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A review on Building Renovation Passport: Potentialities and barriers on current initiatives

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Lack of information and transparency increases risk and undermines investor confidence. Therefore, a systematized and optimized capture and processing of information also supports investment decision making and creates opportunities for innovation and uptake of energy efficiency and sustainability mea- sures, processes and designs. Building passports could play a valuable role in boosting the availability of information to a wide range of market participants. Better information flows are a necessary part of improving the quality assurance system for buildings and the construction industry market overall.

The aim of the paper is firstly to set a Building Renovation Passport (BRP) definition, to explore the potential role of a voluntary scheme across EU as a key tool to help overcome this information imbalance by providing all market stakeholders, including financing institutions, providers of mortgage credit, investors and insurers with access to key building related documentation and information to properly assess the many factors impacting the overall quality of buildings. Within the presented study three initiatives currently developed across EU (Flanders, France and Germany), have been selected to be inves- tigated in details providing an extensive overview of the process supporting the creation of a Building Renovation Passport and covering the main issues necessary for its development and implementation.

Keywords: Deep renovations, Energy performance certificates, Building renovation passport, Step-by-step renovation roadmap

1. Introduction

Buildings are the largest consumers of energy worldwide and will continue to be a source of increasing energy demand in the future. Globally, the sector's final energy consumption doubled between 1971 and 2010 to reach 2794 million tonnes of oil equivalent (Mtoe), driven primarily by population increase and economic growth. Under current policies, the global energy demand of buildings is projected to grow by an additional 838 Mtoe by 2035 compared to 2010, which is equivalent to the total current energy demand of the buildings sector of the United States and China combined. Buildings will therefore add substantial pressure on primary energy supply, if further policy action is not taken at a global level to improve their efficiency [1]. Over the past twenty years, the European Union has adopted a set of directives: Energy Performance of Buildings Directive (EPBD), Ecodesign Directive, and Labeling Directive with the aim to improve energy performance of buildings. "Energy Efficiency First" is a principle that today permeates all aspects of the EU's energy policy. As highlighted in the most recent Commission's legislative proposal EU Winter Package, the so-called "Clean Energy for all Europeans" [2], energy efficiency should be seen as an energy source in its own right, as it will play a key role in speeding up the clean energy transition and boosting growth and job creation, and contributes to the EU's energy security. Buildings account for 40% of total energy consumption and around 75% of them are energy inefficient. Energy efficiency in buildings suffers from underinvestment and numerous barriers. Whereas buildings are regularly maintained or improved, energy saving investments are often disregarded because they face a competition for scarce capital, a lack of trustworthy information, lack of skilled workers or doubts on the possible benefits. At today's rate of renovating around 1.2% of buildings each year, it would take a century to upgrade the building stock to modern, near-zero energy levels [3].

The aim is to have a more harmonized EU label on a voluntary wide scheme. The concept of harmonization arising from Article 11 (9) of the Energy Performance of Buildings Directive. The article states: –"the European Voluntary Certification Scheme

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Abbreviations: BP, building passport; BC, birth certificate; BHHI, building health and hygiene; BIS, building information system; BPIE, building performance institute Europe; BRP, building renovation passport; BSCI, building safety and conditions index; CoBF, concept of building file; EBP, electronic building passport; EED, energy efficiency directive; EPBD, energy performance of buildings directive; EPC, energy performance certificate; HC, health certificate; HIP, home information pack; iSFP, individueller sanierungsfahrplan; NCC, national construction code; P2E, passeport efficacité énergétique; RED, renewable energy directive; MS, member states.

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or EVCS should present as a tool for organizations in the European market–". Property owners in the non-residential sector are often large multinational property investment and development companies demanding international and European comparability of buildings and invest in the most energy efficient ones. The Energy Efficiency Directive (EED) [4] and the Renewable Energy Directive (RED) [5], revised with the "winter package" published on 30 November 2016 to facilitate the clean energy transition, set out a package of measures that create the conditions for significant and long-term improvements in the energy performance of the European building stock. The EED deals with a more efficient use energy throughout the energy chain, from its production to its final consumption. It states that the public sector should purchase energy efficiency in buildings, products and services in all MS. The Directive introduces several measures, such as legal obligations to establish energy saving schemes in MS, energy efficiency national incentives, energy services and audits. According to the Directive, energy distributors or retail energy sales companies have to achieve 1.5% energy savings per year through the implementation of energy efficiency measures. Moreover, according to article 4 of the EED, MS have to establish a long-term strategy beyond 2020 for mobilizing investment in building renovation to improve the energy performance of the building stock.

Despite the promise of attractive returns on investment, the lack of confidence in energy savings and the often prohibitive costs of conducting due diligence create a substantial barriers to investors and building owners taking action. Market participants along the building value chain routinely gather and discard information – information that is in fact immensely valuable to foster competitiveness and sustainability of the industry and market alike, especially in regulatory compliance, planning, cost management, operation and maintenance, insurance and investment and financial decision-making. Most of these information however, are not collated in one place and a systematic approach of organizing and managing this information is currently largely missing. Mappings of information flows between designers, builders, local authorities, regulators and assessors have shown that practically none of the information is being handed down from the beginning to the end of the supply chain. Some of it stays with particular professionals or suppliers, some of it needs to be created two or three times over for valuation, transaction or insurance purposes, and typically almost none of it ends up with end users. Lack of information and transparency increases risk and undermines investor confidence. The Energy Performance Certificates (EPCs) has been introduced in 2002 by the Energy Performance of Buildings Directive [6] as a mandatory requirement for the EU Member States helps overcome these barriers. The recast of the Energy Performance of Buildings Directive in 2010 [7] reinforced the EPC obligation for the Member States and introduced additional requirements. The EPCs are an important instrument to serve as an information tool for building owners, occupiers and real estate actors and they can be a powerful tool to create a demand-driven market for energy efficient buildings, as they allow estimating the costs in relation to energy consumption and efficiency of a building [8].

