EPC and Building Renovation Passport

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DELIVERABLE 6.3

EPC and Building Renovation Passport

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Executive Summary

D6.3 EPC and Building Renovation Passport is the outcome of task 6.3 Linking EPCs with building passports and renovation roadmaps. The objective of the task was to clarify how EPCs can be integrated within the Building Renovation Passports. The aim was to identify, consolidate, and present in a meaningful way, the outcomes and experiences of D^2EPC that can potentially strengthen the development and standardization of BRP. The idea is that the new EPC results can be summarized in a document that can be used as a baseline and benchmark for the definition of renovation activities. D^2EPC's outputs were matched with the key components of BRP and demonstrated in two case studies. To maximise the impact the generic guidelines and technical advisory were prepared to stimulate deep renovation and BRP promotion at various levels.

Table of Contents

List of Figures

List of Tables

List of Acronyms and Abbreviations

Term	Description
EPC	Energy Performance Certificate
BBC	Bâtiment Basse Consommation - Low-Energy Building
EC	European Commission
EPBD	Energy Performance of Buildings Directive
BRP	Building Renovation Passport
IAQ	Indoor Air Quality
iSFP	Individueller Sanierungsfahrplan - Individual Renovation Roadmap
LTRS	Long-Term Renovation Strategy
MS	Member States

1 Introduction

D^2EPC aspires to deliver the next generation of dynamic EPCs for the operational and regular assessment of buildings' energy performance through a set of cutting-edge digital design and monitoring tools and services. It also aims to deliver the practical knowledge which will allow the integration of the produced knowledge of the D^2EPC project into the national and European energy legislative framework. Particularly the topics to be analysed and elaborated include the delivery of the required framework for the upgrade of the existing set of standards, used in the calculation process of buildings energy performance. One of the focuses is the relation of the D^2EPC scheme with building passports and renovation roadmaps.

1.1 Scope and objectives of the deliverable

This document is deliverable 6.3 with the title "EPC and Building Renovation Passport" and is defined within task 6.3 "Linking EPCs with building passports and renovation roadmaps". The objective of this task is to clarify how EPCs can be integrated within the Building Renovation Passport (BRP). The aim is to identify, consolidate and present in a meaningful way, the outcomes and experiences of D^2EPC that can potentially strengthen the development and standardization of BRP. The idea is that the new EPCs results can be summarized in a document that can be used as a baseline and benchmark for the definition of renovation activities. D^2EPC's outputs are matched with the key components of BRP. As a result, two sets of guidelines are presented, the generic guidelines and consultancy for decision and policy makers and technical advisory for building professionals and end-users. The work is demonstrated in 2 pilot cases, namely on the Greek pilot (CS1), and the Cyprus pilot (CS4).

1.2 Structure of the deliverable

This deliverable starts with a thorough literature review on building renovation passports in chapter 2 where existing schemes are also presented. Then in Chapter 3, the disadvantages of current EPCs are listed, together with the aims and ambitions of new-generation EPCs. This chapter then continues with the identification of D^2EPC components which match the components of building renovation passports and points out the similarities and differences between them. Chapter 4 is about the demonstration, where the focus is on CS1 and CS4. Next in Chapter 5, two guidelines are presented, namely the generic guidelines for decision and policy makers and technical advisory for building professionals and end-users. The deliverable finishes with the conclusion and a general sum up in Chapter 6.

1.3 Relation to Other Tasks and Deliverables

This task has a strong relation with many technical tasks, such as T1.4, T3.1, T3.3, T4.2 and T4.3, where architecture and technical components are being developed. It is important to understand the outputs of D^2EPC tools in order to make a comparison with the BRP's components. This task does not provide input for any other task but it uses the outputs of other tasks to investigate the possible connection between the existing EU scheme and D^2EPC results.

2 Literature review

In order to better understand the topic of Building Renovation Passports, a thorough literature has been performed. First, the *Energy Performance of Building Directive* was studied to grasp the purpose and idea behind the definition of the BRPs. Then, the *Technical study on the possible introduction of optional building renovation passports* and *Building renovation passports – Customised roadmaps towards deep renovation and better homes* were reviewed in order to get familiar with the existing schemes. A report titled *Definition of the digital building logbook* offered an insight into the advantages of logbooks. Finally, documents produced by *Deutsche Energie-Agentur* were reviewed to better understand the German version of the Building Renovation Passport.

2.1 Building Renovation Passports

The 2018 revision of the Energy Performance of Building Directive (EPBD 2018/844/EU) [1] stated that European Commission (EC) shall conduct a study on the possibility to introduce an optional renovation passport. According to EPBD 2018/844/EU, Building Renovation Passport (BRP) is "*complementary to the energy performance certificates, in order to provide a long-term, step-by-step renovation roadmap for a specific building based on quality criteria, following an energy audit, and outlining relevant measures and renovations that could improve the energy performance*" [1]. Nevertheless, there is no commonly agreed definition of what BRP is and its purpose and meaning often overlap with other available instruments.

According to the Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the energy performance of buildings (recast) [6], Article 10, the Renovation Passport should be implemented as follows:

1. *"By 31 December 2023, the Commission shall adopt delegated acts in accordance with Article 29 supplementing this Directive by establishing a common European framework for renovation passports, based on the criteria set out in paragraph 2.*
2. *By 31 December 2024, Member States shall introduce a scheme of renovation passports based on the common framework established in accordance with paragraph 1.*
3. *The renovation passport shall comply with the following requirements:*
    a. *it shall be issued by a qualified and certified expert, following an on-site visit;*
    b. *it shall comprise a renovation roadmap indicating a sequence of renovation steps building upon each other, with the objective to transform the building into a zero-emission building by 2050 at the latest;*
    c. *it shall indicate the expected benefits in terms of energy savings, savings on energy bills and operational greenhouse emission reductions as well as wider benefits related to health and comfort and the improved adaptive capacity of the building to climate change; and*
    d. *it shall contain information about potential financial and technical support."*

Deep renovation and staged renovation are two important factors when discussing BRP. Deep renovation is a process which enables the whole potential of a building with the goal of reduction in its energy demand by means of renovation planning. According to The Coalition for Energy Savings [1]:

> *"The successful implementation of a staged renovation requires the definition of a holistic renovation plan to avoid that any stage of the renovation increases significantly the overall costs or precludes subsequent stages in the course of the standard renovation cycle. This renovation plan will look at the building as a whole (including envelope, control systems, technical systems and equipment), and define the sequence of the renovation stages with a view to reach the final goal (the significant reduction of energy consumption)."*

In May 2020 EC's Directorate-General for Energy (DG ENER) commissioned and supervised a study with the title Technical study on the possible introduction of optional building renovation passports. "*The study evaluates the relevance, feasibility and potential impact of BRPs based on a number of aspects*" [2]. Several existing schemes were evaluated based on the three-step criteria, presented in Figure 1.

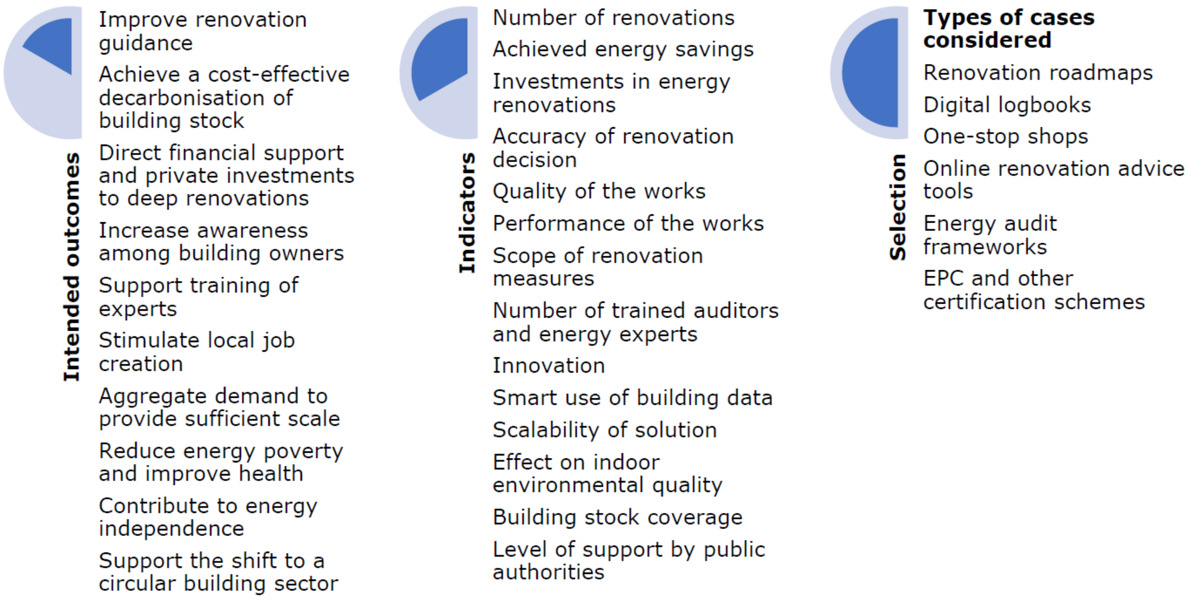

Figure 1 Three-step selection criteria [2]

The 16 highest-ranking schemes were further analysed, and the outcomes are presented in the study report. The conclusion of the comparison highlighted the importance of combining renovation advice with information on financial solutions and support, as many users go for cheaper and less efficient renovation measures due to a lack of awareness of financial possibilities. BRPs can help users to better understand which energy renovation measures to implement and what are their benefits. The actual investments in energy renovations happen in 10,8% of cases, where building owners were contacted and introduced to BRP schemes. However, none of the investigated schemes was considered as fully reaching its potential, as there are still aspects that could be included in BRPs such as Indoor Air Quality (IAQ) and circularity [2].

A proposed definition of the Building Renovation Passport, based on the EPBD, stakeholders' inputs and the technical study is as follows:

> *"A building renovation passport provides a long-term, tailored renovation roadmap for a specific building, following a calculation based on available data and/or an on-site audit by an energy expert. The instrument identifies and outlines deep renovation scenario(s), including steps to implement energy saving measures that could improve the building's energy performance to a significantly higher level over a defined period of time. The instrument can be complementary to energy performance certificates and/or combined with digital logbooks" [2]***.***

BRP components are not clearly defined, but according to stakeholders and technical experts, there could be two components – central and complementary, focusing on the renovation process and non-energy aspects respectively, as illustrated in Figure 2.

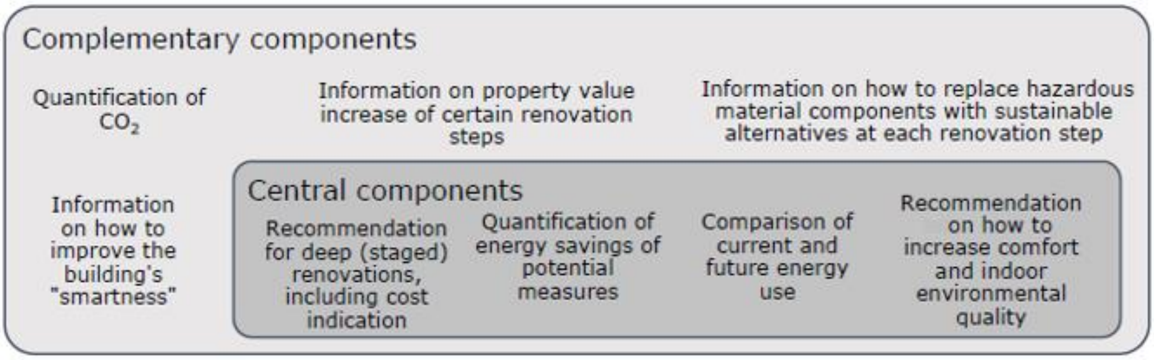

Figure 2 BRP components [2]

In comparison to Energy Performance Certificates (EPC), the BRPs are a more comprehensive instrument, as they provide tailored solutions on how to deep-renovate each individual building, together with information on support and available financial schemes.

BRPs can include information about the one-step renovation and staged renovation.

- **One-step renovation** means renovating a large part of the building in one step, so it becomes a low-energy consumer. This approach addresses the need to drastically reduce energy consumption in a short period of time.
- **The staged renovation** consists of several renovation steps, spread over a few years. This approach decreases the upfront cost, which could encourage more people to undertake renovation measures.

EPBD requires the implementation of a long-term renovation strategy (LTRS), where BRPs could offer support by providing information to public authorities on building stock state, help identify the most suitable financial incentives and give overall information about the long-term projection on the renovation measures to be implemented.

Energy Performance Certificates (EPCs) were introduced by the EPBD in 2002 and upgraded through the EPBD recast in 2010. The BRPs can be seen as an upgrade from the EPCs as they include more detailed and personalised renovation recommendations. The connection between the EPCs and BRPs is not clearly defined, and member States (MS) are taking different approaches to connect these two instruments. Nevertheless, the EPCs can be the basis for introducing BRPs especially if they can be linked to the existing databases and registries, allowing the users to always have up-to-date information. Logbook (repository with building-related information) can thus be used to provide all sorts of information, needed to produce a BRP, such as energy consumption and production, maintenance and floor plans.

