one single space rather than having these scattered across different stakeholders and platforms.
- Revise the inclusion of financing information on EPC recommendations.
- Define the specific communication channel to disseminate information about available financial options for each recommended energy efficiency measure.
- Link information hubs on available financing options to one-stop-shops.

Moreover, the interdependencies between financial instruments and various policy measures must be addressed, meaning a more direct dialogue between financiers, policymakers and other stakeholders is needed. Closer collaboration between financiers and policymakers can enable EPCs to become truly useful market tools.

5.3 Proposed X-tendo methodology

In the X-tendo project, we will identify information sources on public financial schemes that can be provided alongside the EPC, and explore how financing schemes can be more closely integrated with EPCs. The latter task will require the identification of available financing options, linking EPC data with financial underwriting, as well as effective communication with building owners/users.

To achieve the expected output, the following tasks will be performed:

⊙ Actions under EPCs:

- Identify Member States with EPC databases
- Review methodologies used in the evaluation of the energy performance of buildings
- Assess the level of interoperability between data sources
- Identify which kind of information is available in EPCs
- Identify which information supports the financial mechanisms
- Detail how the improvement measures are evaluated and documented, including the type and scope of the data recorded
- Identify any additional information needs.

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

- Expected output:
  - Assessment of building stock needs, based on long-term renovation strategy
  - Identification of the type of data that needs to be collected to support, access and conduct financing
  - Description of different ways of accessing financing schemes, and how EPCs (and their underpinning data) can be shared with financial institutions
  - Improvement in the way EPCs can be used to map improvement needs and access to finance, as well as to document effective implementation
  - Response to the future needs for access to financial instruments
  - Guidance on how to communicate with building owners.

As stated above, the outcomes expected to be included in the X-tendo toolbox are the approaches for linking data on available financing with EPC schemes, and how to communicate this to building owners. The outcome dedicated to public authorities will be guidance on how to link EPC schemes with financial instruments: this could be easily applied by the countries involved, either fully or partially in modules.

Although the core focus will be to describe methodologies for communicating with building owners/users about the available financing options through the EPC, the guidelines could:

- Provide information to homeowners on financing options, cost transparency, payback and other benefits
- Provide information to financial institutions about the quality of the underlying asset and reduce risk associated with the financial instruments
- Describe approaches and mechanisms to link EPC data to available financing options
- Propose specific financial options based on building input data.

These guidelines will be validated during the project testing phase in the implementing countries, through stakeholder surveys and meetings.

6 ONE-STOP-SHOP

The amended Energy Performance of Buildings Directive (EPBD) [Directive/2018/844/EU] calls on Member States, among other things, to consider transparent advisory tools to inform and assist consumers with energy efficiency renovations and related financial instruments. One-stop-shops (OSS) were thus introduced to overcome market fragmentation on both the demand and supply side by offering holistic, whole-value-chain renovation solutions.

OSS can be defined as advisory tools to facilitate access to financial mechanisms, benefits and support schemes; to assist consumers with technical and financial issues; and to guide them through their building renovation process. EPC data has a special role to play in this regard, and should be linked to the OSS.

6.1 Current state-of-the-art

OSS include independent, government-led, and industry-linked advisors that offer services covering the whole – or at least most of – the renovation value chain. The specific detail of their services varies considerably across different markets, but they commonly include general awareness-raising, assessment of energy performance, organisation of renovation projects, technical assistance, and even implementation, structuring and provision of financial support and the monitoring of savings.

OSS were first established in the Nordic countries, where more than 40% of the building stock consists of single-family houses. Energy efficiency renovations are notoriously complex undertakings, which is also the main reason why homeowners are reluctant to adopt cost-effective improvement measures. By reaching across the entire renovation value-chain, OSS can overcome market fragmentation on both the demand and the supply side. EPC practices (e.g. energy efficiency audits, technical and financial advice, benchmarks) are the building blocks of such initiatives.

Several OSS already use EPC data in their business models, but much of the potential is still untapped. OSS need good information to find the right target group and to offer them a convincing product. In addition, post-renovation quality assurance is an essential yet tricky step for many of these business models. [17]

Although OSS and their related business models have not yet reached their full potential, and many of them are still in the development phase, the following key trends are emerging:

Types of OSS

- Industry-driven, whereby manufacturers and installers aim to extend their businesses and realise commercial interests

[17] X-tendo deliverable 2.1 "Energy Performance Certificates, Assessing their status and potential", February 2020

- **Consultant-driven**, whereby market actors develop customer-related business models
- **Energy service company-driven**, whereby these companies extend the value-added solutions
- **Local government-driven**, whereby the public programmes are generally climate- or energy-related
- **Cooperative**, whereby a mix of actors aim at societal benefits beyond energy or cost savings.

Benefits and advantages

- More and better **information** about energy efficiency in general, improving the average renovation depth in terms of energy performance
- Centralised service as a **single point of contact**
- Faster completion of the works
- Possible to incorporate new calculation, installation and monitoring tools to increase the renovation rate
- Information about cost-optimal measures and **tailored recommendations** for buildings
- Evaluation of **alternatives** regarding renovation measures and service providers
- Improving **trustworthiness** by accrediting and quality-controlling local partners
- Assistance in **financing** and inclusion of preferential deals
- Help the customer to develop a **financial plan** and thus assist in informed choices and decisions
- Help the customer identify the best financial solution
- New business **contacts**
- Establishing more **stable partnerships** and cheaper solutions
- Higher customer care and **customer satisfaction**.

Added value for different target groups

- End-user

  - **Centralised and updated information** about the property, including potential roadmaps to improve it
  - **Real-time and automatic recommendations**, based on end-user profile and type of existing solutions
  - Direct contact with the **expert** that issued the EPC and can provide further assistance
  - **Access to finance and incentives,** access to information about available incentives
  - **Access to qualified companies** that provide energy-efficiency solutions, with reviews from other end-users to help inform a suitable choice of provider
  - **Rating of companies and experts**, access to other consumers' experiences and opinions.

- Energy experts
  - **New advisory services and support for end-users**: the chance of being contacted by the building owners to carry out an audit, provide advisory services, put in place improvement measures, or provide technical support or clarification to end-users and installers
  - **Monitoring of work,** giving feedback about improvement measures previously identified or implemented by experts
  - **Increasing profile with end-users,** allowing them to establish a link between their property and the consultant.
- Service providers
  - **New business opportunities,** a new way to promote products and to extend the customer base, acquire market intelligence and access to aggregated data about the needs of building stock
  - **Information from the EPC** will allow easier communication between technicians and owners, as well as helping to develop the energy efficiency market.
  - **Access to OSS,** a unique place in the marketplace to connect demand and supply, providing the link between owners and suppliers of energy-efficiency solutions, as well as financing and incentives.