It has been even confirmed by Building Performance Institute Europe (BPIE) Surveys in 2011 [9] and other report and publications in literature [10–12], that EPCs are currently among the most important sources of information on the energy performance of the EU's building stock. Additionally, EPCs have the potential to become effective instruments to track buildings' energy performance and the impact of building policies over time as well as to support the implementation of minimum energy requirements within the regulatory process. Latest researches investigations [13–15] on EPC effects demonstrated that many homeowners consider this instrument is a waste of money and does not lead to many improvements. They noted moreover that, while EPC can raise awareness on energy renovation, it will probably not generate renovation practice on its own. Moreover the current national EPC scheme provide too general recommendation for improving the energy efficiency without specific information and omit completely indicators related to thermal and visual comfort or air quality that are the most important benefit of the building renovation.

In a recent study [16], BPIE suggests to evolve EPCs into Building Renovation Passports (BRPs), proposing a user-friendly long-term roadmap that owners can use to plan deep renovations, gather all relevant building information in a sole place and get an up-to-date screenshot of the building across its lifetime, with information about comfort levels and potential access to finance.

This paper contributes to the body of knowledge in three ways: (i) it provides an overview on Building Passport (BP) definition from first initiatives in EU and one in Australia; (ii) it presents an updated evaluation and comparison of some BRP experiences developed in some European Member states (Belgium, France and Germany, selected for their advanced phase of development; (iii) it pinpoints the main known barriers and the lesson learned within the review initiatives in order to provide suggestions for the standardization of BRP across EU. Although the paper comparison focuses only on three countries, the overview of barriers and motivators and the overall approach and conclusions can be used to identify gaps and opportunities in other countries policy schemes as well.

The paper builds on the literature's main findings and provides an extensive analysis of the BP concept from its first experiences with a focus on the BP for existing buildings, which requires specific renovation roadmaps.

In details, the paper has been structured as follows. Section 1, sets the scene of the energy efficiency goals, regulations and respective directive on the building sector identifying: challenges, barriers and instruments.

Section 2, explores the concept of BP, introducing definitions and experiences within EU and an initiative in Australia. Section 3, focuses on BP for existing building with the aim to increase understanding on BRP definition, initiatives and researches related to the Renovation roadmap. Section 4, provides a comparison of three ongoing applications of the BRP in EU Member States (Belgium, Germany and France) highlighting weaknesses and strengths of each ones. Finally, Section 5 outlines a series of recommendations for the introduction of BRPs across the EU.

2. Building Passport concept overview: genesis, definitions and structure

In Europe, the introduction of Building Passports has been discussed for decades with the objective to provide information to a potential purchaser, investors, renter or user of the building.

The term Building Passport is currently being used with differing meanings and there is no a single definition. It can denote a certificate displaying the most important performance characteristics and technological data of a building - comparable with motor vehicle documents – as well as a comprehensive collection of various building-related documents (plans, calculations, lists and declarations of materials and products used, operating and maintenance guidelines, etc.).

BPs are increasingly being considered as an important source of information for valuation experts, financiers and insurers [17] but also to improve information for owner occupiers about the quality of their house [18,19]. Name, type, scope and content of building passports have evolved over time and continue to evolve into a tool for communicating diverse characteristics of buildings to multiple beneficiaries in different European countries: Table 1 presents a selection of the first European initiatives on that issue.

Table 1
BP definitions overview.

Name	Definition	Author/s - Source	Country
Building Passport	BP should enhance transparency of technical properties, standards of building services, quality of use and operation costs of buildings for client and buyers of new property but also for tenants, developers and real estate agents. It should communicate comprehensive and in particular comparable information.	Töpfer, 1997 [20]	Germany (D)
ImmoPass	The German "Real-Estate-Passport" is a checklist, documentation-structure and assessment tool for sustainable building qualities. The approach aims at sustainability issues, it was designed for new and existing buildings and claims that it is suitable for all types of buildings and at different stages of the planning and construction process.	Edited and supplied by DEKRA Umwelt GmbH on initiative of HypoVereinsbank, DEKRA, 2000 [21]	Germany (D)
Gëbaudepass	A means of protecting the consumer by providing a description of the key features and characteristics of a property, a quality signal in competition, and an instrument to describe, assess and certify the energetic quality and the environmental and health performance of buildings.	Bundesministeriums für Verkehr, Bau und Wohnungswesen (BMBBW) [22]	Germany (D)
Building folder (Hausakte)	The federal "building folder" (Hausakte) has been introduced under the "cost-effective, quality-conscious building" initiative umbrella in 2001 and targeting single family home. The building folder contains two distinct parts: (1) the Building Certificate and (2) the "House Document". In 2004, the digital version of the building folder was developed in 6 modules: 1. Characteristics; 2. Description; 3. Address; 4. Summary tables; 5. Drawings, calculations, photos; 6. Documents and contracts. In 2009 the "cost-effective, quality-conscious building" initiative was discontinued after a duration of 10 years, however, the digital building folder was still available up until 2012.	European Construction Sector Observatory - Policy measure fact sheet Germany [23]	Germany (D)
Building Passport	BP is an accessible, visual tool that presents the key indicators in environmental efficiency, along with images and the basic facts of the property. The key indicators measured by the Building Performance Indicators can easily be presented in the BP, either for the pre-design or occupancy phases.	Finnish Green Building Council [24] and Virta et al. [25]	Finland (FIN)
Concept of Building File (CoBF)	OPB proposed the introduction of the CoBF, which should describe the quality condition of buildings and would function as a maintenance manual. CoBF consisted of four boxes of information: 1 general info, 2 structural condition of the building, 3 supplementary private law information such as installations, functional quality, lay out of a dwelling, environmental sustainability and facilities in the neighbourhood, 4 (voluntary) user and maintenance guide for keeping the house in a good state of repair.	Dutch Consultation Platform Building Legislation (OPB) [26]	Netherlands (NL)
As-Built File (Oplever-dossier)	An Opleverdossier ('As-Built File', previously known as the 'Dutch Building File') is a dossier of information on a residential property that provides insight into the technical quality of that property or building, as well as guidance on maintenance. Introduced in the Building Quality Law in April 2016, the Full implementation is expected in 2018.	Ministry of Internal Affairs (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties) [27]	Netherlands (NL)
Libro del Edificio	Since 1999, a building booklet has been obligatory for each new building. The booklets are part of the Spanish Building Act (Ley sobre la Ordinacion de la Edificacion). The booklet is given to the building's end users at the end of the building process, and it includes the reception certificate and a list of all agents involved in the building process, along with instructions for using and maintaining the building and its services. The compilation and use of the booklet is mandatory, but each province or city can, within certain limits, design its own standards for the booklet.	Ministerio de Fomento, Spain [28]	Spain (ES)
Fascicolo del fabbricato	Summary, as an identity card, which allow gathering in a single document all the distinctive elements of a house for the purpose of one exhaustive knowledge and consequences of prevention and safety. It is a voluntary document developed around 1999 and the idea to follow its adoption raised with the D.P.R. 380/2001and the new technical standards for buildings - D.M. January 14, 2008. During 2017 it has been discussed the possibility to make it mandatory with moreover the digitalization of it and BIM integration, but it is still an open issue at national level.	Consiglio Nazionale dei Periti Industriali e dei Periti Industriali Laureati [29]	Italy (IT)
Home information pack (HIP)	A HIP is a set of documents that provides the buyer with key information on the property and must be provided by the seller or the seller's agent, plus a new document called the Home Condition Report (HCR), which contains information about the physical condition of a property, including its energy efficiency. The cost of preparing a HIP for an average home will be around £600–700 + £350 for the HCR.	Home Information Pack, Office of the Deputy Prime Minister, Creating sustainable communities [30]	England and Wales (UK)
Building Logbook	It is a single copy of a separately produced document and is not to be confused with the any other documents required for building works e.g. the Operation and Maintenance (O&M) manuals or the Health and Safety File. The Building Log Book is to provide a simple summary document, describing how the new or refurbished building is intended to work and be serviced. It also provides a means to log the energy performance and maintenance of the services within the building and an historical record of building alterations, maintenance and energy performance. The intention of the Log Book is to ensure that sufficient information is available to enable energy consumption to be monitored and controlled in accordance with the design intent.	Cornwall Council, Environment Directorate [31]	Cornwall (UK)
Building Logbook	It is analogous to a car handbook, providing the facilities manager with easily understood information about how the building is intended to work. It allows ongoing building energy performance and major alterations to be recorded. It also helps with monitoring and maintaining occupant satisfaction by keeping a log of indoor environmental quality (IEQ) related complaints and the response actions.	CIBSE Building log book tool kit [32]	UK