To have a real impact, BRPs depend on the design and implementation of its key elements. Three key elements of BRP frameworks are as follows:

1. Reaching out to building owners: it is important to make people interested in deep renovations.
2. Data collection requirements: can be developed based on different data. However, *"A BRP that is primarily based on an on-site audit is likely more accurate than one based on available data, such as EPCs, user-inserted information or automated data (house templates, construction norms, climate data, etc.). On the other hand, gathering onsite data is more expensive" [2].*
3. The technical framework for building modelling: it is important to have the model with up-to-date information on the components. This model will be used for the simulation of energy consumption and comparison with actual energy consumption. This can lead to adjustments in the model and enhancement of modelling reliability. In the end, by defining the energy

demands based on the desired situation of the building owner, a set of renovation packages will be defined.

Currently, no common EU framework exists to ensure these steps.

The intention of BRPs is to provide detailed and customized renovation advice to building owners, taking into account their needs and specific situations (e.g., age, financial situation, the composition of the household, etc.). Based on the technical aspects and the financial planning of the building owner, the number of renovation steps should be defined. EPBD has defined "trigger points" as key moments in the life cycle of a building when energy renovations can be done with less disruption and more economic advantage. When possible, alignment of BRP renovation steps with trigger points is advantageous. A trigger point can be:

a) A transaction: e.g., rental or lease of a building;
b) Renovation: e.g., non-energy related renovation;
c) A disaster or incident: e.g., earthquake, damage caused by hail.

2.1.1 Building Renovation Passport Components

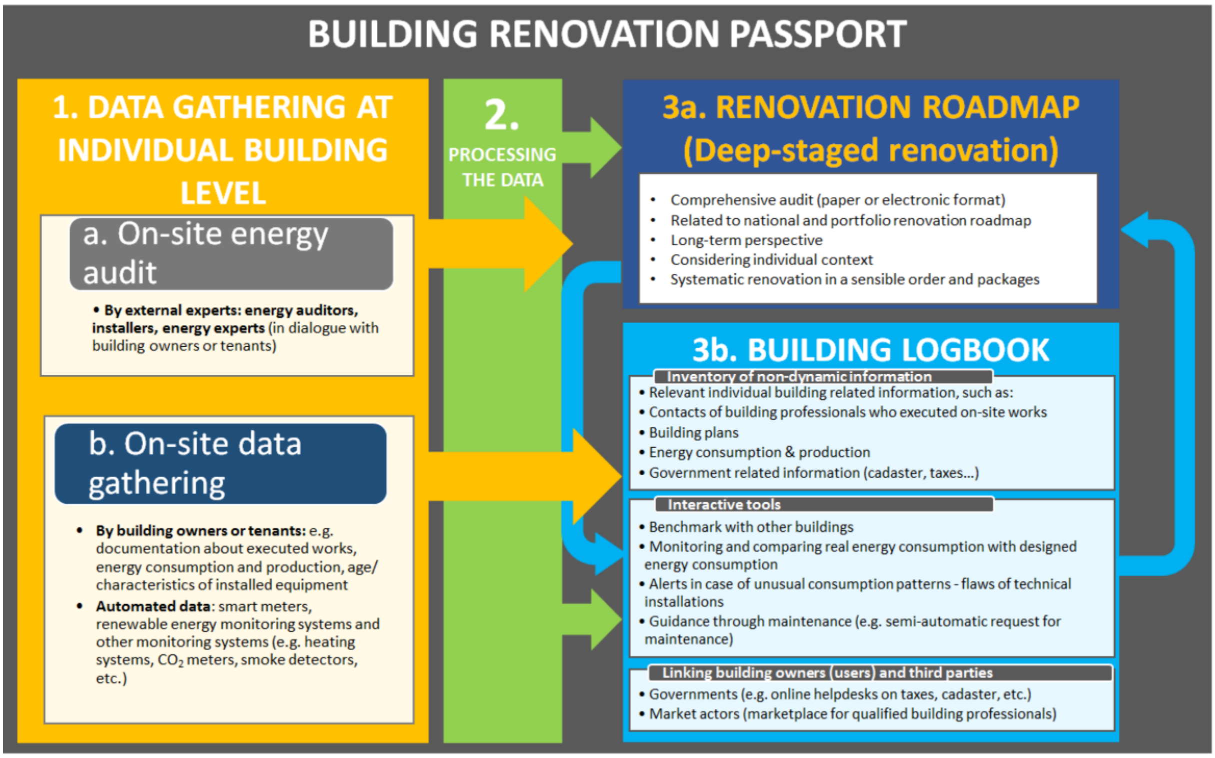

Figure 3 Building Renovation Passport - Overview of its components [3]

Figure 3 shows the main elements of a BRP. The final product of BRP is a renovation roadmap, which outlines renovation steps. They also provide a set of indicators and a dynamic dimension, to stimulate deep or staged renovations. Besides the roadmap, they can also include a building logbook, as a digital register to inventory and update the building's information. This information varies from building features to financing options. Although the main user of the logbook is property owners, access can be granted to other stakeholders, such as public authorities. On a more sophisticated level, they can be used as an interactive tool to monitor real energy consumption, and even to send alerts in cases of unusual patterns in consumption. These components are described hereunder.

2.1.1.1 Data Gathering and Data Processing

The first elements of an effective renovation roadmap are an on-site visit and an energy audit. This includes not only an energy audit but also an opportunity to get input from the owners about their constraints and preferences. Customer engagement includes consideration of the individual situation – their needs and wishes, expectations and also things like living space changes and family planning.

To have a successful tool for data gathering, it is important to have it simplified to be user-friendly. There are different models of data gathering, such as checklists.

2.1.1.2 Renovation Roadmap

After the on-site visit which includes a discussion with the building owner and the energy audit, the renovation roadmap shall consist of the following key elements:

- Performance indicators to measure progress.
- Guidance and recommendations for the building owner.
- Simplified information.

The outcome outlines each renovation step and the links between the implemented measures. Altogether forms a home renovation plan, which does not include only technical interventions, but offers a holistic and detailed plan of the renovation for the building owner [4].

Performance indicators to measure progress can be defined as a measurable value which demonstrates the level of effectiveness of a certain objective achievement. In the case of renovation roadmaps, these indicators can be related to the building's energy performance, but also go further into health, comfort, and behavioural aspects. These indicators are defined based on the conditions of the building, and the objectives that should be achieved. By having these two answers, the final step is to identify what should be measured to be able to implement and monitor performance improvement. The type of measures and the order they should be implemented should be included in the renovation roadmap. It should also include a clear overview and a detailed description of the proposed measures. [4]

Table 1 List of potential KPIs for BRPs

1. Energy Consumption	• Primary energy consumption kWh/m^{2}year (heating, DHW, cooling, fans, pumps, control) • Final energy consumption kWh/m^{2}year (heating, DHW, cooling, fans, pumps, control) • Net energy consumption kWh/m^{2}year (heating, DHW, cooling) • Energy consumption per energy type and carrier kWh/m^2 year
2. Construction characteristics	• Heat transfer coefficients (U-value) of the building elements (Floor, walls, roof, windows)
3. CO_2 emissions	• Equivalent CO2 emissions in kg per year per m^2, kg CO_2/m^2 year (heating, DHW, cooling, fans, pumps, control)
4. Heating system	• Type of heating system
5. Indoor Air Quality	• Ventilation & airtightness ○ Type of ventilation system ○ Efficiency of heat recovery (if available or applicable) ○ Definition of ventilation rates

	○ Airtightness levels ○ Infiltration rates • Air pollutants/contaminants ○ Carbon Dioxide (CO_2), Carbon Monoxide (CO), Particulate Matter (PM), Volatile Organic Compounds (TVOCs)
6. Thermal Comfort	• Factors affecting thermal comfort ○ Air temperature °C ○ Relative humidity % ○ Air velocity (m/s) Metabolic rate (MET) ○ Clothing insulation (CLO) • Evaluation of thermal comfort ○ Qualitative approach- Survey ○ Quantitative approach- Measurements
7. Lighting	• Natural lighting ○ Daylight factor ○ Daylight autonomy ○ Useful Daylight Illuminance • Artificial lighting ○ Type of lighting ○ Power of installed lighting fixtures ○ Spatial light distribution
8. Acoustics	• Sound pressure level dB(A) • Reverberation time
9. Renewable energy production	

2.1.1.3 Building Logbook

A digital building logbook is a repository for all relevant building data. There are different types of data stored in a logbook; some have a static nature, and some are dynamic and regularly updated. The main goal of a logbook is to facilitate transparency, information sharing, and informed decision-making among the sectors' actors;

> *"A digital building logbook is a dynamic tool that allows a variety of data, information and documents to be recorded, accessed, enriched and organized under specific categories. It represents a record of major events and changes over a building's lifecycle, such as change of ownership, tenure or use, maintenance, refurbishment and other interventions* "[5].

A building logbook is not a mandatory component of a BRP [3]. However, a logbook has multiple potential benefits for a BRP as follows [4]:

- Enhanced access to information;
- The reduced associated risk of purchasing a property;
- Increased trust and reliability;
- More accurate risk assessment and risk mitigation;
- Better informed decision-making;
- Improved real estate value of sustainable buildings;
- Increased awareness of energy use and saving potential;
- Optimized operation, use, and maintenance;
- Enabling demand response;

- Checking compliance with certification;
- Innovation through digitalization;
- Enabling public authorities to develop better policies;
- Monitoring building stock compliance with climate objectives.

2.1.2 Existing Building Renovation Passport Schemes

In this chapter, three existing BRP cases from Belgium, France, and Germany are studied to facilitate a better understanding of the realization of BRP.

2.1.2.1 Germany – Individueller Sanierungsfahrplan (iSFP) (Individual Renovation Roadmap)[3]

iSFP is designed based on a preliminary audit, from which a renovation roadmap results. The approach is described as reasonable and dialogue-based (between the auditor and the building owners). This audit includes steps from on-site visits and data gathering to analysing the data and providing renovation options. In this BRP the building owner is at the centre of the process, and the measures are customized based on the needs of the owner, and the specific features of the building. A scheme from iSFP is presented in Figure 4.

The characteristics of iSFP are as follows [3]:

1. Defining relations between different measures, such as feasibility, and sequencing of measures;
2. Possible to have further additional measures overtime;
3. Suggesting optimized solutions to prevent lock-in effects;
4. Aiming to implementation of best possible standards at each step;
5. Customized based on the needs of the owner;
6. Considering the specific features of buildings.

iSFP does not include a digital logbook. It targets privately-owned houses, and its main components are:

1. A long-term planning introduction;
2. Technical documentation of proposed measures and their energy performance;
3. Supporting material for implementation such as financial aspects;
4. Guidelines for the energy auditor.

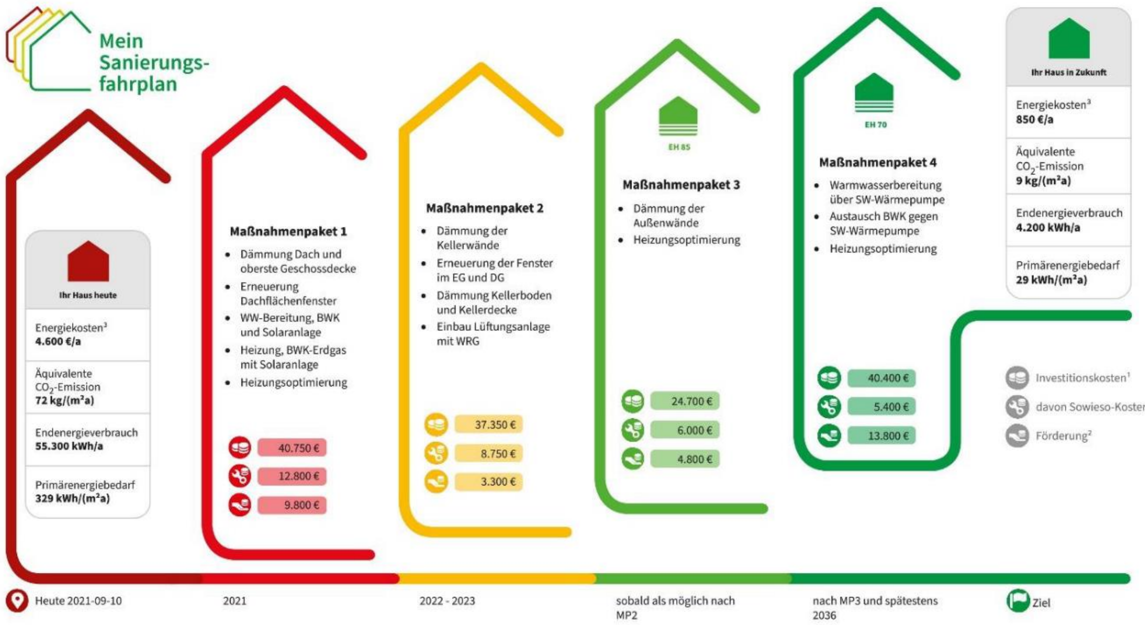

Figure 4 Overview of iSFP Renovation Roadmap [5]

The key features of iSFP are as follows:

