A Digital Logbook as an Interactive Tool to Fulfil Service Companies' Needs and Requirements in Building Renovations

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Abstract. The lack of an appropriate information management along the life cycle of a construction work is one of the major issues that AEC sector is facing. The collection and exchange of information is already complex for new buildings, but it becomes even more difficult for renovations. Thus, the building logbook could have an essential role in improving the availability and quality of data for several stakeholders involved in the building process. The repository of building-related information, such as energy consumption and production or maintenance operations, is a bilateral tool to connect users and third parties. The aim of the paper is to present the digital logbook developed within BIM4EEB, an ongoing Horizon2020 project that has analysed firstly the needs and requirements necessary for its development and then it has defined its structure in order to be stored and accessed inside the BIM management system.

1. Introduction

Buildings are among the biggest consumers of energy in the world. In fact, it is estimated that in many International Energy Agency (IEA) member countries not only the AEC sector is responsible for over 40% of primary energy consumption, but also that this energy demand doubled between 1971 and 2010, guided primarily by population increase and economic growth. Considering buildings number progressive growth, their global energy demand is expected to increase by a further 30% by 2035. In countries where current buildings will remain in place for years, the renovation should be considered the best way to focus on, through implementation of energy codes and minimum performance standards in existing buildings [1]. To meet both the EU 2020 targets and the commitment undertaken in Paris in December 2015, it is crucial to increase the current EU renovation rate from 1.2 % per annum to 2–3 %. Despite building renovation feasibility from an economic and technical point of views but also social and environmental benefits that could come from, the amount of renovations is still low and under the expected level. Building owners and stakeholders encounter numerous barriers to improve the energy performance of their buildings [2].

Several kinds of barriers have to be taken into account in renovation interventions, as financial issues, working time control, discomfort of users and a difficult decision making among different suitable interventions. Difficulties in accessing information concerning the facility, especially when such information is mainly in a paper-based format, are a common barrier for stakeholders. Moreover, during operation and maintenance, the involved stakeholders have sometimes to deal with as-built data that are out of date or with a lack of knowledge about building components and systems that make the choice of the best alternatives for renovation difficult. In some types of renovations, a large number of

stakeholders are involved, and this complicates the exchange of information and it results in bad communication. In addition, financial and legal difficulties have to be taken into consideration.

Energy Performance Certificates (EPCs) could be useful to solve these obstacles, but they have limitations. In fact, they don't give tailor made information about renovation and they don't communicate increased thermal comfort and air quality, higher levels of natural lighting and improved health of occupants that are some of the most important benefits and drivers for renovation.

Consequently, Buildings Performance Institute Europe (BPIE) proposes to expand EPCs into Building Renovation Passports (BRPs), a user-friendly long-term step-by-step renovation roadmap adopted by owners to plan renovations and to collect all relevant information about a specific building and that could be used in combination with the so called logbook [3]. The concept of logbook or building passport born as collector and repository of building information, containing significant data about renovation intervention. Thus, it became not only a fundamental source of information for stakeholders, but it is a beneficial instrument for owners that could improve the knowledge about their buildings and consequently the quality of them [4][5].

Within this context, the BIM4EEB project has developed a structure for digital logbooks [6][7], as an archive of building related information in a digital format coupled with a renovation roadmap within iBRoad project [8][9], with the aim to guide building owners through their building renovation process by giving a customised renovation plan.

The use of digital logbooks has several benefits, for instance, the possibility for building owners to access important data, to do an in-depth building diagnosis, to receive alerts and reminders, to make useful comparisons with other buildings, to read the detailed version of their renovation roadmap, and to assess relevant financing options available for the specific renovation.
Besides the building owners, inhabitants and authorized third persons – such as energy experts, utility companies, facility managers, financial institutions and public authorities – are deemed stakeholders who can contribute or benefit when accessing the logbook.