Referring to Table 1, it reveals that in Germany various initiatives have been taken to develop building passports, at both the local and the national level, to improve insight into the quality of housing.

At the national level, the Bundesministeriums für Verkehr, Bau und Wohnungswesen (BMVBW) developed the Hausakte in 2001 and the district Schleswig–Holstein adopted its own example of a building passport at regional-level developed within a research investigation on the terms BP and 'environmental labelling for buildings' commissioned to the Institute of Ecological and Regional Development (IOER). In this context, the IOER developed a BP basic structure from three separated models, representing the three basic components of a comprehensive approach (Table 2).

The idea of a building passport is often substantiated by reference to much less expensive and enduring commodities, like cars or electrical devices that are often sold with much more com-

Table 2
Basic model components of the BP Schleswig Holstein [33].

Model	Keywords	Tool model characteristics and target
Building Logbook	Transparency, widespread use, comparatively low costs, integration of all participants, communication, responsibility	Considering the owners and tenants buildings point of view, there is a need to introduce a tool that besides presenting data on the properties of the building and archiving relevant documents also provides guidelines for operation and maintenance. As a "building logbook", it should be kept up-to-date by the user or owner, for instance with regard to resource consumption (water, energy etc.), maintenance, and structural changes. The "building logbook "itself does not include any assessment, but it is the basis for further modules that can be added.
Building Passport	Regulation and assurance of quality, avoidance of building damages, consumer protection, marketing, promotion of competition	The concept of a building passport as an independent tool is a good starting-point to put together requirements on planning and good building practice to achieve quality assurance. A widespread use of BP can lead to better market transparency by means of gradually developing a reference system.
Quality Label	Best practice	A quality label for buildings as an element of an ambitious building and environmental policy formally puts into operation the main goals of the issuing institution with regard to a sustainable development in the building and construction industry. The quality label honors outstanding voluntary and innovative achievements concerning environmental and health aspects in building projects. As well as being effective in marketing, a label, which is awarded as publicly as possible, should also communicate best practice.

Table 3
Description of contents for Birth and Health certificate of buildings as introduced by Virta et al. [25].

Building certificate	Contents	Validation
Birth certificate (BC)	BC presents life cycle planning ad key performance indicators specified during the design process or after a first year of operation.	It remains unchanged over the years until the building is refurbished.
Health certificate (HC)	HC compares the operation of building to the operation of previous years and helps maintenance people to operate building more efficiently. Annual indicators are used to plan the short and long-term repairs and retrofitting.	It is updated annually based on the real performance of a building.

prehensive technical information than buildings. From the point of view of market communication, the building passport approach can be seen as a third-party statement on quality in a market environmental characterized by risk and uncertainty [34]. For a while, building passport and labelling approaches were widely considered worthwhile [35]. The building passport used in the district Schleswig–Holstein is similar to the Dutch building file, which recently became As-Built File (Opleverdossier).

However public/political actors in Germany were cautions and reluctant to engage formally with the initiative, especially to the extent to which BPs include assessments and evaluations [34].

In Finland, Green Building Council underlined how today the sustainability is often evaluated using building labelling tools (i.e. LEED, BREEAM, DGNB or HQE), which weight the different areas of sustainability as one or two ratings, without evaluating the actual performance of a building. In order to solve that weakness point, they focus their researches within last decade to determine the key performance indicators (KPIs) for sustainable buildings that ensure the sustainable operation over the lifetime.

In this context, Virta et al. [25] defined the BP as a tool to evaluate sustainability and a way to communicate the performances of a building in a simple format based on a "Birth Certificate" (BC) and "Health Certificate" (HC) of a building. Table 3 summarizes the main characteristics of the BC and HC.