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

One-stop-shops in X-tendo countries

The information below gives an overview of the development of OSS in X-tendo implementing countries (Denmark, Portugal, Romania, UK – Scotland).

Denmark

- *BedreBolig*

The BedreBolig OSS is based on a report and online portal. It is managed by DEA and offers predefined renovation solutions to private homeowners. The OSS aims to better connect homeowners and financial institutions. It supports financial advisers to better inform their customers about the financing of energy improvement projects. By introducing the address of the property, the online portal provides the user with an EPC overview, a list of potential measures (and related costs), and expected energy/cost savings. The offers rely partially on automated and customised services, allowing the future client to pre-inform the installers and pre-select the measures via the website and app. The homeowner is directly connected to the technical team, and the interaction allows the tailoring of the package – both technical and financial – to meet the exact needs of the homeowner.

BedreBolig works with local craftsmen who carry out the actual renovations: they get training and tools to ensure the quality of their work. BedreBolig meanwhile takes care of the promotion, quality assurance, monitoring and customer-facing tasks.

Portugal

- Portal casA+

The Portuguese OSS – called Portal casA+ – is an online portal managed by ADENE, which is also the entity responsible for the national energy certification system. It aims to promote energy and water efficiency, cost and energy savings, and the thermal comfort of homes. The OSS's main goals are to provide detailed information to end-users about their homes, to encourage end-users to improve their homes, to facilitate communication between building owners and experts, and to monitor the uptake of improvement measures.

The OSS allows users to consult on the characteristics of their building (such as building envelope, technical building systems, and maintenance, lighting and appliances) and find out more about renovation measures that would improve efficiency and reduce energy bills, as well as increase comfort. It also provides online access to all the building-related information, including equipment and energy consumption data. Once the appliances and other equipment are registered, it is possible to keep records of home renovations over time, in an organised and convenient way. Portal casA+ is quick and intuitive to access, and it allows building owners to make direct contact with qualified experts and request proposals from service providers, gives them access to the available financial support and tax incentives, and signposts appropriate financing opportunities.

The OSS is in a pilot phase, available for residential building owners with valid EPCs issued after 2014, and suppliers of glazing products. The planned improvements for Portal casA+ are described in the next chapter.

Romania

There is no OSS in Romania.

UK – Scotland

- Home Energy Scotland

Home Energy Scotland (HES) is a government-funded network of energy advice centres, operated by the Energy Saving Trust. HES is based on online forms and a call centre, and is a comprehensive advice service offering help and support and a 'single point of contact' for all households in Scotland, particularly people struggling with energy bills.

Free impartial advice is available on building refurbishment, energy savings, renewable energy, sustainable transport, waste prevention, and finance options either through loans or grants. The HES advisors can access each caller's EPC and discuss its recommendations.

Financial support is only available for measures recommended in the EPC: this reflects the already strong link between financing, OSS and EPCs.

6.2 Identifying EPC end-users' needs

The project performed an EPC end-user survey in five X-tendo countries:[18] Denmark, Greece, Poland, Portugal and Romania. The survey aimed to better understand their perception, needs and expectations regarding the new EPC features, including OSS. With this survey, it was also possible to evaluate the needs of the implementing countries under this feature (Denmark, Portugal, Romania and Scotland). We tried to answer two broad questions with the survey:

- Will the end-users use an OSS web portal when planning a building renovation?
- Which type of OSS services would the end-users like to receive?

57% of the respondents would use an OSS but only if it was offered for free, while 24% said they could pay a small fee for the service and 2% were simply not interested. Respondents in Poland and Portugal are relatively less willing to pay a fee for OSS. Greece, Poland and Portugal are the countries with the greatest interest in using OSS if they are free, while Denmark has the most "no" or "I don't know" answers.

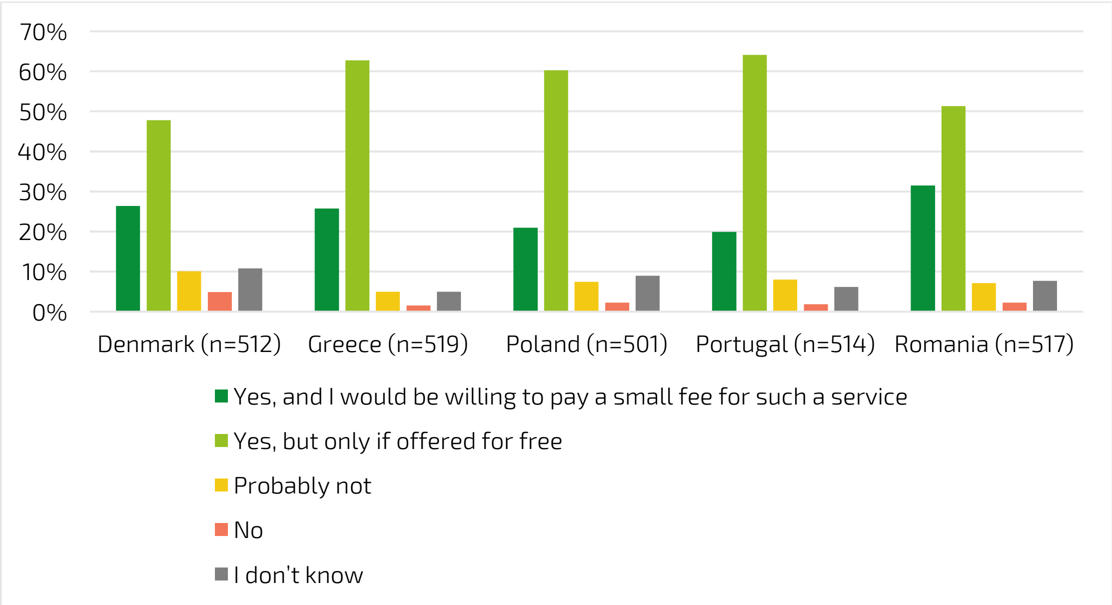


Figure 16 – Interest in OSS services by country

As for the preferred OSS services, per Figure 17 below, Portugal is one of the countries that would like services such as company rankings, online quotations, information on how to update EPCs, and cost-saving estimates. Greece reveals particular interest in technical solutions and online quotations. Poland has the least interest in actual and post-renovation aspects of the EPC. Respondents in Romania are the most willing to receive services related

[18] X-tendo deliverable 2.4 "Understanding end-user needs and expectations of the next-generation EPC-scheme", September 2020

to technical solutions, direct access to companies and cost savings. Denmark shows the least interest in the services provided by OSS.