- Linked to a national long-term target for the energy performance level of the building stock
- Building owner-centered process
- On-site audit and dialogue as the basis of the recommendations
- Including customized measures and support materials for the building owner
- Including guidelines for energy auditors
- Providing training to energy auditors

The steps for planning a renovation roadmap for an individual building in iSFP are elaborated hereunder [9]:

1. Consultation and on-site data acquisition:
    - Mandatory kick-off meeting with the client and a site visit.
        - This visit aims to gather information about the current energy-related condition of the building. Besides, it is so important to consider the individual needs of the client. For example, consider comfort aspects apart from purely energy efficiency-related aspects. These additional, non-energy aspects can be very helpful when creating packages of measures and can play an important role in further discussion on improvements.
        - It is important to agree on the scope of the services of the EPC Assessor.
        - It is suggested to create an initial framework for the renovation strategy of the building.
        - It is important to explain to the client that the renovation roadmap does not replace planning but conveys a systematic renovation strategy that takes into account cost-effectiveness and customer requests.
    - Fill out the checklist for data acquisition at the initial visit.
2. Recording of the actual energy state:
    - The current energy performance of the building is analyzed according to the standard GEG2020. The overall energy condition is evaluated independently of the specific usage pattern and behaviour and therefore shows demand-based parameters, which are

  - based on the standard boundary conditions according to GEG2020. For this purpose, it is necessary to use one of the approved software to do so.
  - Energy simulation classifies the building into a certain energy class. The outputs of the simulation are shown as colour classes from dark green to dark red and are used in the timetable document both to characterize the current status and to clearly show improvement measures.
3. Development of renovation proposals:
  - Once the energy performance has been analyzed, it is necessary to consider the personal and financial requirements of the owner. The methodology is focused on involving the owner in agreement on the different renovation options.
  - Depending on the owner's demands, several renovation scenarios can be compared.
  - The document makes emphasis the fact that the renovation roadmap is limited to showing renovation principles and their energy effects. It cannot and should not replace any architect, specialist or work planning.
  - The EPC must find the right balance for the owners in order to protect them from inadequate energy standards in the long term. The EPC assessor must try to achieve the "best possible" energy performance considering the available resources. For example, the assessor must not recommend a 100% improvement at any cost. A cost vs performance balance must be considered.
  - If possible, in an ideal situation of having enough resources, the roadmap must aim to have the dark green class. Nevertheless, the standard can be lowered as far as absolutely necessary, although the EPC assessor should be able to explain the reasons to lower it.
  - A feature of the step-by-step renovation in the individual renovation roadmap is the formation of packages of individual renovation measures that can be sensibly combined together in one package. Some guidance about how to combine the proposals is given.
  - The renovation proposals must present a cost analysis.
4. Aligning the owner to the roadmap:
  - Once the different proposals have been drafted, the assessor must help the owner to decide on a concrete package of measures. In this process, the EPC assessor must explain not only the energy improvements but also the improvements in terms of comfort, sound protection, building value, safety, accessibility, etc.
  - The owner must consider the different options, costs and benefits and make a decision accordingly.
5. Creation of the final renovation roadmap:
  - Once the owner has decided which measures will be implemented, the detailed development of the individual renovation roadmap begins.
  - The different measures accepted must be simulated jointly in the software.
6. Printing the results:
  - The two mandatory documents: "My renovation roadmap" and the "Implementation aid for my measures" can be printed.
  - Once all the last changes, additions and corrections have been made, the renovation roadmap can be exported as a PDF file.
7. Final discussion and explanation of the schedule:
  - In the end, the final results are handed over to the homeowners and explained in a final discussion.
  - The owners must receive two documents: the document "My renovation schedule" and the document "Implementation help for my measures".

The above-mentioned Checklist for data acquisition, the so-called "iSFP Checklist" [9][10] serves as an aid in filling in the data and it is to be completed by the energy consultant on site. The four parts of the checklist are presented below:

1. Information about the ownership and usage.
2. Information about the building.
3. Recorded data from the building.
4. Information about the technical systems.

Annex A presents this information in more detail.

2.1.2.2 Belgium – Woningpas (Dwelling ID)

This BRP includes two main parts, the "renovation advice" and the "digital logbook". It is linked to EPCs. The renovation advice provides a roadmap for renovation planning. This BRP supports the needs of two target groups, a) building owners, and b) potential property buyers and tenants. The renovation advice is designed for the former, and "EPC+" is designed for the latter group. The renovation advice contains measures beyond only energy. On the other hand, the EPC+ is an enriched EPC which not only informs the users of the energy value of the building but also gives a clear image of what should be done to achieve a future-proof energy-efficient standard. The digital logbook which is called "Building Passport" is filled with the collected data about the building.

The main features of this BRP are as below [3]:

1. Automated advice;
2. Customized advice based on the proposed measures;
3. Customized renovation steps based on the user's needs;
4. Includes a digital logbook.

To avoid conflict between objectivity and personalisation, this BRP suggests three scenarios; the first one is the optimum long-term path without personalized wishes, the second scenario is tailored to the user's needs, and the third one is a path that goes beyond the long-term objective. For each scenario, the desired energy level to achieve can be incorporated. A combination of renovation measures would be offered based on the selected scenario, including:

- Building envelope elements;
- Renewable energy systems;
- Technical elements;
- Lock-in preventive measures.

An overview of performance indicators in the renovation advice is shown in Figure 5.

Step	0	1	2	3	4	5	Total
Measure	Initial situation	Roof	Walls	Installation	Renewable Energy	...	Total Renovation
Energy performance label	F	C	B	A	...	AAA	AAA
Investment (€)	0	20.000—30.000	30.000—40.000	4.000—6.000	...-...	...-...	...-...
Comfort	☹	😕	😐	🙂	🙂	😀	😄
Real estate value	+ 0%	+ 5%	+ 10%	+ 3%	+ 3%	+ 1%	+ 22%
Annual CO_2 - savings (kg)	0	5.500	5.000	4.000	7.000	1.500	23.000

Figure 5 Overview of performance indicators in the Renovation Advice [3]

The key features of Woningpas are as follows:

- Linked to the regional long-term target (2050) for the energy performance of the building stock
- Linked to EPCs

- Building owner-based process
- Including customized measures for deep renovation
- Including a digital logbook
- Easy-to-use

2.1.2.3 France – Passeport Efficacité Énergétique, P2E (Energy Efficiency Passport)

The Energy Efficiency Passport (P2E) is a web platform which offers three independent connected areas, designed for three target groups: owners, auditors, and renovation professionals. P2E has a pragmatic approach. It aims to maximise the opportunity for energy renovation when maintenance work is done in a building. The passport suggests a set of solutions by combining the best measures allowing to achieve BBC level (Bâtiment Basse Consommation - Low-Energy Building), and it is based on the features of the building, such as age, climate, type, etc.

The passport has the following dimensions [3]:

- A collaborative tool for all stakeholders;
- Based on EPC as the starting analysis point, goes further to personalized advice;
- A pedagogical tool, aiming to simplify the renovation jargon for owners;
- A flexible tool providing tailored paths, and monitoring the evolution of the building;
- Open-sourced and evolving tool.

The process starts with a certified audit in three steps technical visit, a discussion with the occupant, and completion of the renovation scenario. The results are provided online, with an overview of the indicators: energy, comfort, detailed features, valuation, and financial aspects. The web platform is also linked to a page for storing the relevant documents and files for the building's renovation and maintenance. This will contribute to the Energy Performance and Renovation component of '*Carnet numérique de suivi et d'entretien du logement*' (Digital notebook for building operation and maintenance) from the French government. An example of P2E is shown in Figure 6.

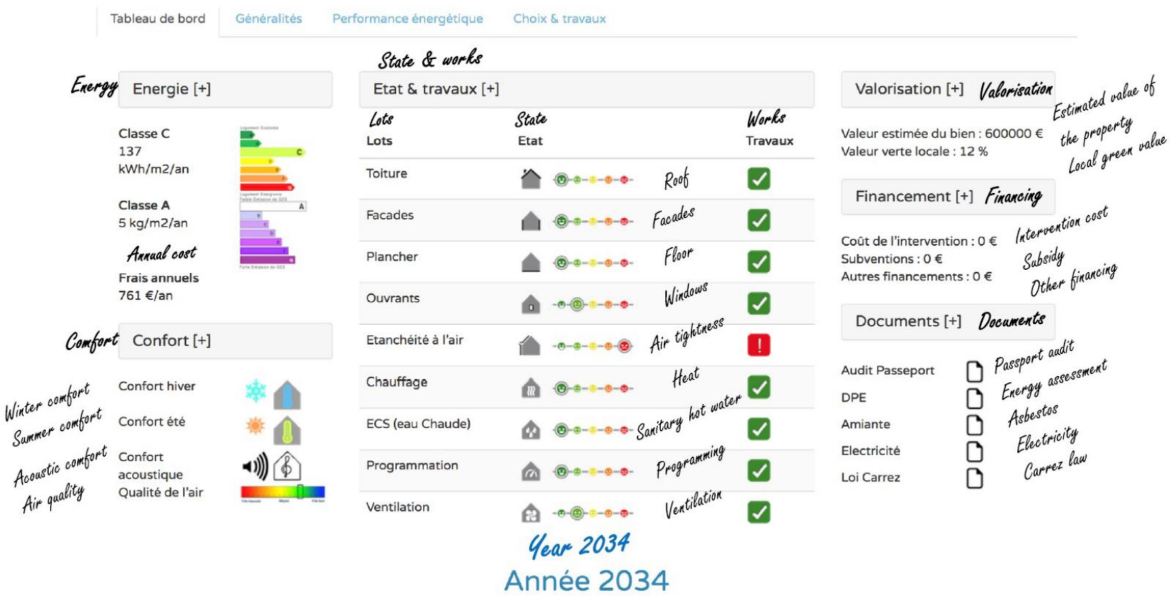

Figure 6 Energy Efficiency Passport Dashboard [2][3]

The key features of P2E are as follows:

- Linked to a national long-term target (2050) for the energy performance of the building stock
- Building owner-centered process
- On-site audit

- Industrialized renovation approach
- Main users: owners, auditors, renovation professionals
- Including Comfort as a KPI

2.1.3 Other similar schemes

A. Denmark – BetterHome

BetterHome is not a BRP per se, however, it has many similarities with a BRP. BetterHome is an innovative business model with a focus on deep renovations. It is an "industry-driven one-stop-shop model" which simplifies and structures the renovation process for installers. It can be called a home-owner-centric business model, with an advanced service-oriented role of the installers. Figure 7 shows a scheme of BetterHome[1].

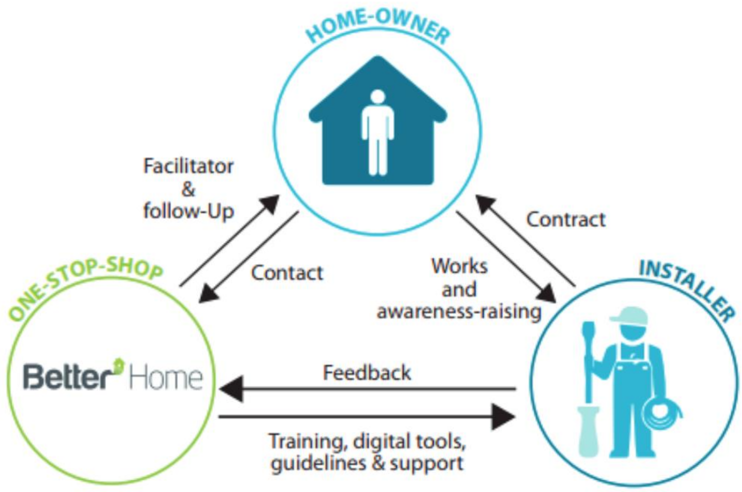

Figure 7 BetterHome's Scheme

2.1.4 Comparison of existing schemes

A comparison between all four schemes can be seen in Figure 8. When comparing whether different processes are present in the existing scheme or not, the German iSFP earns the highest score.

[1] https://www.betterhome.today/

Process	BE-Flanders (EPC+)	France (PEE)	Germany (iSFP)	Denmark (BetterHome)
Definitions (Deep or staged deep renovation and/or alternative definition)	√	√	√	X
Long-term target for the existing building stock (2050)	√	√	√	X
Identified barriers	√	√	√	√
Stakeholders mapping	√	√	√	√
Stakeholders engagement	√	!	√	√
Market analysis	√	√	√	X
Energy Audit – On-site visit	X	√	√	√
Auditors training	X	√	√	√
Tailored solutions (renovation roadmap)	!	√	√	√
CO_2 reductions	√	!	√	√
Logbook/Database	√	!	X	!
Integrated financial support	!	N/A	√	!

√ = Yes   ! = Under development/consideration   X = No

Figure 8 Overview of key features in the existing schemes [8]

3 Next-generation EPC and BRP

BRPs create the opportunity to strengthen the use of EPCs. The current application of EPCs does not contribute much to the increase in renovation rates. EPCs are either not taken into account (e.g., Germany), or just considered as a reference (e.g., France) [4]. The recommendations for energy upgrades are automatically generated by a standard list (e.g., increasing insulation, replacing windows, etc.) and do not offer a user-friendly document that would motivate renovation. Thermal and human comfort aspects related to occupant well-being in inhabited spaces are currently not considered by the existing EPC schemes and even though thermal and acoustic comfort, indoor air quality, and daylight are among the primary drivers for buildings renovation, they are not considered in current EPCs [11].