In response to the European initiatives, in 2014 an Australian study of residential buildings that alluded to key systemic, process and compliance weaknesses in the application of energy efficiency requirements of the National Construction Code (NCC), the state and territory governments funded a pilot project to develop and test a web-based Electronic Building Passport (EBP) to address information asymmetry, especially in relation to improving the process and quality control of documentation relating to the 'as designed' and 'as constructed energy performance of buildings' [36].

Miller and Luetzkendorf [37] from their investigation identified four main concerns: (i) a disconnect between the goals and responsibilities of local government and the NCC goals and expectations; (ii) lack of clarity as to what metadata and data sources are considered valuable; (iii) the technical benefits and limitations of an EBP; and (iv) issues of privacy and data security.

From the European examples presented in this section, it is clearly seen that the concept of BPs is continuing to evolve in tasks, content and scope. The BP, however, is only one of the possible tool to support information management and exchange between different target groups and actors within construction and real estate sectors. A deeper understanding of other documentation management instruments, information creation processes and information needs of the various actors over the lifetime of buildings, is needed to more closely align each of the instruments to capture the full economic, environmental and societal benefits of building information.

The main lessons learned from the Australian experience is that a large amount of information are normally generated for an individual dwelling over its lifetime, but the various actors are not able to capture the full benefits of their investment in these data. Miller and Luetzkendorf [37] remarked the importance to create a low cost documentation system for individual dwellings which collect data, by the various stakeholders, from the design phase, through the construction phase and into the operational phase. Moreover, the actors involved in different building phase design and construction, need to be educated to respect the information needs of other stakeholders/target groups, and the system must be flexible to provide practical and comprehensible information to both consumers and experts.

Electronic Building Passports play an important role in such a system and the exchange of ideas, practices and project analysis between Australia, Europe and other parts of the world is beneficial in the ongoing development of such an instrument [37].

The presented overview on the evolution of different concept related to building information in construction, within this section, highlighted the importance to have a clear data flow between different operators (such as prospective buyers, banks, insurance companies, and the government) on the qualities of buildings, to give them a positive recognition and encouragement to properly-managed buildings as a whole.

In construction project management, therefore attention has to be paid to where information imbalances occur. Although the inadequacy of the current level of building management and maintenance is usually known to building owners, it may not be enough to compel them to improve on it if it cannot be easily revealed to other parties. This is a problem of information asymmetry in building quality, which will result in under-investment in building maintenance [38].

A construction project is characterized by a high number of project participants and a multitude of contract relations. The Principal Agent Theory deals with the design of contracts, especially with respect to asymmetric information, which can have effects before as well as after closing a building project contract.

To tackle asymmetric information in the property market, it is necessary to have a mechanism for buyers to distinguish high quality properties from low quality ones [39]. Lützkendorf and Speer [40] pointed out that informational asymmetries in the property market resulted from the failure of the supply side to meet the building information needs of the demand side in regards to the quality, performance, and service provided by a building and to reduce the problem, they proposed a Building Information System (BIS) to create an all-embracing data pool of building information, from which certain information can be easily extracted, depending on the requirements of the different stakeholders for such information.

However, the BIS is tailored for new development, and difficult to implement for existing buildings, for which the problem of information asymmetry is the most severe.

Further studies advocated the development of a building classification system as a signaling mechanism. Chau et al. [41] focused on the need to reveal the quality of existing multi-ownership buildings, Ho et al. [42] devised a simple assessment scheme called the Building Health and Hygiene Index (BHHI) to evaluate the health performance of multi-storey residential buildings; Ho and Yau [43] took one step further and developed another index named the Building Safety and Conditions Index (BSCI) for evaluating a building's safety performance.

In this framework, all the investigated indices are good examples of how a building classification system can be used as a signaling mechanism to tackle information asymmetry in the property market.

In conclusion, Ho et al. [39] clearly stated that once more information is available on the market, there is likely to be a net welfare increase, although the gap in property values will widen. That is, the market value of buildings with a lower quality rating will decrease, while those of a higher quality will increase. However, the total value of all buildings will increase (total welfare gain). The assessment scheme can also motivate developers and building designers to develop higher quality buildings and assist in the development and promotion of the building care culture.

3. Building Renovation Passport: a focus on existing buildings

Despite the proven economic and technical feasibility of building renovation, and despite the societal and environmental benefits it could bring, renovation rates are still low, close to 1.2% per annum and considerably below the expected level (2–3% annually). Building owners and potential investors face multiple barriers to improve the energy performance of their buildings. Together with difficulty to access finance, one of the most often quoted barriers is the lack of knowledge about what to do, where to start, and which measures to implement in which order [44]. To meet long-term energy savings objectives, policymakers are actively trying to do two things: increase the percentage of buildings being renovated annually and to increase the level of ambition of those renovations.

EPCs could be the appropriate tool to provide this information in a meaningful and comprehensible way. However, they are not designed to provide tailor-made and understandable information about renovation potentials. As a result, they are not usually considered a decisive factor by potential investors and building owners and their stimulation effect for the renovation of buildings is limited [44].

The importance of the EPC evolution into a BP is a well know issues in the last decades.

Abt, representing the European Insulation Manufacturers Association (EURIMA), highlighted in 2015 that EPC's should be developed into an individual renovation roadmap or building passport, which follows the building throughout its life and is linked to a MS database, and facilitates the realization of consistent tailor-made renovation recommendations. Such a passport would include steps to undertake to achieve a targeted level of performance. Furthermore, ensuring sustainable financing mechanisms for major and ambitious actions such as deep renovation can help consumers with the up-front financing and thus implement the recommended steps in their passport [45].

Within the ZEBRA2020 European research [46], 35 recommendations, based on project outcomes and related researches, have been derived for EU Member States divided in six different categories: legislative and regulatory, economic, communication, quality of action, new business models and social measures.

In particular, they conducted a survey: "Barrier to speed up NZEB transition" with Building and real estate Professionals and the results was that many did not think there was a link between EPCs and the improvement of energy efficiency of buildings.