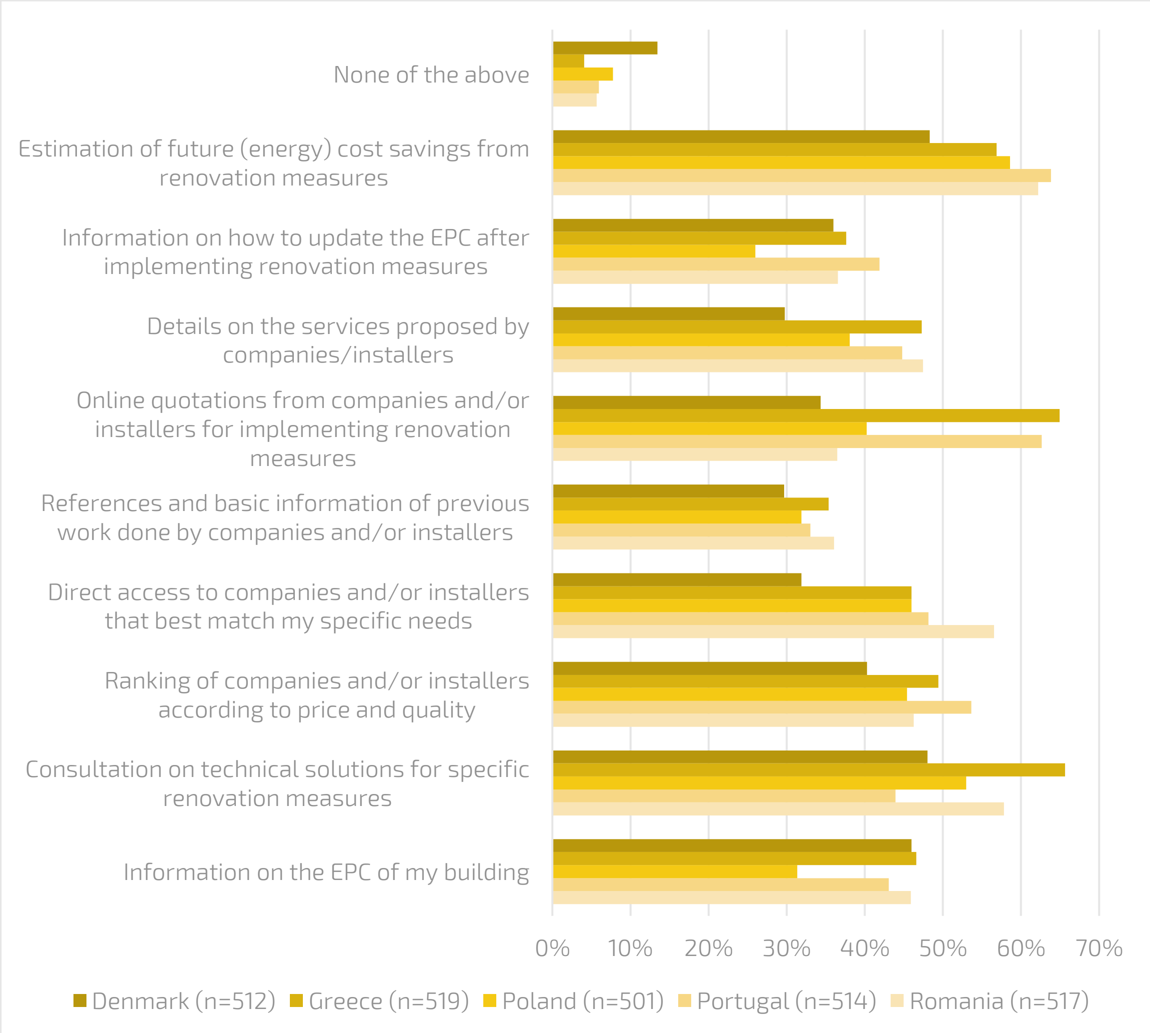


Figure 17 – Most popular OSS end-user services, by country

The majority of respondents were comfortable with sharing their data with third parties, with the exception of financial institutions (64% answered "no"). This aspect is relevant to the required data for OSS and their interoperability with other platforms and databases. Greece, Poland and Portugal have the highest scores for sharing information with energy advisors and contractors. Overall, consent to provide EPC data to third parties is important for setting up OSS in Member States. Due to the characteristics of OSS, some functionality barriers still need to be overcome to allow third parties to get access to them.

The majority of responses (82%) show an interest in using an OSS service, which indicates high potential for introducing the feature in other Member States. Consultation on technical solutions, a ranking of companies, online quotations and an estimation of future cost savings are the most popular OSS services according to the countries we surveyed.

To integrate EPCs and OSS more closely, the following core needs should be considered:

- Better integration of EPC data with other datasets
- Need to identify which OSS/business model is the most appropriate given market/legal specificities
- Make access to OSS dependent on a valid EPC to enable closer integration with databases and building logbooks
- Provide a boost to the networking of local professionals, financial institutions and public bodies
- Facilitate access to digital/online, phone and face-to-face advice.

OSS provide comprehensive information to home and property owners on renovation packages, benefits, support schemes, technical solutions, craftspeople etc. As OSS are seen as a key means to reduce barriers and transaction costs, these functionalities could be linked to EPCs. Direct links with EPC databases, building logbooks and financing schemes are seen as the most relevant features, so these should be considered and incorporated in OSS.

Exchanges with the implementing partners identified some key actions to take alongside the energy certification schemes or existing OSS:

Portugal

- Considering the current pilot phase of Portal casA+, open up to companies operating in other energy efficiency areas (thermal insulation, air conditioning, domestic hot water, ventilation, renewable energies, lighting systems).
- Make available Portal casA+ to building owners with EPCs issued before 2014, as well as building owners without an EPC. For building owners without an EPC it should be possible to request an energy audit from qualified energy experts.
- Follow up all the national EPC developments, according to the new EPC layout.
- Automatically redirect the end-users to official sources of financing schemes and tax benefits.
- Consider the possibility for end-users to benchmark and compare their properties to the building stock.
- Have a contact centre to provide faster and more effective service to end-users.
- Analyse and improve the different business models and fee structures.
- Improve the support mechanisms to encourage building owners to use Portal casA+ and increase their participation.