Integration of EPCs in the process of BRPs development is advantageous and creates an opportunity to encourage deep renovation [2]. A BRP can be identified as an evolution of the EPC, since in addition to an indication of the energy performance of a building, it also provides the owners with tailored renovation options [7].

A big community of researchers, market actors, and policy makers, is working towards a more sustainable energy approach while exchanging synergies with similar projects under the Horizon 2020 initiative. The synergy of these projects under the topic "Next-generation of Energy Performance Assessment and Certification" includes proposals that should consist of measures that encourage EU-wide convergence of EPC schemes and enhance the linkage between EPCs and deep renovation. For example, the "*Integrating Building Renovation Passports into Energy Performance Certification schemes for a decarbonized building stock - iBRoad2EPC*" project investigates energy performance assessment schemes and certification methods for the promotion and showcasing of the integration of Building Renovation Passport features into EPC schemes [11].

The analysis of the iBRoad project over the current use of EPCs and the potential links to individual building roadmaps and logbooks shows the following results [7]:

- More detailed renovation advice is required (than what current EPCs provide) as support of the decision-making process for deep renovation.
- EPC systems have not tackled barriers to renovation.
- Recommendations in EPC are often too generic.
- Owners generally have a moderate understanding of EPCs.
- EPCs do not increase the owner's awareness enough.
- The cost of an EPC scheme is high compared to the perceived benefits.
- EPCs should be more user-friendly and provide recommendations with a long-term perspective.

Also, the "*High-quality Energy Performance Assessment and Certification in Europe Accelerating Deep Energy Renovation – QualDeEPC*" project intends to improve the quality and cross-EU convergence of EPC programs, as well as the link between EPCs and thorough rehabilitation by providing refurbishment recommendations [11].

3.1 D^2EPC architecture and components

D^2EPC tools and components that are directly related to and can contribute to the Building Renovation Passport components or processes are being developed within the tasks shown in Figure 9 and compared with the BRP scheme in Table 2.

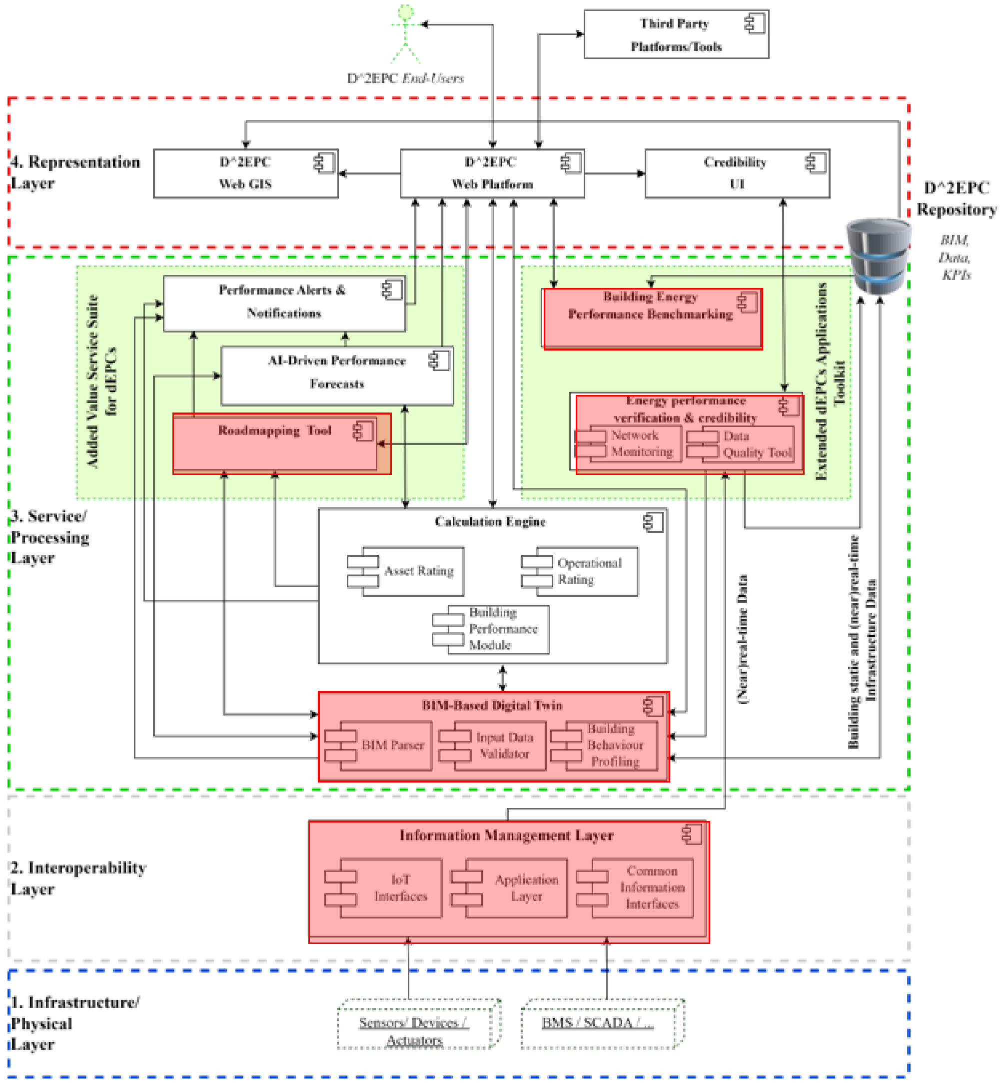

Figure 9 D^2EPC Layered Conceptual Architecture [12]

Table 2 Connection between D^2EPC components and BRP scheme

D^2EPC components	BRP scheme
Information Management Layer	Data gathering, Pre-Processing the data
Energy performance verification & credibility	Pre-Processing the data
Roadmapping tool	Renovation roadmap
BIM-based digital twin, Repository (not a tool)	Building logbook
Building energy performance benchmarking	Building logbook

3.1.1 Information Management Layer (T3.1)

The Information Management Layer (IML) is the cloud-based component responsible for administrating the sensing and metering datasets extracted from the Wireless Sensor Network deployed at the pilot premises. To accomplish this, the IML comprises the different software elements necessary for handling the collected data streams and interfacing between the modules of the project.

The role of the D^2EPC IML is not limited to simply collecting information coming from the Wireless Sensor Network and forwarding it to the D^2EPC repository. The component implements well-known and established algorithms responsible for cleansing and normalizing the various datasets related to energy consumption and ambient conditions. Furthermore, it is equipped with specialized tools capable of displaying and monitoring the respective datasets.

The IML Cloud component interacts only with two modules of the D^2EPC architecture: the D^2EPC repository and the Energy Performance Credibility & Verification module as seen in Figure 10. No other interfaces with the rest of the D^2EPC modules have been foreseen. This happens because the data extracted from the locally deployed wireless sensor network is transmitted from the IoT Gateway to the IML. After being cleaned and processed, the data is streamed to the D^2EPC common repository. It remains available to all the tools and services of the project that require real-life data during their operation. The second component interacting with the IML is Energy Performance & Verification. Its purpose is to ensure the reliability and credibility of the acquired data from the Wireless Sensor Network. This happens by applying an automated procedure that evaluates the collected information and identifies irregularities related to the data patterns that IML's cleansing mechanism could not have detected.

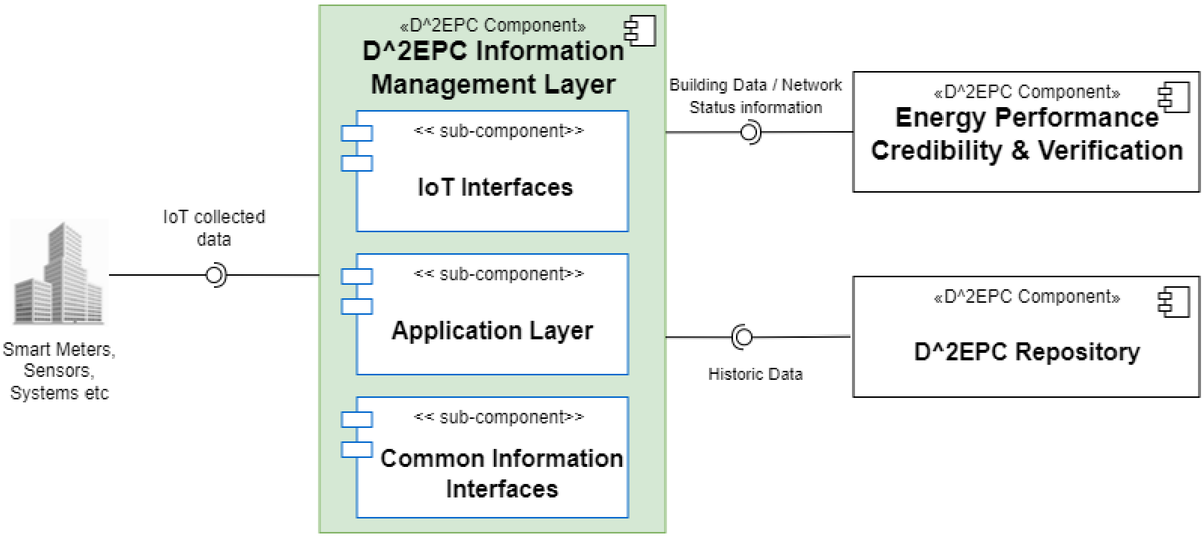

Figure 10 Information Management Layer functional diagram

Required inputs for the Information Management Layer are data from meters, sensors, systems, etc. and irregularities detected by the Energy Performance & Verification tool. The output of the tool is real-time, high-quality, cleansed data which is streamed to the Energy Performance & Verification tool.

The outcomes of the IML tool are a set of cleansed and normalised data, meaning that it corresponds to two different BRP components, namely the Data gathering and Processing the data, where for the later one a more precise naming would be pre-processing of data. This way it offers a reliable set of data, enabling accurate calculations of the renovation roadmap.

3.1.2 Energy Performance Verifications & credibility (T4.3)

The information regarding each building is categorized as information that concerns static elements and information regarding dynamic elements. Static elements represent the configuration of a building, such as its location, size, type, and building materials, while dynamic elements are represented by recorded data, provided by sensors. The Energy Performance Verification and Credibility (EPVC) module which has been developed for the D^2EPC project, is designed to continuously monitor the status of deployed devices and automatically check specific data quality features.

EPVC is a composite component that comprises two separate sub-components, the Network Monitoring Tool and the Data Quality Tool as seen in Figure 11. The former is responsible for receiving and analysing the operational status of the IoT devices installed locally at the pilot sites. The latter is responsible for verifying the qualitative and quantitative reliability of the collected data defining their suitability to be used by other project components.

The process of the Network Monitoring Tool consists of checking the current state of the IoT Devices and IoT connections and, in case of a malfunction, the tool will send an alert and represent the wrong behaviour in the UI to be presented to the final user.

Regarding the Data Quality Tool, which performs additional validation of the streaming datasets to deliver even more reliable data, the process consists of assessing specific applied checks, which evaluate various features relevant to the type, shape, and range of the collected data. Depending on the results of the assessment, a series of data verification KPIs are calculated: percentage of empty values, deviations from the baseline value and amount of dark data.

If the data is reliable enough, the module streams the processed information to the D^2EPC BIM-based Digital Twin. If the data quality is not acceptable, an alert is generated.

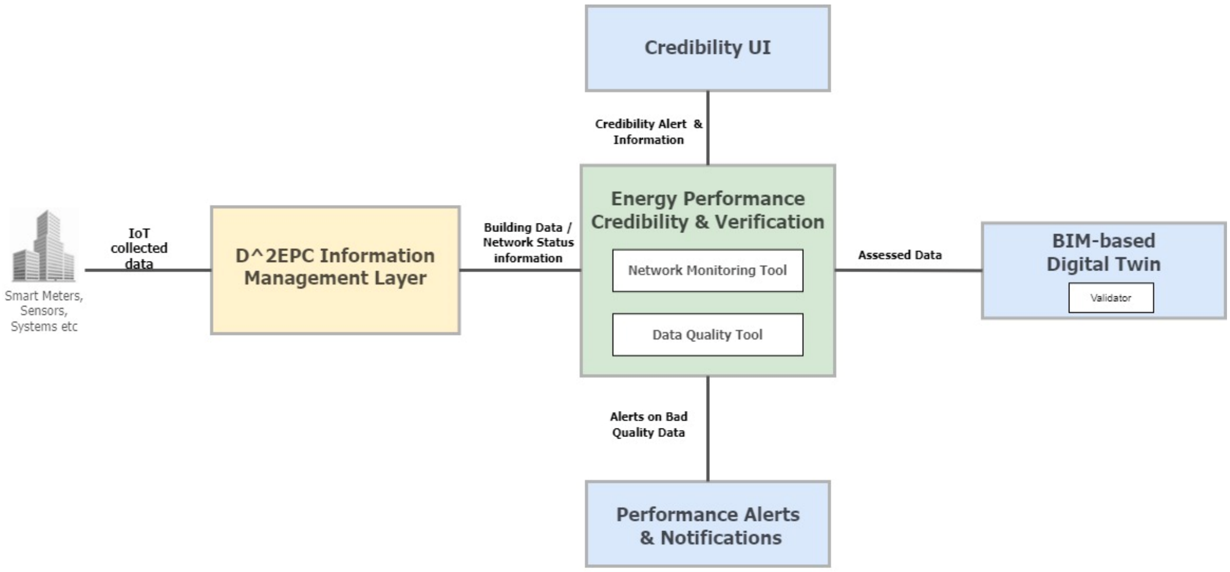

Figure 11 Energy Performance Credibility & Verification functional diagram

Inputs, which are needed for the Network monitoring tool are the state of the IoT devices and the state of the connections (IoT gateway). The outcomes include alerts and reports to the end user, informing about the malfunctioning of the system, diagnosis issuing and physical representation of the network to report equipment malfunctions. On the other hand, the Data Quality tool requires data from IoT devices (meters, sensors, …) in order to provide two outputs: in case the data quality is acceptable, it is sent to the Digital Twin while for the case of data quality not being acceptable, an alert is generated and sent to the Performance Alerts and Notification module which is responsible for connecting and pushing notifications to the D^2EPC platform.