The EPBD amendment, approved at the end of April 2018 by the EU commission, will trigger a further evolution of the EPCs in a more comprehensive and user-friendly instrument: the Building Renovation Passport (BRP). In addition to containing information regarding the energy performance, it will support building owners with personalized instructions on renovation options (roadmap) quantifying the potential energy saving and related costs of the potential measures. The main object of this initiative is to accompanying a building through its life cycle and include proposals and advice for owners and investors on how to improve the building to become nearly zero-energy (in a step- by-step approach to energy renovation which avoids lock-in-effects and looks towards better solutions). The BRP can thus trigger the renovation market increasing the building owner awareness and reducing the investor's risks.

Considering the existing building, Blum underlined the necessity to structure the BP more flexibly and open than one for new buildings. The agreements on on-site reviews, for example, cannot simply refer to the installation and/or modification of building components but rather will be determined by the need to scrutinize the existing structure and condition of the building-substance. Moreover, compiling an inventory of the used building materials often proves to be considerable difficult, monitoring is necessary where harmful substances are suspected in order to record the extent of the contamination qualitatively and quantitatively and undertake appropriate steps in refurbishment [33].

A Building Renovation Passport (BRP) has been moreover defined, within the BPIE report [16], as "a document – in electronic or paper format – outlining a long-term (up to 15 or 20 years) step-by-step renovation roadmap for a specific building, resulting from an on-site energy audit fulfilling specific quality criteria and indicators established during the design phase and in dialogue with building owners". Thus, importantly, the passport follows a staged renovation plan for a specific building in a comprehensive manner.

BRPs are centered around the combination of technical on-site energy audits and quality criteria established in dialogue with building owners.

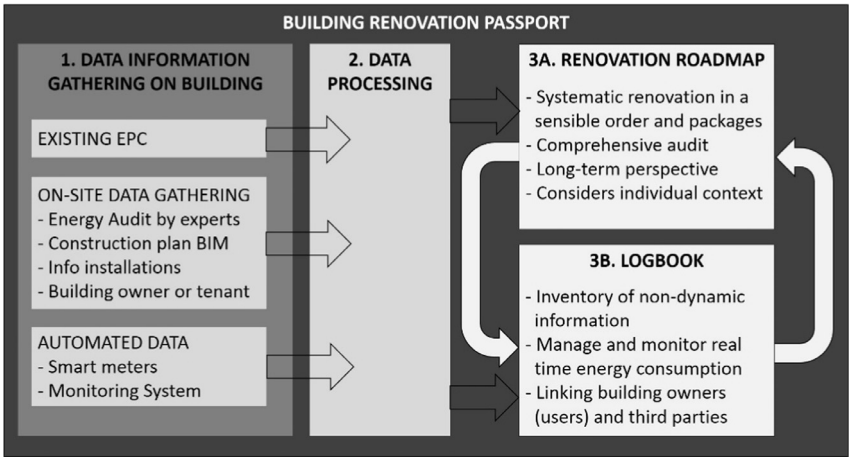

Fig. 1. BRP structure (Rielaboration of the authors from BPIE study).

The expected benefits in terms of reduced overall energy bills, comfort and well-being improvement and $CO_{2\ equivalent}$ reduction are a constitutive part of the BRP and are explained in a user-friendly communication. The renovation roadmap can be combined with a repository of building-related information (logbook) on aspects such as energy consumption and production, executed maintenance and building plans [44].

Fig. 1 presents an overview of the main components of the BRP to provide a common understanding of the terminology and the different elements covered by the examples analyzed in the following section.

On-site data gathering is the first step towards the creation of a BRP. The data processing can change per each model (e.g. by using a dedicated software or by adapting the existing energy audit software) with the aim to collect all the data related to a building for which BRP needs to be created.

The result is a user-friendly comprehensive step-by-step renovation roadmap, with tailored solutions aiming at achieving deep-staged renovation, gather all relevant building information in a sole place and get an up-to-date screenshot of the building across its lifetime, with information about comfort levels (air quality, daylight entry, etc.) and potential access to finance.

The step-by-step renovation roadmap is a renovation plan also called staged renovation because by looking at the building as a whole, suggests the installation of selected measures in a certain order (sequencing) avoiding the lock-in effects. In other words, to avoid that at any stage of renovation the installation of additional measures is precluded or energy savings measures are not going to be realised due to un-ambitious and insufficiently stringent energy requirement targets for buildings, building element and equipment. In fact, IEA defines the lock-in vision as the action to translate the building energy saving goals into collective long-term goals, with shorter-term commitments that are consistent with the long-term vision [47].

The fact that BRP is a challenging topic, it is moreover remarked from new currently European research initiatives on that issue. One is called iBRoad - Individual Building Renovation Roadmaps [48], it is a H2020 research project started in June 2017 with the main goal to develop a customized renovation plan (iBRoad-Plan) over a long-term horizon (15–20 years). The renovation roadmap is like a home-improvement plan, which considers the occupant's needs and specific situations (e.g. age, financial situation, composition of the household, etc.) and avoids the risk of lock-in future renovation solutions due to a lack of foresight. The iBRoad-Plan is combined with a repository of information, i.e. a building logbook or passport (iBRoad-Log) on aspects like the energy consumption and production, executed maintenance and building plans.

At the end of 2017 another EU project related to the BRP started, the so-called ALDREN [49]: ALliance for Deep RENovation in buildings; implementing the European Common Voluntary Certification Scheme, as backbone along the whole deep renovation process. The ALDREN objectives are to achieve higher renovation rates and better renovation quality by overcoming market barriers and preparing the ground for investment.

The excellence of the ALDREN solutions offered are:

1) A harmonized Energy performance rating based on the European Voluntary Certification Scheme (EVCS) verified by measurements to increase comparability, confidence and market uptake by standardized solutions (CEN / ISO);
2) Associating low energy renovation with high quality indoor environments to trigger renovation and to promote health and comfort;
3) Aligning market recognition of high quality with enhanced building value by financial tools and capacity building. Establishing business case for deep renovation to motivate private investment.