Romania

- There is no platform in the country: despite existing barriers, the intention is to develop an OSS.
- As a first pilot, OSS functionalities could focus on comfort, environment and energy.
- A link between the EPC databases and the OSS should be established.
- Create a link between EPCs and financial support schemes.
- Allow OSS registration not only for end-users with an EPC, but for all those who are interested in implementing renovation measures.

- National professional associations should have access to the OSS in order to verify and quality-assure the processes it encompasses, .
- Allow end-users to evaluate the work done by the service providers, and rank the companies involved.
- Develop the appropriate OSS business model taking into account the country needs and public authority guidelines.

UK – Scotland

- Advisors could prepopulate or add information from the EPC to the customers' records.
- EPCs could offer more bespoke information on direct running costs for the householder and link to the OSS service.
- When requested by the home owner, provide access to the Home Energy Scotland customer database.
- Occupancy details could be considered within the EPC's recommendations section to ensure that the measures covered by a scheme reflect the requirements of individual households.
- Improve the current application of GDPR, mainly concerning data protection issues.
- Improve data quality in order to allow better targeting of advice and more accurate messaging encouraging homeowner engagement.
- Reinforce data quality control and access in order to allow third parties to access the modelled data and promote energy efficiency.
- Explore how to link direct to a range of suppliers and installers without damaging the reputation and existing impartiality of the Home Energy Scotland OSS.
- Plan a web service arrangement with the EPC register, so when an advisor speaks to a customer, they can operate a macro on the CRM database.
- Increase the use of digital advice.

Denmark

- Considering the current status of Danish OSS and their link with the EPC, no further actions are being planned.
- With the development of the X-Tendo methodology and during the implementation phase, potential actions to improve the BedreBolig OSS will be defined.

6.3 Proposed X-tendo methodology

The X-tendo project will describe approaches for linking EPC data to OSS and will demonstrate the applicability of these approaches for the different implementing countries (Denmark, Portugal, Romania and UK – Scotland), considering their existing EPC data, building stock renovation activities and needs.

The following tasks will be performed in order to achieve the expected output:

- Actions under EPCs:
    - List of Member States with EPC databases

- Identify which types of data are collected in EPC databases
- Overview of methodologies used to evaluate energy performance of buildings
- Review of interoperability status among databases
- Identify which kinds of information are available in EPCs
- Identify which information is needed for OSS
- Detail how the improvement measures are evaluated and documented, including which types of data are recorded how they are integrated into OSS
- Identify any additional information needs.

◉ Actions under OSS:

- Evaluate the existing types of OSS, including descriptions, functionalities, applicability and main target groups
- Assess the focus of these OSS and which areas/sectors are covered
- Evaluate which kinds of information and criteria the OSS are based on and which types of data are used
- Map the needs and barriers faced by stakeholders
- Analysis of the compatibility of EPC data
- Identify existing best practices and flagship projects
- Evaluate the potential business model and cost structure
- Identify recommendations on the use of EPCs and data in OSS.

◉ Expected output:

- Identification of the types of data needed to support, access and set up/improve an OSS
- Identification of OSS functionalities that can be adopted
- Understanding of how the EPC or its data can be channelled to the main target groups using the OSS
- Understanding of how the EPC can be used to map improvement needs and access the OSS, leading to effective implementation
- Provision of detailed information to homeowners about their homes and monitoring of the uptake of improvement measures
- Reduced barriers to finding information
- Responses to future EPBD-related provisions
- Methodologies for communicating to building owners and experts.

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

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

The developed guidelines will be validated during a testing phase. This will include analysis of the existing OSS, discussions with stakeholders about the possible design elements of OSS and their corresponding links with EPCs, the identification of possible pathways to implement or upgrade OSS, and consideration of how EPC data can be effectively integrated.

It should be noted that the partners targeted for implementation have different policy and market contexts and varying potential for considering the future implementation of OSS. In Romania there is no OSS and so it needs to be designed from scratch. In Scotland, the current OSS is based on a consultancy approach: making the available data accessible online would create better links with funding schemes and installers. Even the relatively well developed OSS in Portugal and Denmark still have the potential for improvements.

7 CONCLUSIONS

This report identified the user needs and technical specifications regarding features of EPC databases, building logbooks, tailored recommendations, financing options and one-stop shops. It included a status quo analysis, a description of the implementing partners' needs and the potential for each feature to be further developed and implemented.

Overall findings revealed by the status quo and user needs analysis are summarised below:

- There are overlaps and interdependencies between features, such as fully accessible EPC databases are a cornerstone of effective building logbooks, or tailored recommendations and financing options are part of an effective one-stop-shop.
- Considerations will need to be given how these additional new features will fit into the national market and policy context, e.g. the availability of finance, development of real estate markets, transposition of GDPR and data governance rules.
- The approach for setting up EPC databases varies from country to country: some store the detailed input data required to generate the EPC, while others only collect a PDF copy of the certificate but no data.
- Although some data is missing, difficult to access or their ownership is disputed, there is a wealth of information which could already be linked to the logbook, for example, administrative and general information, building description and characteristics, building's operation and use, as well as performance data.
- In terms of targeted recommendations, end-user surveys concluded that homeowners are most interested in estimated renovation costs however, in most countries, EPC software are not linked with cost databases.
- Likewise, end-users flagged available financing as one of the key support measures needed in order to embark on renovations.
- Several OSS already use EPC data in their business models, but much of the potential is still untapped, e.g. data can help targeting homeowners with the most appropriate product or setting up post-renovation quality assurance which is still somewhat missing from current schemes.

To achieve the anticipated benefits, the common theme across this report is that EPC regimes at the Member State level have to be properly implemented and endorsed, supported by well-functioning management, control and monitoring mechanisms, as well as, generally, to encourage a more open approach to data sharing and access.