Similarly to IML, one of the purposes of the EPVC tool is to ensure data quality and reliability and due to its pre-processing functionalities, it can be compared to the Pre-processing of the data component of the BRP.

Additionally, another important outcome of the tool, the alerts in case of malfunction of the devices and/or the network can be compared to the BRP component Building Logbook. The Building Logbook comprises a set of interactive tools, that include (among others) a log of alerts in case of unusual consumption patterns or flaws in technical installations.

3.1.3 Roadmapping tool (T4.2)

The Roadmapping tool's main purpose in the D^2EPC project is to evaluate and assess the building in order to provide renovation actions for energy performance upgrades considering environmental and economic indicators. The BIM-based decision support tool suggests optimal steps towards improvement of the EPC class and further feeds the information for the building renovation passport.

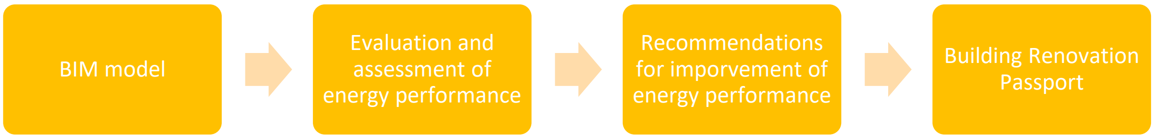

Figure 12 Roadmapping tool simplified steps

It leverages on the Asset Rating (AR) Module calculations, which provide the Roadmapping tool with crucial feedback for energy performance indicators. Therefore, the Roadmapping tool's strategy making is based on asset-based data, which is retrieved from the BIM-based Digital Twin.

In order to provide recommendations for an energy performance upgrade, the tool evaluates the building's envelope and indicates which elements should be improved based on thermal transmittance. Further on, the building systems are assessed based on minimum efficiency standards for heating and cooling systems and the minimum solar share of Solar Thermal Collector (STC) technical systems' attributes, followed by the consideration of installing or improving renewable energy sources. In order for the tool to be applied in all MS, the national minimum requirements for the relevant EU country must be acquired. The violation of the minimum requirement indicates the necessity of the renovation action, as shown in Figure 13.

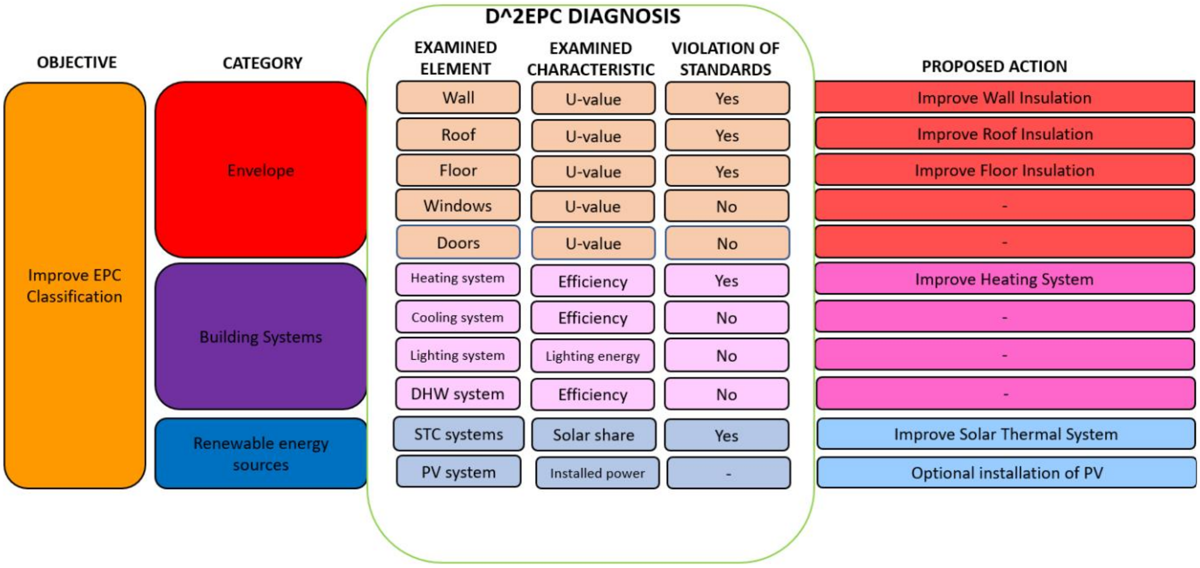

Figure 13 Workflow of Roadmapping Tool [12]

With the three steps of D^2EPC diagnosis, the elements' characteristics which can be improved are identified, and relevant action is proposed. At this point, it is important to evaluate these actions regarding the impact they would have on the improvement of the EPC classification of the building. Therefore, for each action, a scenario is generated, and these scenarios can be prioritized based on the performance improvement and high return investment with short payback year period.

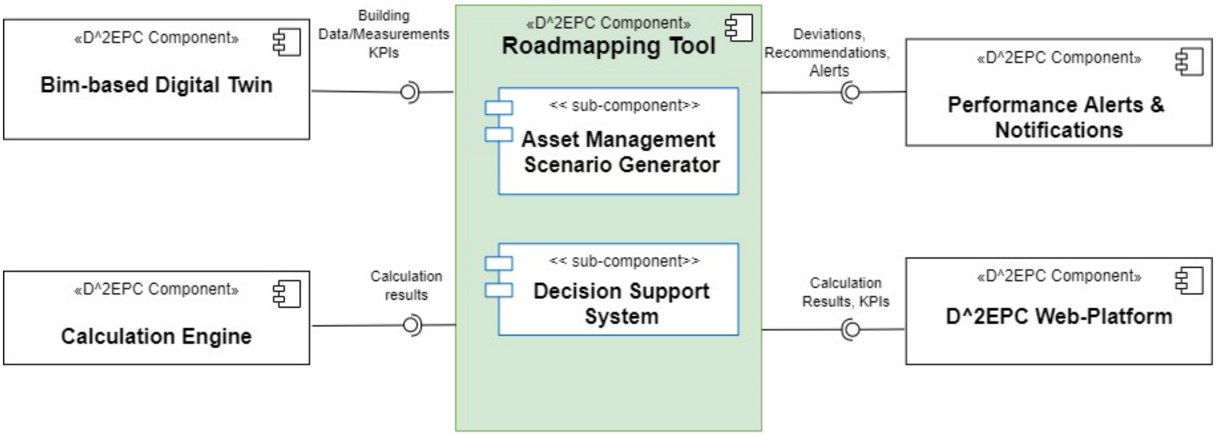

Figure 14 Roadmapping tool functional diagram [12]

The required inputs for the Roadmapping tool to operate are the minimum national requirements and BIM data (area of each thermal zone, thermal characteristics (e.g., U-value) for each envelope element, technical systems efficiency and nominal power). The outcome of the Roadmapping tool is a complete renovation roadmap to guide the end-user about the environmental and economic impact of the renovation action. After energy and renovation cost calculations, all data are gathered per renovation action in a table. The table contains all the possible renovation actions prioritized by payback years.

The outcomes of the Roadmapping tool can be integrated into BRP, based on the following characteristics:

- Providing multiple recommended renovation actions which enables the user to select and prioritize them, define different scenarios and plan the renovation based on them.
- The building-specific approach of the Roadmapping tool aligns with the requirements of the BRP renovation roadmap.
- Standards can be varied in each state, and the Roadmapping tool enables a national approach regarding minimum requirements, such as U values for the envelope, the efficiency of the technical system or RES shares.
- It indicates the expected benefits in terms of saving indicators (energy savings, cost savings, emissions) and primary energy consumption indicators and building heat transfer coefficient.
- Based on the existing BRP cases, a renovation roadmap outlines the improvements in the energy performance class, as a result of the recommended renovation measures. The Roadmapping tool provides the expected energy performance class of the building as a result of each renovation action.

Areas where the Roadmapping tool could be improved to better fit the BRP component:

- It shall indicate steps to meet the objective of transforming the building into a zero-emission building by 2050.
- It does not indicate the expected wider benefits related to health and comfort and improved adaptive capacity of the building to climate change.
- It does not contain information about potential financial and technical support.
- The renovation roadmap shall “indicate a sequence of renovation steps building upon each other”. The Roadmapping tool provides renovation recommendations prioritized only by a chosen KPI.
- Building renovation passport shall “outline deep renovation scenario(s), including steps to implement energy saving measures”. The Roadmapping tool does not provide groupings of the recommended renovation actions.
- Building renovation passport outlines the renovation scenarios “over a defined period of time”. The outcomes of D^2EPC renovation actions are not time-bound.

3.1.4 BIM-based digital twin (T3.3)

The Building digital twin is a building description model in a digital environment with static information, enriched with real-time building data, coming from the installed IoT devices. The foundation of a digital twin is a detailed BIM model which stores all the building-related data that reflect the building’s reality. AI computational capabilities can use the information, coming from the BIM model, simulations and IoT data for forecasting and advanced decision-making processes - by identifying the building energy behaviour patterns, the opportunity for near future energy performance predictions will be given.

The building digital twin of the D^2EPC includes three core sub-components, namely the BIM Parser, the Input Data Validator and the Building Behavior Profiling, and it is equipped with interfaces for other modules that require access to static and dynamic data. The main input data providers are the user, inserting static data through the WEB platform, and the Information Management Layer (IML), delivering close to real-time (dynamic) data, which is collected from sensors and meters installed in the actual building sites. Input from the user may be realized using two different formats. On the one side, a BIM file in IFC format can be uploaded to the platform and then utilized by the BIM Parser to extract any necessary data automatically. On the other side, any information, which is not or cannot be included in the IFC file, yet is necessary for the desired calculations, can be inserted manually through a proper web form [13].

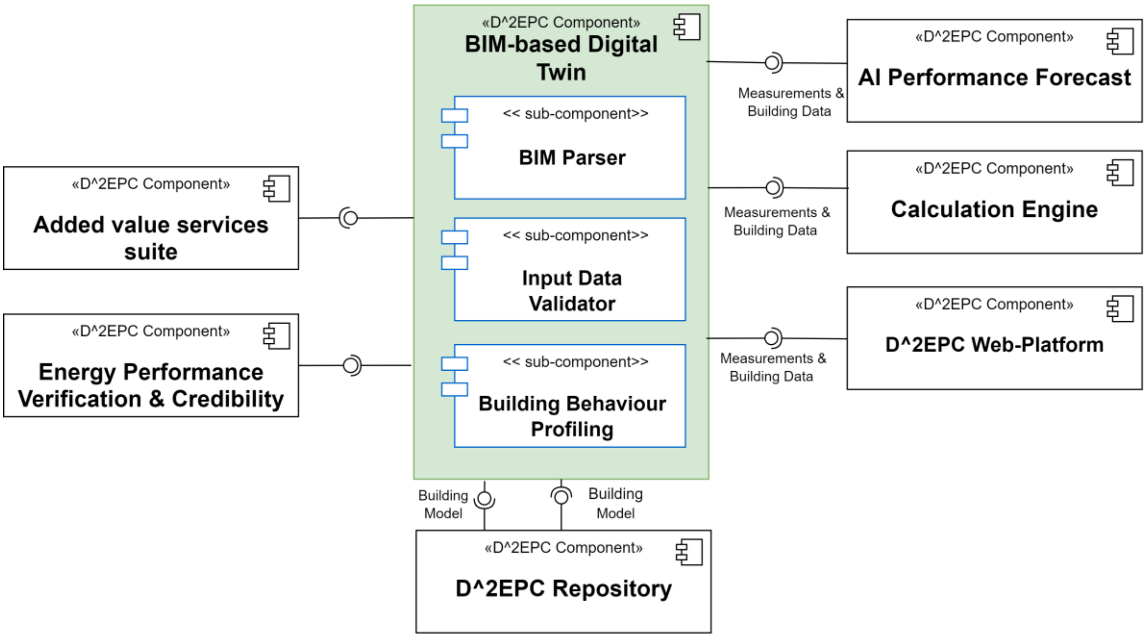

Figure 15 Digital twin functional diagram [13]

A BIM Parser has been developed as a core component of the Digital Twin module, serving as a tool that enables the extraction of building information from an IFC file.