These solutions will be integrated in a consistent, common way in a BP to ensure the results and effective financing in case of step by step renovation. iBroad and ALDREN are two of the latest EU projects recently started which are working on that issues focusing in particular on existing buildings.

4. Overview on three European BRP running experiences

Three are the European models of BRP presented in this section and respectively developed for: Flanders in Belgium, France and Germany. These European regions have developed their own concept of BRP and they are working on its implementation. First of all, based on these examples, it is evident that BRPs are centered on the combination of technical on-site energy audits and quality criteria established in dialogue with building owners. Moreover, all of them have the same main aspects and goal: to improve the overall building stock energy efficiency through a customized set of measures for each building and their owners separately. However, many differences in each approach and outcome are to be underlined. Furthermore, it is important to notice that - at least for the time being - all BRPs are meant to be a voluntary tool to help people to renovate in a proper way with a tailor-made renovation plan and customised recommendations, and, that only single-family houses are being targeted. The three BRP examples

are in fact all targeted to residential buildings, but in principle, BRPs could also be adapted to other building typologies (e.g. multi-family, public and commercial buildings).

After an introduction on overview on each BRP experience, a comparison has been conducted (Section 4.4) to set the scene on that issue.

4.1. Woningpas in Flanders (Belgium)

BRPs in Flanders (Belgium) are being developed as the so called 'Woningpas' or Dwelling ID. The focus of this project lies mainly on single family dwellings. However, over time, the goal would be to extend the concept to a 'Gebouwenpas' or building ID, to be used also for non-residential buildings [50]. The Flemish Energy agency (VEA) government, in cooperation with a network of stakeholders, is developing the so-called "Renovation Pact, with the aim to improve the energy efficiency of the existing housing stock (towards E60) for 2050.

The "light version" of the Dwelling ID will be release at the end of June 2018 in a static version and it will focus mainly into renovation purposes with the goal to digitalize all information related to each building over its entire lifespan. To accomplish this, the Dwelling ID involves the cooperation between house owners, several government bodies, such as the departments of urban planning, energy, environment and waste management and, professionals such as architects, engineers, contractors and service providers. Thus, the passport goes way beyond the notion of energy consumption or the EPC. It contains all information about the building in a logbook, ranging from on-site collected data and measurements, restauration or improvement works done with their respective invoices, up to building permits and subsidies. Furthermore, it is meant to provide a tailored renovation advice for the building owner and an expanded energy certification for tenants and potential buyers, called EPC + . [51]

Aside from improving the long-term energy efficiency of the current building stock, also the dynamism of the renovation market and, providing the average private house owner with an easy-to-use tool to keep track of his property, it is found to be crucial aspects of a well-designed passport by VEA. They stated furthermore very clearly that the graphic design is of major importance: an appealing and clear layout with adequate visualizations etc. can be very stimulating for the normal private owner to be engaged in renovation works [51]. Charts, schemes, colors and icons as used in the mock-up by BPIE make a non-trained eye notice the elements of major importance much more easily. Finally, an important concept in the Dwelling ID is the one of a step-based approach: a single household cannot account for a full deep-renovation as is needed to meet future standards in one single project. By planning measures well, a lock-in at any point can be avoided too. The idea is to guide the proprietors to a better preforming building over time by taking the most important measures first, in an economical viable way. This, whilst taking care of investment/output rates, property value and comfort improvement. The implementation is foreseen to start gradually from 2018 onwards.

4.2. Individueller Sanierungfahrplan–iSPF (Germany)

In Germany Energy Performance Certificates (EPCs) are compulsory for all new and existing buildings when sold or rented, and when buildings undergo major energy renovations. The German EPCs are grouped in two categories depending on the type of assessment: the certificates based on the calculated energy demand (asset rating) and the certificates based on the measured energy consumption (metered rating), the latter only allowed for multi-family buildings (more than 5 dwellings) and residential buildings built after 1977 [52]. In Germany, EPCs are not considered reliable enough to stimulate renovation and are often viewed as an administrative obligation. On the other hand, there is a strong culture of on-site energy auditing, but the very detailed reports delivered to building owners (up to 150 pages) are often left unread and do not promote staged renovations.

The concept of Sanierungsfahrplan (SFP) was initially developed and tested by IFEU and ECONSULT in the federal state of Baden-Württemberg in 2011–2013 and officially launched in 2015. The Sanierungsfahrplan BW" is an energy audit instrument, publicly funded by the State Bank (L-Bank) and carried out by certified energy auditors. It can also serve as a partial fulfilment of the Renewable Heating Obligation of Baden-Württemberg. Besides residential buildings, the official decree defining the Sanierungsfahrplan, the Sanierungsfahrplan-Verordnung SFP-VO, also defines requirements for a Renovation Roadmap for non-residential buildings.

A newly developed Individueller Sanierungsfahrplan (iSFP) was launched at the national level in 2017 aiming to provide long-term guidance on deep renovation to the building owner. The iSFP is part of the National Energy Efficiency Programme and of the "Federal Efficiency Strategy for Buildings" (ESG) published in December 2015 [53]. IFEU (Institute for the Energy and Environmental Research), DENA (the German Energy Agency) and the Passivhaus Institute (Passive House Institute) were in charge of the project, in collaboration with the German Ministry of Economic Affairs and Energy (BMWi). Since July 1, 2017, the iSFP is accepted as audit report within the federal Office for Economic Affairs and Export Control (BAFA) support programme "Energieberatung vor Ort".

The iSFP is based on two site visits and on proper dialogue between the owner of the building and the energy auditor, of which the whole process is described in the handbook dedicated to the energy auditors [54]. It provides, through a face-to-face approach, individualized information and measures, starting from a standardized format. Furthermore, it works with the best possible principle (bestmöglich Prinzip), taking into account the opinion, needs and possibilities of the owners to achieve a reasonable result avoiding excessive costs. The iSPF appears a user-friendly tool, which contains short and long-term measures included in a unitary vision, avoiding lock-in-effects and assuring a high quality of the overall result. The primary objective towards the owners, is an increase in comfort and health conditions to provide a good environment to live in but not the energy efficiency on itself [54]. These future improvements are explained in a qualitative way to the owner, in order to be clear and to encourage the actual implementation [55].