More specifically, the report has identified the following concepts and tools to be developed in the further activities of the X-tendo project:

EPC databases

- A four-step quality control method will include:
  - First threshold value verification (broad range)
  - Second threshold value verification (narrow range)
  - EPC flagging of EPCs that will require manual checks
  - Methodology to improve the skillsets of professionals by highlighting commonly made mistakes

Building logbooks

- Logbook data model, including guidelines for the organisation of logbook data and protocols for data capturing.
- Overview of existing databases and the trustworthiness of their data, as well as guidelines to enable interoperability, data consistency and information exchange
- Documentation of the technical solutions and logbook concepts, e.g. stakeholder related benefits and relevant data governance issues
- Visual guidelines for the design and implementation of logbooks, such as roadmaps, process flows, business models and good practice examples

Tailored recommendations

- The proposed method is built on three pillars:
  - Enhance actual recommendations by software-generated additional building-specific recommendations
  - Describe how the costs of recommended measures can be included in the EPC provision process, enabling calculation of the cost-effectiveness of the recommended measures
  - Set target values for recommendations in order to guarantee that they are in line with national long-term and climate strategies for the building stock

Financing options

- Assessment of building stock needs, based on long-term renovation strategy
- Identification of the type of data that needs to be collected to support, access and conduct financing
- Description of different ways of accessing financing schemes, and how EPCs (and their underpinning data) can be shared with financial institutions
- Improvement in the way EPCs can be used to map improvement needs and access to finance, as well as to document effective implementation
- Response to the future needs for access to financial instruments
- Guidance on how to communicate with building owners

One-stop shops

- Better integration of EPC data with other datasets
- Identify which OSS/business model is the most appropriate given market/legal specificities
- Make access to OSS dependent on a valid EPC to enable closer integration with databases and building logbooks
- Provide boost to networking of local professionals, financial institutions and public bodies
- Facilitate access to digital/online, phone and face to face advice

Figure 18 - Feature-by-feature overview of technical specifications and user needs

REFERENCES

ADENE, 2016. Concerted Action EPBD. Implementing the Energy Performance of Buildings Directive (EPBD) – Part A.

Energy and Climate Change Directorate, 2018. Energy Efficiency Standard for Social Housing post-2020 (EESSH2): consultation – gov.scot [WWW Document]. URL https://www.gov.scot/publications/consultation-energy-efficiency-standard-social-housing-post-2020-eessh2/ (accessed 9.14.20).

EST, 2020a. Home Energy Scotland – Hub – Home Energy Scotland HUB [WWW Document]. URL https://homeenergyscotland-advice.est.org.uk/Home/?ReturnUrl=/Hub/UserDetails/I7fCGsg0uKWwBT9WtMjVCc8lPVg9EJXY7TADL~733v_vKZiqgGxcw_Vnw~dsDihmyaUn41H3svY!-__FQbTShXH8!&q=XIvWucFLfYYibjulrAb2JQ!!-lhboKRvAs8k! (accessed 9.14.20).

EST, 2020b. Tools and Calculators [WWW Document]. Energy Saving Trust. URL https://energysavingtrust.org.uk/scotland/tools-calculators (accessed 9.14.20).

EU Commission, 2019. Commission Recommendation (EU) 2019/786 of 8 May 2019 on building renovation (notified under document C(2019) 3352) (Text with EEA relevance.) (No. 32019H0786), OJ L.

European Parliament, 2018. Directive of the European Parliament and of the Council – amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficienc [WWW Document]. URL http://data.consilium.europa.eu/doc/document/PE-4-2018-INIT/en/pdf (accessed 6.12.18).

Gonzalez-Caceres, A., Rammer Nielsen, T., 2020. Is the tailor recommendation useful? Policy suggestions to upgrade the EPC recommendation report. IOP Conference Series: Earth and Environmental Science 410, 012080. https://doi.org/10.1088/1755-1315/410/1/012080

HEEPS Portfolio Energy Analysis Tool [WWW Document], n.d. URL https://homeanalyticspeat.est.org.uk/About.aspx (accessed 9.14.20).

Scottish Government, 2018. Energy Efficient Scotland: route map – gov.scot [WWW Document]. URL https://www.gov.scot/publications/energy-efficient-scotland-route-map/ (accessed 9.14.20).

Stewart MSP, K., 2020. The Energy Efficiency (Private Rented Property) (Scotland) regulations 2020: consultation analysis – gov.scot [WWW Document]. URL https://www.gov.scot/publications/energy-efficiency-private-rented-property-scotland-regulations-2020-analysis-responses-public-consultation-exercise/ (accessed 9.14.20).

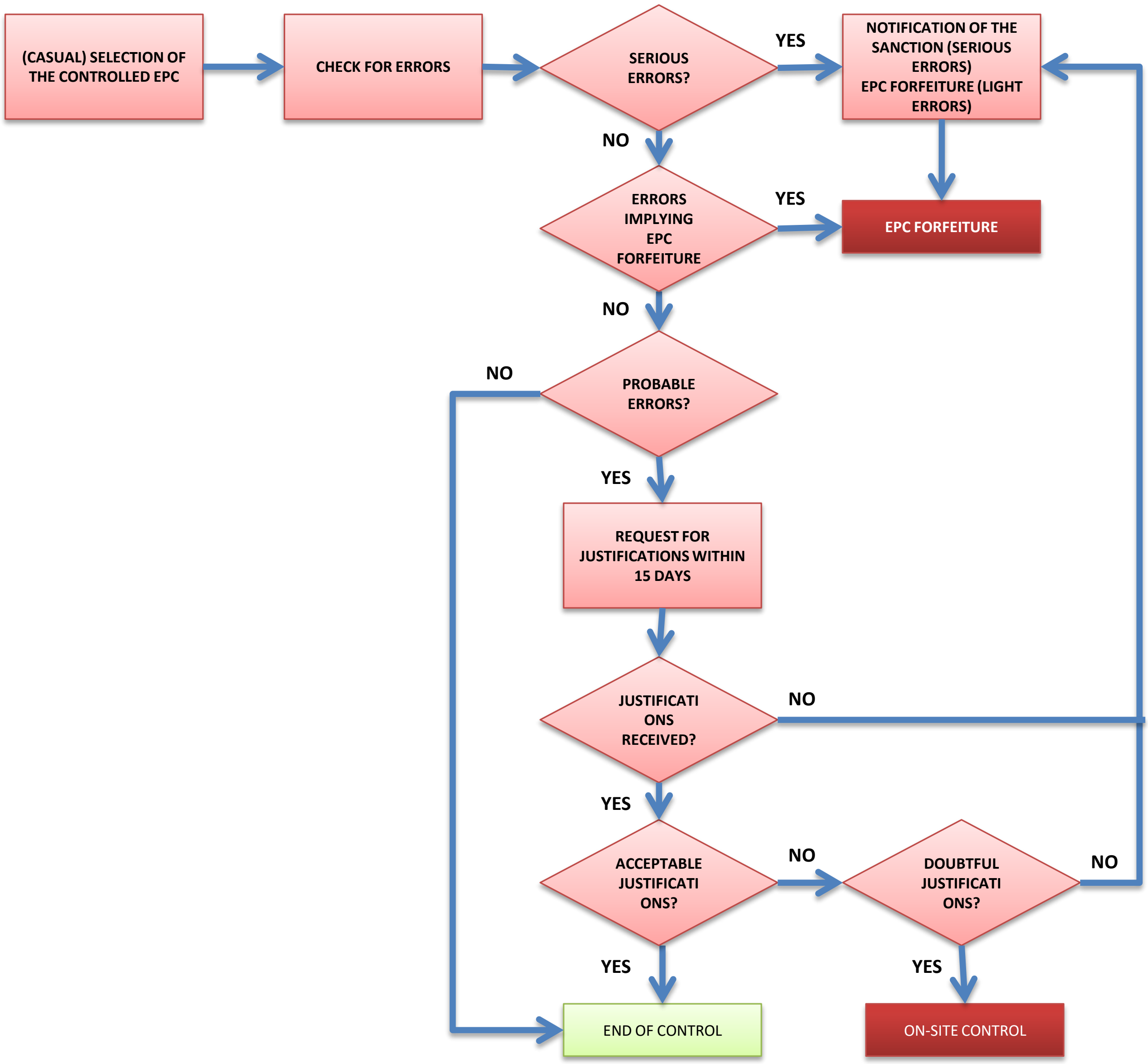
Zuhaib, S., Borragen Pedraz, G., Verheyen, J., Kwiatkowski, J., Hummel, M., Dorizas, V., 2020. X-tendo report – Exploring innovative indicators for the next-generation EPC features – Project deliverable 3.1.