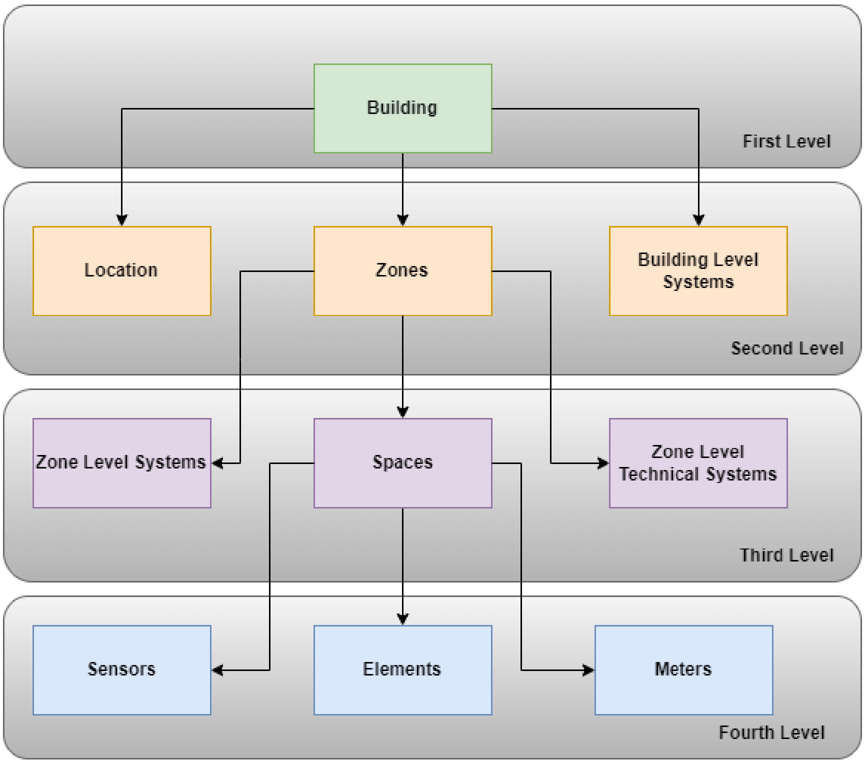

Figure 16 BIM Parser conceptual level architecture [13]

Required inputs for the creation of the operational digital twin thus include a BIM model, with defined location, zones and building level systems. Further on, the zones should include information on zone-level systems, spaces and zone-level technical systems. Spaces should include information about the elements that are needed for calculations. Besides the BIM model, required inputs include information from the user, if needed, and close to real-time data, coming from sensors/meters. The BIM-based digital twin thus collects all the required information that is needed for other modules which require static and dynamic data of the building, such as the operational rating calculation engine and the building performance module.

The outcomes of the BIM-based digital twin can be integrated into BRP, based on the following characteristics:

- A digital twin is a digital register of building information.
- It can be used as an interactive tool to monitor real energy consumption and to send alerts in cases of unusual patterns in consumption.
- It collects static and dynamic data on buildings.

Areas where the BIM-based digital twin could be improved to better fit the BRP component:

- Including an inventory of non-dynamic information such as contact of building professionals who executed on-site works, and government-related information (cadaster, taxes…).
- Linking building users and third parties such as governments (online helpdesk on taxes, cadaster, etc.,), and market actors (marketplace for qualified building professionals).

Besides the BIM-based digital twin, the D^2EPC platform consists of the Repository as well, where building information is stored. Although this is not considered a tool, it complements the digital twin and thus supports the calculation process within the D^2EPC platform.

3.1.5 Building energy performance benchmarking (T4.3)

The Building Energy Performance Benchmarking (BEPB) module is being developed in T4.3. This module consists of two sub-components, namely the Classification tool, and the Benchmarking tool. The module's objective is to develop a categorization mechanism for buildings under study and provide benchmarks for various cases regarding energy performance. The tool collects information for buildings under study from the D^2EPC framework database. A dataset is constructed in order to implement benchmarking algorithms and derive insight. After data pre-processing, several data-frame columns are used for benchmarking cases implementation, such as Heating, Cooling, Ventilation, Lighting, DHW(domestic hot water), Electricity, Dynamic Envelope, EV Charging, Monitoring & Control, SRI General Score, SRI Class Country, European Region, Building Primary Usage, Construction Year, Construction Decade, Building Area, Building Area Label, Asset Rating Class, Operational Rating Class, Operational Rating Cooling, Operational Rating Heating, Operational Rating Lighting & Electrical Appliances, and On-Site RES.

A clustering algorithm is implemented for the categorization mechanism, which is fed with data regarding smart readiness. Insights are presented in tabular form of bar charts for each building category. The plan is to enrich the clustering dataset with data that refer to Asset Rating and Operational Rating.

The benchmarking cases fall into two categories. The first category derives insights for the entire D^2EPC building collection, while the second category is about a specific building under study. To provide benchmarks for a specific building, the building model (in IFC format) must be processed by SRI, Operational Rating, and Asset rating tools, as the output of these tools is required as input for the benchmarking tool.

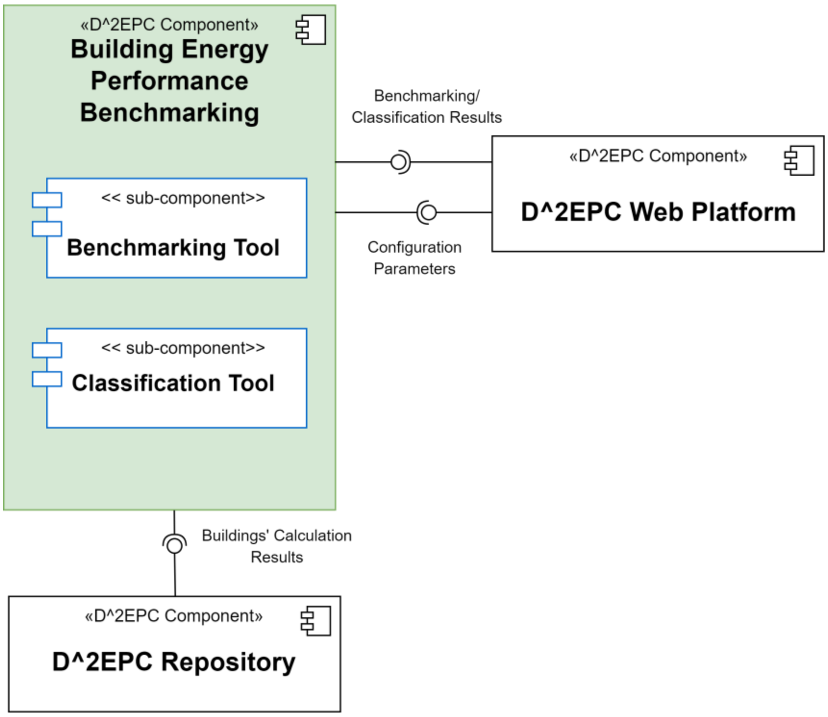

Figure 17 Building Performance Benchmarking functional diagram [12]

The required inputs for the component to operate are SRI-related data, operational rating related data, asset Rating related data and building information (country, European region, construction year, etc.). The outcomes include the insight regarding SRI, Asset, and Operational Rating for the whole building repository, the insight regarding SRI, Asset, and Operational Rating for buildings under the same category (cluster) and the benchmarks for a building under study regarding SRI, Operational Rating and Asset Rating in combination with additional benchmarking options (country, European region, construction decade, building area etc.)

The outcomes of the BEPB tool can be integrated into BRP, based on the following characteristics:

It provides comparative results of the building energy-related performance (as-operated, as-designed, smart-readiness) for buildings under the same category (e.g., country/region/building type etc.), indicating the improvement potential.

A full building benchmarking report can be held in the LOGBOOK regarding energy performance according to D^2EPC tools which include:

- Asset Rating results
- Operational Rating results
- Smart Readiness Results

and statistics related to the above results combined with other benchmarking options such as:

- European Union region,
- European Union country,
- building construction decade

etc.

Areas where the BEPB tool could be improved to better fit the BRP component include:

The BEPB tool could be optimized to produce benchmarks regarding some of the potential KPIs for BRPs as those are described in paragraph 2.1.1.2 of section 2. Given KPIs results for a decent number of buildings, useful comparisons and statistics can be derived and act as renovation triggers, in case the BEPB tool results indicate that a building's under study scores are far lower than KPIs mean scores or in comparison to a reference building. The BEPB tool provides statistics based on the European Union region, European Union country, building construction decade and any available combination of the aforementioned options. In that way, interested parties could use the BEPB tool for decision-making regarding renovation action/plans.

A simple ranking system could be implemented with recorded history so that the impact of building interventions in the benchmarked energy-related performance is visible.

4 Implementation in demonstration cases

Information Management Layer (IML) and Energy Performance Verification and Credibility (EPVC) modules work in the same way for all buildings, regardless of the number and type of meters and sensors. The IML module is in charge of data gathering from sensors and meters and also of the first pre-processing of those data. IML takes the data and carries out the process of cleansing and normalizing them. EPVC module further contributes to the pre-processing of the data, performing an additional validation of the datasets to deliver even more reliable data. Furthermore, EPVC comprises the Network Monitoring Tool, which checks the status of the devices and the network and, in case of a malfunction, sends an alert and represents the wrong behaviour in the UI to be presented to the final user.

The other components that were identified as BRP-related, namely the Roadmapping tool, the BIM-based Digital Twin and the Building Energy Performance Benchmarking tool work in the similar manner for all the pilots. Below the outcomes for Case Study 1: nZEB Smart House DIH (CS1) and Case Study 4: Mixed-use building in Nicosia (CS4) are presented, highlighting the differences per pilots.

4.1 Case Study 1: nZEB Smart House DIH

4.1.1 Renovation roadmap

The Renovation roadmap which is an outcome from the Roadmapping tool provides renovation actions for the building. In case of CS1 only one renovation action was identified due to building's high efficiency.

Table 3 Renovation actions for CS1

Renovation Action	Emissions	Emissions Saving	Energy Bill Cost	Energy Bill Cost Saving	Energy Class	Energy Saving Percentage	Payback Years	Primary Energy	Renovation Cost
DHW Upgrade Residential	0	0	-539.9	174.2	A	47.6	9.8	-9209.4	1700

The renovation actions, timeline and energy are clearly presented in the D^2EPC platform.

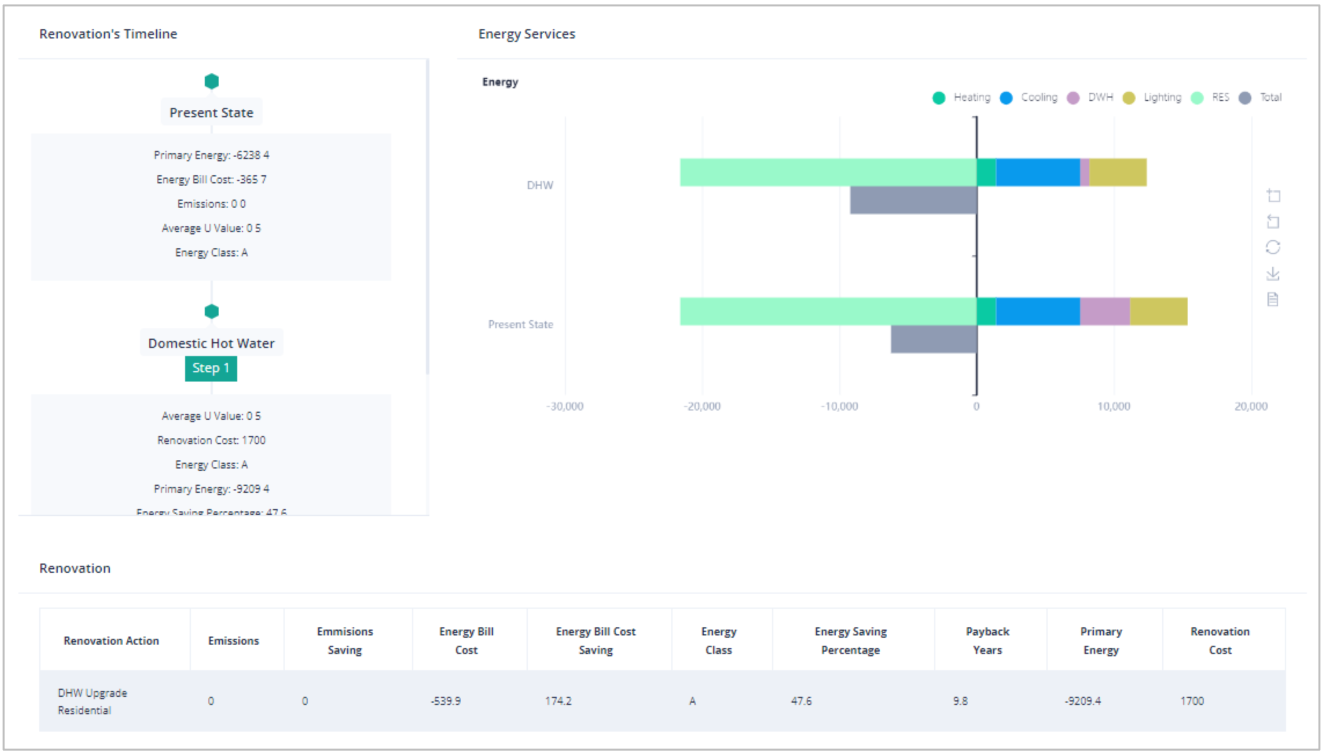

Figure 18 Roadmapping tool outcome for CS1

4.1.2 Building logbook

The approach to building the logbook for the Greek pilot is the same as for all the other pilot buildings. The slight differences are related to the amount of information stored in the BIM file and its actual content. The BIM file was enriched to reach the detailed state that was needed in order to effectively test the tools. The main edits were:

- The building spaces were grouped into thermal zones.
- The mechanical systems were corrected, along with several values that did not make sense.