The BRP additionally includes a chapter on how to save energy in the use-phase by changing the users' behavior. The energy auditors' handbook [54] clarifies that two documents are included for the owner: an overview page of all measures to be taken along the road and a well-explained technical report containing the more detailed documentation on the renovation works, their costs, effects and impact. These documents have a self-explanatory graphical layout to guide the user towards the final renovated stage.

Contrary to the initiative in Flanders (Woningpas), the German building renovation roadmap does not foresee the introduction of a digital logbook associated with the renovation roadmap. The owners of buildings receive the iSFP as a printed document and in .pdf format. Just like in Flanders, the opinion of many stakeholders played a major role in the BRP's development. The iSFP aims at the privately-owned houses, like the examples of Flanders and France, though, from the get-go, including multiple family buildings. The implementation of the iSFP is under elaboration.

4.3. Passeport efficacité énergétique – P2E (France)

In France, Building Renovation Passports are being developed in the form of the so-called 'Passeport éfficacité énergétique' (abbreviated P2E) as part of the Energy efficiency action plan for France

Table 4
Summary of the BRP comparison in Belgium, Germany and France.

	BRP issues	Woningpas/Flanders (BE)	Sanierungfahrplan/ iSPF (DE)	Passeport efficacité énergétique/ P2E (FR)
Aim	**Key principle:** Building renovation passports are developed as a voluntary tool, complementary to the EPCs.	'Radically digitalized': keeping track of buildings in a unique system, and at the same time stimulating renovation	'Best-possible principle': setting out a roadmap to improve all houses over time within realistic boundaries	'Energy reflex': taking every possible maintenance points a possibility to improve the energy efficiency of homes
	Ambition (long-term target for existing stock):	Flanders refers to the notion of "long-term efficiency" (an energy efficiency level to be achieved by 2050).	Germany has introduced the "best possible principle", which establishes that auditors have to recommend the most ambitious measures to achieve the efficiency level established for the building stock and must justify any deviation from the best standard.	Passeport Efficacité Energétique (P2E) has adopted a definition of deep renovation (corresponding to BBC11 level of renovation to be achieved by 2050, equivalent to 80 kWh/ m^2 of primary energy per year, including heating, hot water and cooling).
Content	**Format**	Digital, online shared platform including renovation advice and a full logbook	Printed and .pdf format report	Digital, online shared platform
	Logbook	YES. Flanders foresees the full development of the building logbook as part of the BRP.	NO. Germany has not planned to include the logbook in the iSFP.	NO: a logbook is developed separately. P2E will contribute to the Energy Performance and Renovation Component of the so-called 'Carnet numérique de suivi et d'entretien du batiment'13 developed by the government.
	Graphic design	Visually appealing and easily understandable	Not yet available, but the importance is known to the developers	Visually appealing and easily understandable
	Geo-localization and climatic data	YES the exactly address with climatic data.		
	Building typology	Single family home. In future both residential (all typologies) and non-residential buildings.	Single family home. In future multiple family residential buildings	Single family home. In future multiple family residential buildings
	Performance indicators	Most of the performance indicators are presently under development or undergoing an internal approval. Thus, the technical details are not currently publicly available.		
	Comfort	All three concepts have included indoor air quality and comfort level among the main indicators, but it is not yet clear how they will be accounted for. All three models are exploring a new way to measure comfort.		
		Both in Flanders and Germany this indicator will be measured not based on technical calculations, but in a more subjective way for which more information are not yet available.		P2E is also considering the adoption of a mixed approach, combining technical elements with subjective criteria. By using "permanent feedback" from the upcoming pilot implementation, P2E intends to adapt its criteria based on the lessons learnt on the ground during the implementation.
Initiators	**Model of development**	Public authorities	Public authorities	Mixed model, private companies and public authorities
	Financial scheme base information	The cost for setting up the instrument (web-based platform) and until the first release of the building passport (Voningpass) is carried by the Flemish government.	The public actors of the Sanierungfahrplan" initiative support the on-site building audits. The L-Bank (State Bank of Baden-Wurttemberg) manage the financial program on behalf of the Federal Ministry of Economic Affairs and Energy (BMWi)	The costs for the design and testing of P2E has been covered by private actors: the Shift Project association initially introduced the concept and a group of private companies agreed to provide seed funding for the creation of the Expérience P2E association, in charge of developing the design and testing the building passport concept.
Development Process	**On site audit**	All three concepts have on-site energy audits (performed by qualified energy auditors) as the first step towards Building Renovation Passports and tailored solutions as one of the main featured results.		
	Building owners and users' involvement	Building owners are at the centre of the three approaches and invited to a dialogue with the auditors. In particular, for the Flemish BRP, with the beginning of 2018 has started a new and more active phase of users' involvement in order to make it a more dynamic tool.		
	Stakeholders engagement	All have identified the main barriers to deep renovation in their market, mapped the main stakeholders and regularly involved them in the design of the renovation roadmap.		
	Political support	Public authorities in Flanders, France and Germany have shown interest for this concept and supported its development.	The German government is supporting the preliminary work to introduce the individual renovation roadmap in the country (based on the results of a pilot in Baden-Wuerttemberg)	the Energy Transition Act (Loi de Transition Energétique et pour la Croissance Verte) mentions that a digital notebook (carnet numérique) has to be deployed by 2017;
	Training	NA	Training for the auditors is offered as part of the process to establish a Building Renovation Passport and it also includes communication skills and the life-cycle approach of building elements.	Training for the auditors is offered as part of the process to establish a Building Renovation Passport.
	Auditor's training	NO: not yet planned, but considered	YES: planned	YES: planned

(*continued on next page*)

Table 4 (*continued*)

BRP issues	Woningpas/Flanders (BE)	Sanierungfahrplan/ iSPF (DE)	Passeport efficacité énergétique/ P2E (FR)
Expected starting of BRP implementation in practice	Light version will be realized in Spring 2018.	None of the models is available on the market yet. The implementation phase will be realized between 2017 and 2018.	

Table 5
Potential list of KPIs necessary for a BRP [16].