ANNEX I: EPC VALIDATION AND CONTROL PROCESS - REGIONE LOMBARDIA (ITALY)

EPC validation and control process – Regione Lombardia (Italy)
FIRST-LEVEL CONTROLS: These include both the verification of the admissibility of the input data, which prevents the compilation of the EPC if unacceptable data is inserted; and also the validation of its reasonableness – the EPC expert is warned if values do not fall within predetermined probability thresholds based on statistical analysis. These assessments are conducted on all EPCs (XML files) sent to the regional EPC database. First-level checks are manifold and of different types. Here are some examples: 1. Ratio between heated/cooled net volume and gross volume For each thermal zone, the ratio between the sum of the net volumes of all the rooms in the thermal zone and the gross volume of the thermal zone itself is calculated: for this ratio there is an admissibility interval and several reasonableness intervals based on the time of construction of the building/building unit. 2. Ratio between net volume and heated/cooled area (net height) For each thermal zone, the value indicated by the user for the average net height is verified: this must be positive and within certain values (validation of admissibility). 3. Thermal transmittance of the heat-losing surfaces For each heat-losing surface entered by the user (vertical walls, roofs, floors, windows) there are different intervals of reasonableness regarding the thermal transmittance based on the construction period or the year of renovation of the building/building unit. There are also admissibility and reasonableness ranges for the main calculation quantities related to heat generators (thermal powers, efficiency coefficients/COPs, electrical auxiliaries etc.), to building systems, to heat storage, to RES systems, to emission terminals etc. The first-level controls are divided into 'exclusionary' and 'warning'. The presence of a negative check in the former prevents the inclusion of the EPC in the regional database. The presence of a negative check in the latter activates a warning, but it does not prevent the inclusion of the EPC in the regional database.
DOCUMENT CONTROLS: These involve the verification of the EPC data without a site inspection. During the process, the presence of both serious errors (which lead to the immediate notification of the sanction) and of minor errors (that only forfeit the validity of the EPC) are verified. This check level is casually performed on 2% of the EPCs produced each year – 50% of the checks are made on EPCs in either A1, A2, A3 or A4 energy classes, and 50% are made on the remainder. During this kind of check the following information is considered: adopted energy performance calculation method, heated area (comparison with the cadastral plan), heated net volume (comparison with the cadastral plan), orientation of the building (comparison with the cadastral plan or aerial photo), heat-losing surface elements (comparison with the cadastral plan), false

insertion of renewable energy sources (comparison with aerial photo), presence of digital signature on the EPC, absence of tailored recommendations, wrong cadastral data.

The document controls are shown below.



Serious errors

- Wrong energy performance calculation method
- Declared net surface (considered negative if the difference between the net surface deduced from the cadastral plan and the declared net surface is greater than 20%)
- Declared net volume (considered negative if the difference between the net volume deduced from the cadastral plan and the declared net volume is greater than 20%)
- Building orientation (the assessment, carried out by using cadastral plan or aerial photography combining the surfaces for orientation with a tolerance of ± 45°, is

considered negative if more than 30% of the surfaces losing heat towards the outside are affected by errors greater than 30%)
- Outward heat-losing surface (the assessment, carried out through the use of the cadastral plan, is considered negative if there is a deviation of more than 30% between the outward heat-losing surface considered by the EPC expert and the one detected by the inspector)
- Presence of renewable energy sources (the assessment is carried out by aerial photo).

Minor errors

- Absence of the digital signature on the EPC
- Incorrect cadastral data.

<u>ON-SITE CONTROLS:</u>

These are aimed at verifying that the calculation input data declared by the EPC expert corresponds with the actual state of the building. This control is performed on a share of the EPCs which are already part of a document control procedure which has had a 'doubtful outcome'. A portion not exceeding 20% of the number of inspections scheduled during the semester may also include the EPCs for which a reasonable request for control has been sent by the owner, or the buyer, or the tenant, or the building administrator, or a public official. If the number of control requests exceeds the 20% limit, the EPCs to be verified are randomly chosen from the requests received in the previous semester.

If the inspectors in charge of the on-site controls are prevented – in any manner whatsoever – from accessing the building or its thermal power station, the EPC is cancelled.