Some extra steps were also needed to register the sensors/meters that were not included in the BIM file to allow correct identification of the real-time collected data. This relates to the sensors that were installed recently within the project and are measuring the human comfort & well-being indicators that were proposed within T2.2. They were registered through the D^2EPC Web Platform and not through the BIM file.

The benchmarked energy-related performance of the Greek pilot was used in order to evaluate the BEPB functionalities. The as-designed, as-operated and smart-readiness assessment actual results (as calculated by the corresponding D^2EPC tools) were compared to a synthetic dataset of results. The comparison outcomes can indicate where the building stands against the building stock in terms of energy-related performance and what the improvement potential is. The input data from the Greek pilot as well as some of the BEPB results are displayed below.

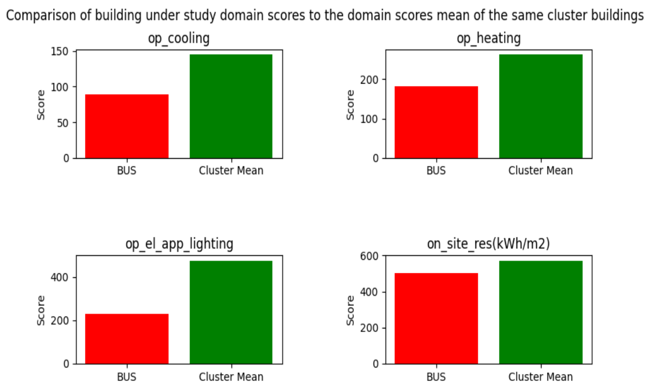

Figure 19 Comparison for the benchmarking tool – same cluster building

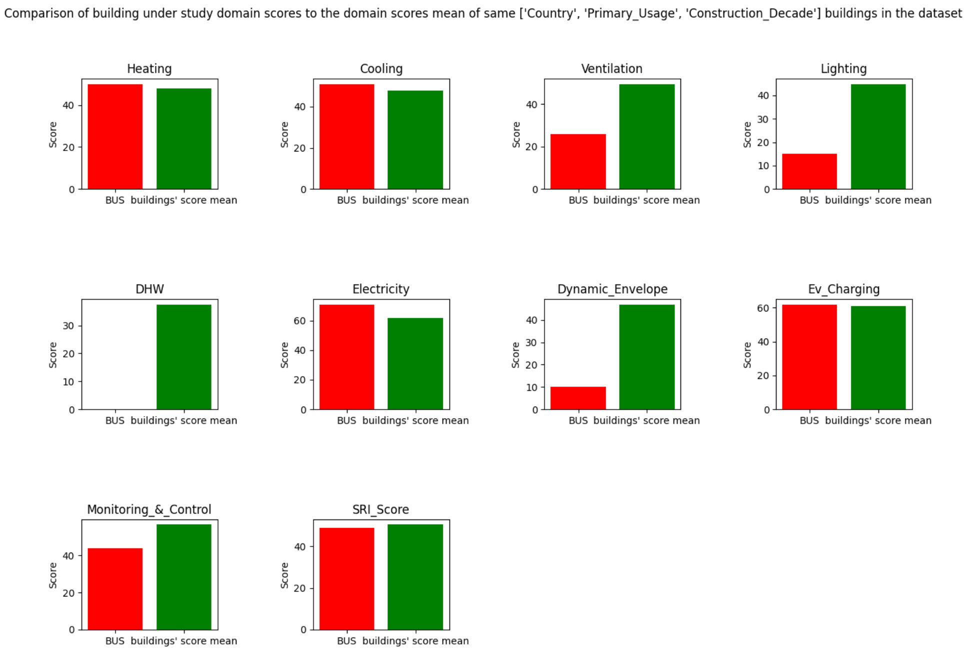

Figure 20 Comparison for the benchmarking tool – same buildings in the datasets

4.2 Case Study 4: Mixed-use building in Nicosia

4.2.1 Renovation roadmap

In case of CS4, the Roadmapping tool identifies 9 renovation actions, that should be taken in three steps which brings the building from class C to class A.

Table 4 Renovation actions for CS4

Renovation Action	Emissions	Emissions Saving	Energy Bill Cost	Energy Bill Cost Saving	Energy Class	Energy Saving Percentage	Payback Years	Primary Energy	Renovation Cost
Lighting In Offices	33686	6897.2	9464.2	1937.8	B	17	0.1	80204.7	180
Lighting In Seminar Room 3	38963.4	1619.8	10946.8	455.1	C	4	0.4	92769.9	180

Lighting In Lobby	40306.7	276.5	11324.3	77.7	C	0.7	2.3	95968.3	180
Lighting In Canteen	39999.4	583.8	11237.9	164	C	1.4	2.3	95236.7	370
Lighting In Seminar Room 2	40354.7	228.5	11337.7	64.2	C	0.6	2.8	96082.6	180
Lighting In Seminar Room 1	40354.7	228.5	11337.7	64.2	C	0.6	2.8	96082.6	180
A PV With 1613 SM	29981.5	10601.7	8423.4	2978.6	B	26.1	16.2	71384.6	48384
Renovated External Wall	38902.6	1680.6	10929.8	472.2	C	4.1	65.7	92625.2	31035.5
Renovated Window	38557.7	2025.5	10832.9	569.1	C	5	179.7	91804.1	102262.6

The renovation actions, timeline and energy are clearly presented in the D^2EPC platform. Providing a list of renovation actions and grouping the actions into step-by-step guidance for renovation aligns with BRP requirements for the renovation roadmap.

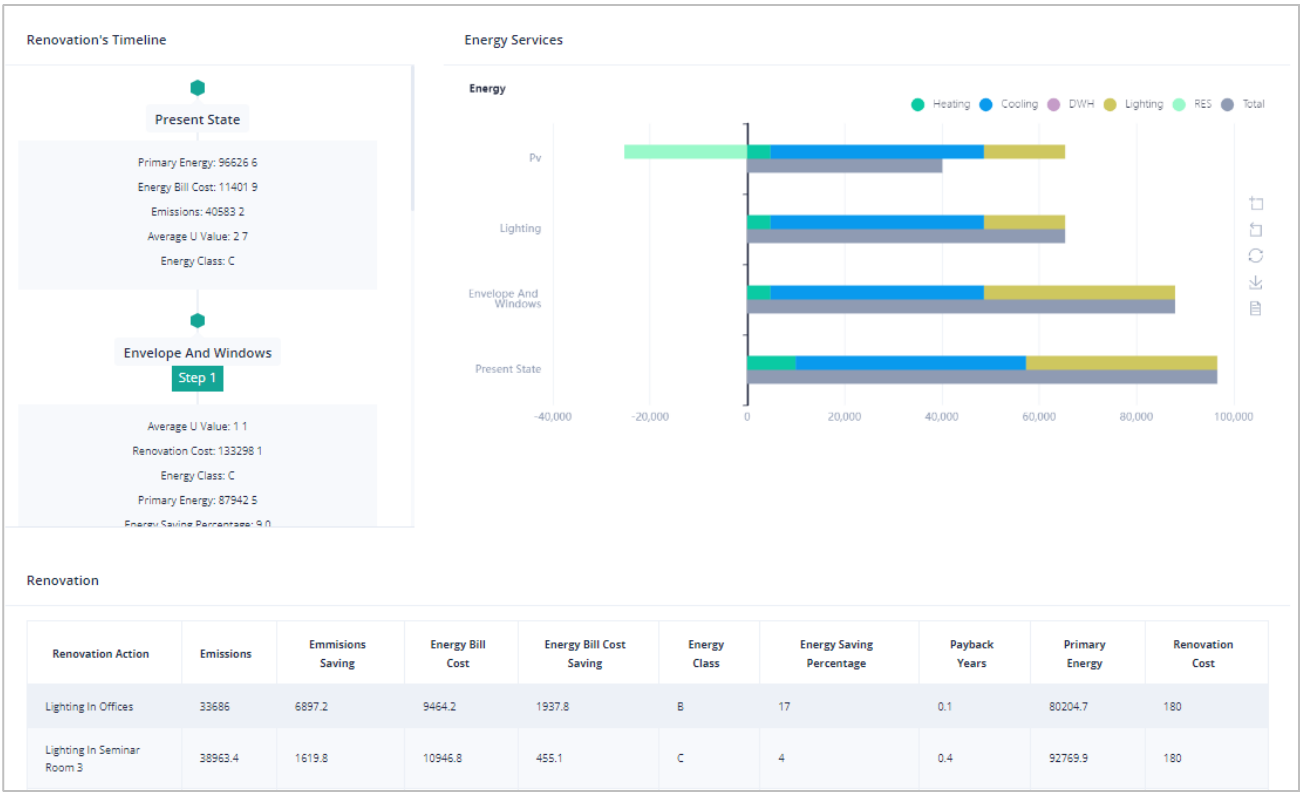

Figure 21 Roadmapping tool outcome for CS4

5 Guidelines

The scope of this task includes the development of two types of guidelines to maximize the impact, namely the generic guidelines and consultancy for decision and policymakers and technical advisory for building professionals and end-users. Such guidelines can be used to stimulate deep renovation and BRP promotion at various levels. The following two chapters describe the two guidelines, wherein the generic one a general approach is described, including identified barriers, steps to set up the BRP, success factors etc. In the technical advisory, the focus is on the steps that should be taken in order to support the two groups of users, namely the professionals and the end-users, who can be residential or non-residential.

5.1 Generic guidelines and consultancy for decision and policymakers

This sub-chapter offers an overview of the generic findings from the already implemented BRP schemes and thus supports future implementations through lessons learnt.

Identified barriers to residential renovation include the lack of knowledge about “where” and “how” the renovation should start, which measures to implement and what should the order be. The complexity of work and complexity of existing tools (EPCs), lack of effective communication, and different levels of quality provided by professionals add to the uncertainty. Finances are not always easily accessible and sometimes there is a lack of awareness regarding available financial support. A lack of follow-up after the energy audit or issuing of an EPC can result in performing no renovation at all. There are no quality control mechanisms, and the lack of checks contributes to the gap between designed and actual performance [8].

A lot of effort is required in order to set up a building renovation passport, such as the definition of a concept design, involvement of all the relevant stakeholders, including initiators, which can be public authorities or private actors, analysis of the market, development of the software for this purpose, legal and financial preparations and training of the experts. Then the testing period can start, followed by the implementation phase. This can differ depending on the type of initiator, available budget, scope of the implementation, geographical coverage, required adjustments, and the market. In general, the process for successful implementation of the building renovation passport can be divided into four steps: exploration, concept design, implementation and evaluation as seen in the figure below [8].