Performance indicators	Indicators
Energy consumption	■ Primary energy consumption [kWh/m^{2}a] (heating, DHW, cooling, fans, pump, elevators, control) ■ Final energy consumption [kWh/m^{2}a] (heating, DHW, cooling, fans, pump, elevators, control) ■ Net energy consumption [kWh/m^{2}a] (heating, DHW, cooling, fans, pump, elevators, control) ■ Building component heat transfer coefficient U value [W/m^{2}k] (average value of wall, windows, roof, basement) ■ Energy consumption of lighting system kWh/m^2.year ■ Energy need for Heating & Cooling kWh/m^2.year
Thermal comfort	■ The exceeding hours of a defined threshold [no. of h] ■ PPD [%] and PMV [−3 + 3] (EN ISO 7730) for 4 categories of comfort level in accordance with EN 15,251 standard ■ Use of scale/color code to express: Cold - extremely uncomfortable, Cool - uncomfortable, Slightly cool- slightly uncomfortable, Neutral - Comfortable, Slightly warm - slightly uncomfortable, Warm -uncomfortable, Hot - extremely uncomfortable (Qualitative level)
Airtightness and ventilation	■ Type of ventilation system ■ Air exchanges rate (ACH) ■ Heat recovery efficiency [%] ■ Building airtightness by 50 Pa (ventilation) or by % = Pa 1/h (infiltration)
Indoor air quality	■ ACH or CO_2 equivalent concentration in indoor air above outdoor concentration in PPM, for different categories in accordance with EN 15,251 ■ PM and TVOC content in indoor air ■ The percentage of pollutants (CO_2)
Noise insulation	■ Sound pressure level [dB]
Daylight	■ Daylight factor ■ Daylighting autonomy ■ Useful Daylight Illuminance
Artificial lighting	■ Typology of lighting ■ Power of lighting [W/m^2] ■ Spatial light distribution
CO_2 emission	■ Equivalent CO_2 emissions per m^2 [kgCO_2/m^2 year]

[56,57]. The concept for this Energy Efficiency Passport was developed by a French think tank on sustainable economy (the Shift Project) together with multiple stakeholders [58,59].

Identical to other examples, the BP has a set long term vision targeting in this case at transforming the whole French building stock to Low Energy Building standards by 2050, under the law promoting energy transition for a green growth [60]. Hovorka [61] claims that the thermal renovation of buildings has been intended as a primordial step towards de-carbonizing the economy in France and the objectives for 2025 are to have all F and G class (according to EPC) buildings renovated, and by 2050 having the whole building stock listed as A or B class.

The P2E is based on a pragmatic approach, in which an energy reflex is established amongst the owners and building professionals who engage themselves into optimizing the overall energy efficiency with every work (also maintenance) done to a building. Contrary to other examples of BRPs, the French version aims to standardize the measures to be taken, based on the building's current technological status [62]. This can help offering the policymakers a nationwide overview and gives the industry a set of benchmarks. The goal is then to combine these standard solutions together and to make adaptations based on the specific case in order to get a customized solution for each specific building.

The Energy Efficiency Passports are placed on an open-source (free) web-based platform that is shared between the owners, the governmental instances and all involved professionals [57]. It all starts with a certified audit, leading eventually to a complete renovation scenario in concordance with the owners' needs and possibilities [63].

The final report includes a clear graphical layout to visualize the results for each step clearly to individuals not familiar with the construction industry. Later, all files related to the building's maintenance, equipment replacements and renovation can be stored in an online digital logbook.

Although the Energy Efficiency Passport is not planned to become a full logbook itself, it does contribute to energy aspect of the French digital logbook ("carnet numérique de suivi et d'entretien du logement") that is obligatory for all new buildings from 2017 onwards.

4.4. Comparison and overview on performance indicators for BRPs

In this subsection, the comparison on the above presented BRP is presented coupled with an overview on the performance indicators individuated and considered in such a tool.

The review on the three models has been structured according three macro topics: aim, format and content and development process. For each topics the main important issues has been investigated.

Table 4 is the result of the BRP comparisons conducted.

Which are the key performance indicators for a building renovation passport is still an urgent question to solve in order to standardize the approach within Europe. Within the three case investigated, the KPIs are still different due to many reasons, one for sure is the dependence to their respective laws and directive on the energy efficiency. Fabbri et al. [44] noticed an increased interest in the notion of thermal and lighting comfort, not only from a quantitative point of view, but also in a qualitative way.

A potential list of the KPIs necessary for the BRP has been developed by BPIE in cooperation with experts and building owners to support the development of step-by-step renovation roadmap.

Table 5 provides a list of potential set of relevant Key Performance Indicators (KPIs) included in the BRP. These information has a great potential and value for building owners, investors and valuation agents, because they increase their confidence on the buildings and consequently they can trigger a long-term perspective and allow them to clearly outline robust renovation plans; including short-term actions and measures that need a more adaptive and flexible approach.

5. Conclusions

Tackling the issue of increasing the renovation rate with new instruments is of major importance for the building sector. In recent years, the concept of BRP and its current applications, they are demonstrating to be a possible way to achieve higher (and deeper) renovation rates.

The paper, with the overview on the BP concept evolution and the critical review of the running initiative, comes to some important conclusions and recommendations for developing a BRP that can listed as following:

(i) long-term perspective needed;
(ii) timing and sequencing of actions developed;
(iii) customer engagement and consideration of the individual renovation context;
(iv) attractiveness and motivation;
(v) automation and dynamism of the process instead of static tool.

According to the authors, these lessons learned will help other countries as they explore the options for such BRP. Moreover, the review of the EPBD with the Clean Energy for All Europeans policy package, they introduce the importance to include such an instrument in national renovation strategies and they emphasize the role of consumers and their ability to actively participate to Europe's energy transition. As remarked also by Fabbri [44], Engaging customers and considering their specific situation to ensure the advice they receive is personalized, reliable, low risk and provides both a long-term perspective and suggestions about the right timing and sequencing of action, will contribute to drive the EU towards a clean energy transition and promote a better involvement of consumers.

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