The remaining 80% of EPCs to be checked are randomly chosen based on the following risk factors:

Anomalous values of EPgl,nren (Risk factor A):

- 2 Points if EPgl,nren > 10 * EPgl,nren,ref
- 1 Point if 7 * EPgl,nren,ref < EPgl,nren ≤ 10 * EPgl,nren,ref
- 0 Points if EPgl,nren,ref <EPgl,nren ≤ 7 * EPgl,nren,ref.

Anomalous values of U value (Risk factor B):

- 2 Points if in the EPC's XML file there are U values not included in the "Ustandard" range shown in Table
- 0 Points if in the EPC's XML file there are U values included in the "Ustandard" range shown in Table.

		U standard [W/m2 K]
Vertical opaque	Residential	U >= 0.1
		U <= 2.99
	Not residential	U >= 0.1
		U <= 3.59
Roof opaque	Residential / Not residential	U >= 0.1
		U <= 2.2
Floor opaque	Residential / Not residential	U >= 0.1
		U <= 2

Windows	Residential / Not residential	U >= 0.8 U <= 6

Anomalous thermal power values of heat combustion generators for autonomous systems (Risk factor C):

- 2 Points if the thermal power is less than 0.05 [kW / m2] * Heated surface [m2] or greater than 1 [kW / m2] * Heated surface [m2]
- 0 points in all other cases.

Large number of EPCs produced by the same EPC expert (Risk factor D):

- 3 Points if the number of EPCs produced in the regional system by the EPC expert in the previous 365 days is greater than 100
- 2 Points if the number of EPCs produced in the regional system by the EPC expert in the previous 365 days is between 51 and 100
- 1 Point if the number of EPCs produced in the regional system by the EPC expert in the previous 365 days is between 26 and 50
- 0 Points if the number of EPCs produced in the regional system by the EPC expert in the previous 365 days is between 0 and 25.

Energy class of the building (Risk factor E):

- 3 Points if the energy class is A4 or A3
- 2 Points if the energy class is A2 or A1
- 1 Point if the energy class is B
- 0 Points in all other cases.

EPCs to be checked randomly in relation to the risk factors listed above are selected from a group in which each EPC inserted in the regional EPC database in the last four years appears n + 1 times, where n is the sum of the risk scores attributed to the EPC.

ON SITE CONTROLS details: the procedure is quite complex.

ANNEX II: PROVIDED EPC RECOMMENDATIONS IN POLAND

Example of recommendations provided in EPCs in Poland.

ŚWIADECTWO CHARAKTERYSTYKI ENERGETYCZNEJ BUDYNKU	
Numer świadectwa[1)]	

Wskaźnik rocznego zapotrzebowania na energię użytkową EU [kWh/(m² · rok)][17)]					
	Ogrzewanie i wentylacja	Ciepła woda użytkowa	Chłodzenie	Oświetlenie wbudowane	Suma
[kWh/(m² · rok)]					
Udział [%]					
Wskaźnik rocznego zapotrzebowania na energię użytkową EU: … kWh/(m² · rok)					

Wskaźnik rocznego zapotrzebowania na energię końcową EK [kWh/(m² · rok)][17)]					
Rodzaj nośnika energii lub energii	Ogrzewanie i wentylacja	Ciepła woda użytkowa	Chłodzenie	Oświetlenie wbudowane[11)]	Suma
1)					
2)					
n)					
Suma [kWh/(m² · rok)]					
Udział [%]					
Wskaźnik rocznego zapotrzebowania na energię końcową EK: … kWh/(m² · rok)					

Wskaźnik rocznego zapotrzebo…					
Rodzaj nośnika energii lub energii					
1)					
2)					
n)					
Suma [kWh/(m² · rok)]					
Udział [%]					
Wskaźnik rocznego zapotrzebow…					

Recommendations for the cost-effective and technically feasible improvement of energy performance building in terms of:

18) The filling is obligatory, unless there is no reasonable possibility of such improvement compared to the applicable requirements contained in technical and construction regulations.

Zalecenia dotyczące opłacalnej ekonomicznie i wykonalnej technicznie poprawy charakterystyki energetycznej budynku w zakresie[18)]**:**

1) przegród budynku w przypadku planowania robót budowlanych polegających na ociepleniu budynku, obejmujących ponad 25% powierzchni przegród zewnętrznych tego budynku

building partitions in the case of planning construction works consisting in building insulation, covering over 25% of the area of the building envelope

2) systemów technicznych w budynku w przypadku planowania robót budowlanych polegających na ociepleniu budynku, obejmujących ponad 25% powierzchni przegród zewnętrznych tego budynku

technical systems in the building in the case of planning construction works consisting in building insulation, covering over 25% of the area of the building envelope

3) przegród budynku niezależnie od planowanych robót budowlanych, o których mowa w pkt 1

partitions of the building, regardless of the planned construction works referred to in point 1

4) systemów technicznych w budynku lub części budynku niezależnie od planowanych robót budowlanych, o których mowa w pkt 2

technical systems in a building or part of a building, regardless of the planned construction works referred to in point 2

5) innych uwag dotyczących poprawy charakterystyki energetycznej budynku (w tym wskazanie, gdzie można uzyskać szczegółowe informacje dotyczące opłacalności ekonomicznej zaleceń zawartych w świadectwie oraz informację dotyczącą działań, jakie należy podjąć w celu wypełnienia zaleceń)

other comments on improving the building's energy performance (including an indication of where to obtain detailed information on the cost-effectiveness of the recommendations included in the certificate and information on actions to be taken to fulfill recommendations)

ANNEX III: PROVIDED EPC RECOMMENDATIONS IN SCOTLAND

Example of recommendations provided in EPCs in Scotland.