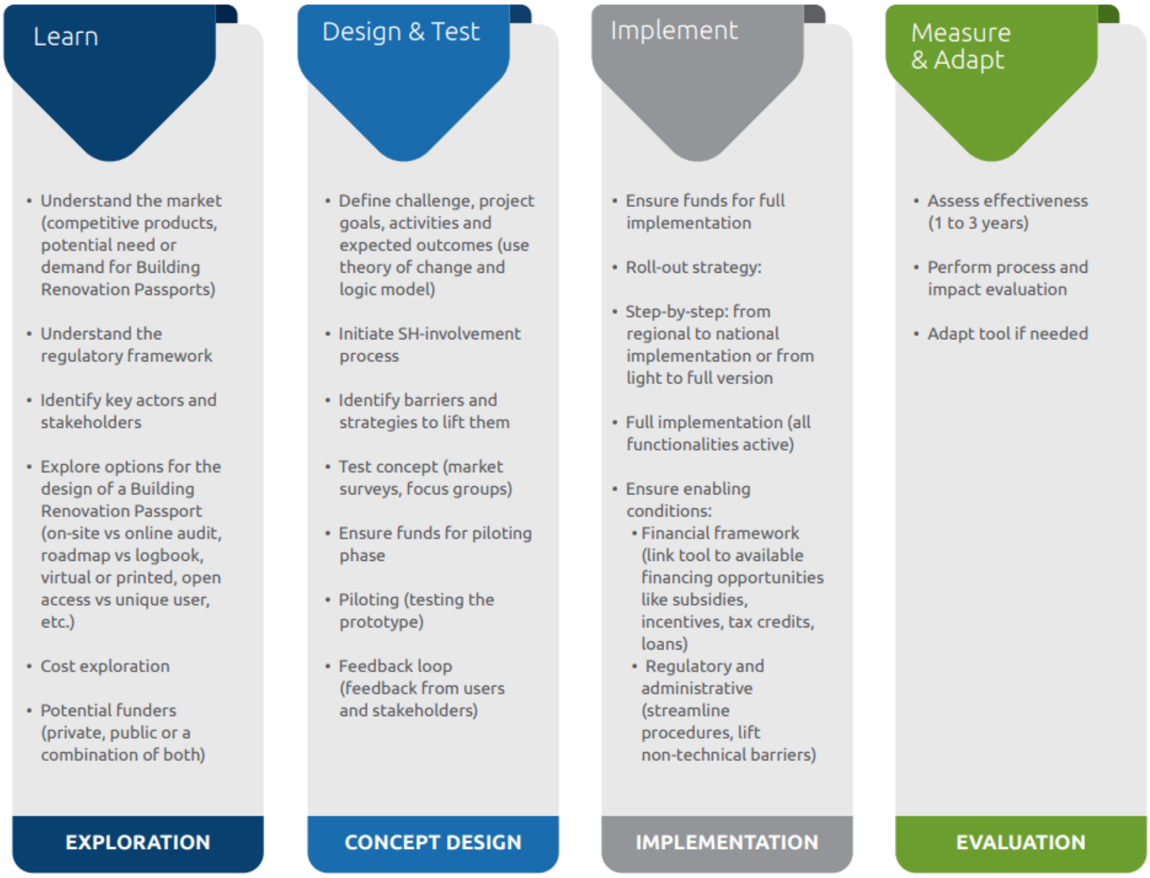

Figure 22 Four steps of implementation [8]

Based on the four existing building renovation passports in Germany, France, Denmark, and Belgium, a list of success factors was identified [8]:

- Include the right stakeholders, who can add value to the process.
- Ensure proper timing of each phase to avoid unnecessary stops.
- Guarantee the necessary funds for all phases of the implementation.
- Provide additional information about the building in the BRP besides the energy.
- Ensure user-friendliness and affordability.
- Promote the BRPs to ensure the demand, which can be driven by need, desire for service, or obligation.

5.2 Technical advisory for building professionals and end-users

This sub-chapter describes what are the main ingredients that the technical advisory should include. It was decided to follow this approach instead of providing an actual technical advisory, as the technical advisory itself can change and adapt throughout the development of the project. The technical step-by-step instructions are already described in the deliverables of each D^2EPC tool which is needed for the BRP calculation.

A technical advisory aims to provide a comprehensive understanding of BRPs and EPCs. It outlines the significance of these tools in promoting energy efficiency, sustainability, and cost-effectiveness in building renovations. Through a detailed examination of the concepts, benefits, and implementation strategies, this advisory equips users with the knowledge and guidance necessary to navigate the complexities of BRPs and EPCs effectively.

It is divided into two parts, namely for the professionals (engineers, auditors) and for the end-users (users of residential and non-residential buildings). The below sections are divided in the same way, presenting an overview of the main parts that the advisory should have.

5.2.1 Building professionals

The technical advisory for building professionals should cover different areas.

Firstly, a technical explanation of BRP would be needed. This explanation should cover what a BRP is, what is its purpose, how BRP is related to cost-effectiveness (i.e., provide some economic guidance), the importance of involving the owner and pros and cons of performing the renovation step-by-step or complete renovation in one go.

The advisory should explain the steps in order to perform a BRP and provide some examples or use cases. In the first stages of consultation and data acquisition, building professionals should know what information must be explained to the owner and what aspects should be agreed with the owner (individual needs, scope of the renovation, non-energy related aspects…). Building professionals will need a common (standardized) checklist for data acquisition, which contains the minimum information to gather for starting the process.

In the phase of assessing the current state of the building, professionals should be guided about how to analyse the current performance of the building, what results are expected, what KPI are relevant, how to estimate the costs and the savings, which parameters must be taken into account in order to consider an installation as efficient and what information is shared with the owner.

In the phase of development of renovation proposals, building professionals should be guided about how to consider the client needs or concerns to prioritize opportunities, how to consider client's budget, and what results or information must be shown in the proposals.

Lastly, in the phase of presentation the renovation roadmap, it would be needed to provide guidance about the contents of the report, format, etc.

Other interesting issues that should be considered in the technical advisory are compliance with legislation and the explanation of the existing available tools which can be useful to complete the process. In this sense, D^2EPC Platform can play an important role, as an EU-Range platform to assess energy performance of buildings and provide a renovation roadmap.

5.2.2 End-users

5.2.2.1 Residential end-users

Although there is no uniform definition of the Building Renovation Passports, the takeaways from the existing schemes are that BRPs should be user-friendly, meaning that the information should be presented in a clear and understandable way for every building user, regardless of their knowledge and background.

The sequence of the renovation steps should be clearly defined, including:

- An exact description of the renovation action in technical and non-technical language.
- Expected cost and time for performing the action.
- Expected benefits in terms of energy savings, translated into savings on energy bills.
- Expected wider benefits such as improved health and comfort.
- Information about potential financial and technical support.
- Information about the status of the building if no actions are being taken.

Values related to the renovation steps should be presented on a (colour) scale, allowing the user to allocate the performance of their building. An example of such clear representation is the label of the Energy Performance Certificates.

5.2.2.2 Non-residential end-users

It is proposed that the advisory for non-residential end-users begins with an introduction highlighting the purpose, scope, and significance of these tools in promoting energy efficiency and sustainability in building renovations. The document should delve into the core concepts, benefits, and components of BRPs and EPCs.

The advisory should explore BRPs in detail, elucidating their definition, objectives, and key components. It should emphasize the importance of data requirements and the role of various stakeholders in implementing BRPs effectively. Moving forward, the document could provide a comprehensive overview of EPCs for non-residential buildings, including their regulatory context, purpose, types, and validity periods.

To assist end-users in navigating the complexities of BRPs and EPCs, the advisory must outline key considerations for their implementation. It should cover legislative and policy landscapes, technical and data requirements, assessment methodologies, and data collection and verification processes. Additionally, it could highlight the benefits and incentives of utilizing BRPs and EPCs, such as energy efficiency, financial savings, enhanced building performance, and compliance with regulatory requirements and certifications.

The advisory should also provide practical guidance on implementing BRPs and obtaining EPCs. It should suggest engaging with qualified professionals and service providers, undertaking building retrofitting and energy conservation measures, and establishing monitoring, reporting, and continuous improvement processes. To illustrate real-world applications, the document must include case studies, best practices, and examples of successful BRP and EPC implementation projects. It could also explore lessons learned, challenges faced, and emerging innovations in the field.

Furthermore, the advisory should shed light on regulatory and industry trends shaping the future of BRPs and EPCs. It could examine evolving legislative frameworks, integration with other building performance standards, and potential developments on the horizon. By offering insights into the future outlook, the advisory can empower end-users to stay informed and prepared for forthcoming changes.

In conclusion, this technical advisory will equip end-users of non-residential buildings with the necessary knowledge and guidance to effectively utilize BRPs and EPCs. Also, it will emphasize the significance of these tools in achieving energy efficiency, sustainability, and cost-effectiveness in building renovations. By understanding the concepts, benefits, and implementation strategies outlined in this advisory, end-users can make informed decisions and contribute to a greener and more efficient built environment.

6 Conclusion

The goal of this task was to investigate how outcomes of the D^2EPC components can be integrated into Building Renovation Passports. Currently, there is no common methodology available in the EU that would prescribe the steps for forming the BRPs, so a literature review on the existing schemes was the first step of this task. In general, all schemes follow a similar approach, including a long-term target for the existing buildings stock in 2050, engagement of the stakeholders and identification of their needs, on-site visits, preparation of tailored solutions in the form of a renovation roadmap, and a database/logbook of the building.

According to BPIE, the Building Renovation Passport should combine three steps: data gathering, data processing, and renovation roadmap in connection to the building logbook. Those three steps were compared to the architecture of the D^2EPC and similarities in some of the D^2EPC components were identified. The on-site data gathering and auditing during the design phase is the first step towards the development of a BRP and is also the only step that was not envisioned by the D^2EPC. Further on, the data processing and renovation roadmap steps were found to be covered by the following D^2EPC components: The Information Management Layer, the Energy Performance Verification & Credibility tool, the Roadmapping tool, the BIM-based digital twin, and the Building Energy Performance Benchmarking tool. They were investigated by comparing them to the descriptions of the BRP components. Similarities, drawbacks, and advantages of each of the D^2EPC components were described. It was found that some of the components could be improved to fit the BRP, while there were also features that the BRP does not envision and could be considered as added value. The "dynamic" feature of the D^2EPC is one of the advantages that increases the quality of the provided information and allows a more in-depth analysis and definition of the renovation roadmap.

Implementation in case studies was the next step, where it was demonstrated how D^2EPC components could be used to form a BRP. The data gathering and data processing do not differ per pilot, whereas the renovation roadmap looks at each building individually and forms a step-by-step process that leads to the improvement of the building. These parts were presented for CS1 and CS4.

Finally, based on all that, the guidelines were formed for building professionals and decision- and policymakers. Here it is described what the BRP guidelines should include to ease the implementation and is based on the literature review that was performed at the beginning of the task.

The identification, analysis, and presentation of D^2EPC components and the description of what the guidelines should include together can strengthen the development and standardisation of BRPs. This document can be used as a baseline and benchmark for the definition of renovation activities within BRPs.

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ANNEX A: iSFP Checklist

Part A: ownership and usage information	
Building owner	name, address
General usage data	number of residents, hours of daily presence, family with children, age of children
Energy measures in the building	what energy renovations have been carried out in recent years, what structural and design measures are planned for the next few years, available budget, performed analyses (airtightness, thermography, statics), integration of smart home elements
Room temperature	room temperature and living comfort and weak points (draughts, noise…) for the owner
Partial heating of the room	temperatures of different rooms
Ventilation behaviour	type of ventilation, start, and duration
Hot water consumption	High/middle/low
Part B: Information about the building	
General building data	address, building category, year of construction, extensions
Basic data on the building	number of floors, type of use, living space / commercial space area, number of apartments (self-used, rented, empty), structural features, owner's awareness of relevant regulations (monument preservation, fire protection
Plan documents for the buildings	plans of the building (site plan, floor plans, sections, views), paper (original, copy)/ digital version, thermal envelope definition, heated rooms definition
Part C: Data recording outside and inside	
Tour of the outside	surroundings, façade/ exterior wall (type, condition, material, insulation), weak points (humidity, cracks, thermal bridges), roof (shape, roof windows, condition, suitability for solar system or photovoltaic system
Tour of the inside	GROUND (BASEMENT) - heated basement: floor towards the ground (material, insulation, moisture damage), walls (thickness, insulation, moisture damage, seals), walls towards the ground (thickness), wall towards unheated basement (thickness, insulation, moisture damage) - unheated basement: room height - basement ceiling (material, thickness, insulation, moisture damage) - exit from the unheated basement, GROUND (FLOOR SLAB, CEILING TO UNHEATED BASEMENT)

	- floor slab to the ground (material thickness, insulation, moisture damage), - ceiling downwards – outside (material, insulation, moisture damage), OUTER WALL (thickness and structure, niches, wall to unheated room, condition of inner plaster/cladding), ROLLER SHUTTER BOXES (alignment with the façade, insulation, condition), WINDOW (condition, type, are there subsequently installed windows, window frame conditions, detailed recording of individual window type (year, material, glazing type, Ug value, leaks)), ATTICS – HEATED PART - roof surface (thickness, construction), - the outer wall (thickness, insulation, condition), - the wall against unheated space (thickness, insulation), - dormers (detailed recording), ATTICS - UNHEATED PART: - top floor (thickness, material, insulation, plans for reconstruction))
Part D: Data acquisition technical	
The heating system and hot water preparation system	DISTRIBUTION OF ROOM HEAT (design) - heating elements (heat dissipation, regulation of heat emission, hydraulic adjustment, impairments, other devices), - decentralized heat generator (energy source, year of construction, nominal heat output, location, estimated coverage percentage), - - decentralized hot water generator (energy source, year of construction, nominal heat output, location, estimated coverage percentage)
Heat generation	- heat generator (type, manufacturer, number, construction year, energy source, location, mode of operation, heat output, degree of utilization, flow/return temperature, night reduction, energy label, efficiency class, particularities, renewal planned), - solar system (construction year, location, type, area, solar cable insulation, mode of operation, coverage of heat generation (space heating/hot water/space heating + hot water) - storage type (design type, construction year, location, mode of operation, type of heater used, storage capacity, insulation of storage - distribution (distribution type, location to the thermal envelope, length of the pipes, middle pipe diameter, type of insulation, middle insulation thickness) - circulation pumps o heating (construction year, power, control)

	○ DHW (construction year, power, control, type of operation)
Ventilation system	Type, ventilated spaces, degree of heat recovery, air exchange, design flow rate, operation, regulation/control, fan, heat exchanger, distribution inside or outside the envelope, air outlets, subsequent supply air heating
Photovoltaic system	Construction year, location, modular design and area, performance, storage, use (own consumption/feed-in usage)
General aspects of the technology	Is gas connection possible, are storage facilities available, is solar system possible, can waste heat be used, is district heating possible, is there an area development plan, which district-related supply aspects must be considered