Measure	To be considered when existing dwelling is/has:
Loft insulation Note. This is assumed to include insulation of the loft hatch.	Pitched roof (slates or tiles), accessible loft, insulation at ceiling level, not thatched roof. Note: This does not include insulation of a room-in-roof
Flat roof insulation	Flat roof, not unknown insulation or Pitched roof with sloping ceiling, not unknown insulation
Roof room insulation	Roof rooms, not thatched roof, as built age band <= F or insulated with U > 0.5
Cavity wall insulation	Unfilled cavity wall (assessed as "as built" and not "unknown")
Party wall insulation	Unfilled party walls
Secondary glazing	Single glazing present but assessor de-selected measure O. See Note 6
Insulated doors	House or bungalow or park home or (Flat or maisonette) and (no corridor or more than one door) i.e. door directly to outside
Photovoltaics	House or bungalow, not thatched roof
Wind turbine	House or bungalow in rural location

ANNEX IV: SUMMARY REVIEW OF FINANCIAL INSTRUMENTS IN THE RESIDENTIAL SECTOR ACROSS THE EU [19]

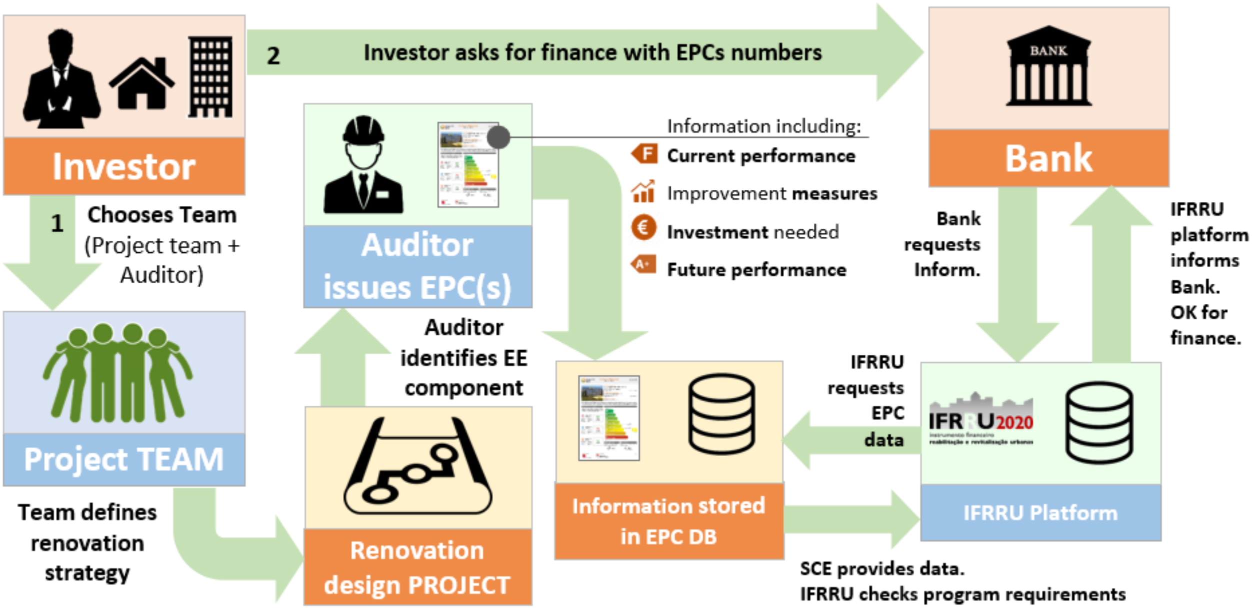
				Main barriers addressed					
Financial instrument	Adoption rate	Good EU practices	Source of finance	Upfront cost	Cost of finance	Split incentive	Advantages	Challenges	Buildings/ households best suited
Grants & subsidies	High	Better energy homes scheme (IE)	Taxpayer & Subsidy recipient	X			Support of new emerging technologies; help to kick start market; can be combined with other types of instruments	Public budget restrictions; free riders; mostly shallow measure support	Vulnerable/low income households; hard to reach properties (e.g., rented properties)
Energy efficiency obligations	Medium/ high	Energy savings agreement (DK)	Energy consumers	X		X	No public budget burden; wide range skills offered by energy suppliers; third party involvement	Energy bill surcharge; low consumer trust to energy suppliers; mostly shallow measure support	All
Tax incentives	Low/ Medium	Eco-bonus (IT)	Taxpayer				Useful at promoting new technologies; lower burden to public resources than subsidies	Reduced tax revenue to government; success depends on tax collection rate; less beneficial to low-income households	All
Preferential loans	Medium	KfW (DE)	Government/ private investors	X	X		Less burden on public resources than grants; support to deeper renovations	Upfront cost barrier due to down-payment; reluctance to take on additional debt; large transaction costs in small projects	Households with sufficiently high credit score
Revolving funds	Medium	KredEx (EE)	Government/ private investor/ repayments	X			Repayments cycled back into fund for future projects	Fund may "revolve" quite slowly; limited short-term impact of public funds	Depends on financial product supported by fund
Energy performance contracts	Medium	Renesco (LV); lemon (IT)	ESCO/client	X			No upfront costs for consumers; know-how of ESCOs	Performance risk; high fees charged by ESCOs	Large condominiums
Energy service agreements	Low	N/A	ESCO/client	X		X	Finance improvements "off-balance sheet"	Not adapted for deep renovations	Large condominiums
Energy efficient mortgages	Low	Raifaissen; Nordea; Muenchener Hyp	Lender	X	X		Easy access to capital (low cost); increase in ability to pay monthly installments; long repayment period; support to deeper renovations	Large transaction costs in small projects; strict collateral requirements	Creditworthy homeowners;
Property assessment clean energy	N/A	EuroPACE (ES)	Municipal bonds	X	X		Long repayment period; lower transaction costs by streamlining application processes; support to deeper renovations	Available only to homeowners; not available for small investments; high set up costs for municipalities	Property owners only
On-bill finance	Low	Green Deal (UK)	Utility or third party	X		X	Attractive option for leased properties; no upfront cost to consumer; easy repayment	Potentially high-interest rate attached to on-bill loans; not suited for very large projects	Rented properties
Crowd-funding	Low	Bettervest (DE)	Individuals	X			Access to finance for consumers not eligible for conventional financing products	Difficulty to reach funding target; risky investments; weak regulatory framework	Communal projects
Feed in tariffs	N/A	N/A	Consumer			X	Incentive to maximize savings given they are output-based	Complex design issues; budget restrictions	All

[19] Source: Bertoldi P, Economidou M, Palermo V, Boza-Kiss B, Todeschi V., 'How to finance energy renovation of residential buildings: Review of current and emerging financing instruments in the EU', WIREs Energy Environ. 2020, May 2020, doi: 10.1002/wene.384

ANNEX V: PORTUGUESE CASE STUDY: EPC INTEGRATED INTO FINANCIAL INSTRUMENT

As indicated in chapter 5.1, in Portugal the EPC is used to check conformity with programme requirements, investments needed and potential energy savings, and inform financial institutions.

Below is a flowchart illustrating a Portuguese case study – EPC integrated into Urban Rehabilitation as an Instrument for the Revitalization of Cities (IFRRU 2020).



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