The lead consultant/designer, responsible for developing the building logbook, provides benefit ensuring that the client's requirements are satisfied throughout the process and that the actual design intent is passed to the facility manager. Facility managers can have firstly a better understanding of the building and they can contribute in tracking changes, furthermore they may have ready access to information on the design, commissioning and energy consumption allowing a better management and possible improvements in energy efficiency. Occupants or inhabitants may understand better how to use spaces and to improve comfort and energy efficiency. Eventually, detailed information about the real time status of the building, materials and systems and energy consumption is needed by financial entities and real estate professionals.

Once defined on one hand the barriers that stakeholders have to overcome during renovations in order to obtain an improvement of building conditions and on the other hand the several benefits that each stakeholder gains from the digital logbook, the first step in order to develop a digital logbook is the definition of needs and requirements.

2. Research and methodology

BIM4EEB, a current Horizon2020 project founded by European Union, promotes BIM-based renovations through an impressive toolset that is capable to support designers, construction companies and services companies respectively in design and planning phase, to perform efficiently the work and to provide interesting solutions for building renewal. Therefore, the project is creating a BIM management system with specific tools for quickly mapping buildings, for improving HVAC design, operation and management, and for better tracking renovation operations. To define which information should be collected within the BIM4EEB digital logbook, the paper analyses existing logbooks because they have different developments and also different name, purpose, concept, and features across European countries. The various European initiatives on such tool will be firstly examined. The second part of the chapter will be instead reserved to the investigation of the methodology adopted to create the digital logbook.

2.1 State of the art

The table below presents a series of European measures on building passports and logbooks.

Table 1. Building passport / logbook overview

Name	Country	Structure/Documents
Building folder (Hausakte)	Germany	The building folder is characterized by two 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 [10].
As-Built File (Oplever-dossier)	Netherlands (NL)	Opleverdossier (As-Built file) is a record of information on a residential building giving details about the technical quality of that building and guidance on maintenance. It has been introduced in the Building Quality Law in April 2016. Collected information relate to the completion of the building, building maintenance and servicing, moisture and ventilation, construction and maintenance of heat insulation, mechanical ventilation, electrical installation drawings, pipework and sewerage drawings, information on materials used, and other plans and drawings [11].
Fascicolo del fabbricato	Italy (IT)	It is a technical document containing all the distinctive elements of a building - identification, design, structural and plant information - with the aim of having a complete knowledge and consequences of prevention and safety. The document is voluntary and was developed in 1999. Thanks to the D.P.R. 380/2001 and the new technical standards for buildings - D.M. January 14, 2008 – the Italian logbook spread more widely, and its use increased. Municipalities, provinces and regions have declined it in different ways, but the key contents are the same. An example of contents is the following: records in relation to the location of the property in the territory, cadastral card and size of the property; techno-typological data (to be updated with information on the evolution of conditions of the building and its parts); data on materials and components used; data on changes and adjustments (i.e. structural and plants systems, intended use) [12].
Building Logbook	UK	Generally, in UK reference is made to CIBSE Building logbook. It offers a standard format covering how a building is intended to work and how it is meant to be maintained and serviced. It provides a mean to record the energy use and maintenance of the services within the building and it also helps with monitoring and maintaining occupant satisfaction by keeping a log of indoor environmental quality (IEQ) related complaints and the response actions. This tool collects information grouped into: Building history; Purpose and responsibilities; Links to other key documents; Main contacts; Commissioning, handover and compliance; Overall building design; Summary of areas and occupancy; Summary of main building services plant; Overview of controls/BMS; Occupant information; Metering, monitoring and targeting strategy; Building performance records; Maintenance review; Results of in-use investigations [13]. When speaking about UK building logbook, it is important to mention Home information pack (HIP), containing all the documents usually required when buying and selling a home, valid in UK and Wales [14]. In addition, also the building logbook used in Cornwall, a summary document describing the new or restored building and how it works, can be considered [15].

2.2 Case study: the digital logbook within BIM4EEB project

The first step to build the logbook is the definition of stakeholders needs and requirements. Since the EU project involves partners from different countries (Italy, Finland, Spain, Sweden, Ireland, Cyprus, Germany, Belgium, and Poland), national differences were taken into account because of the influence on needs and requirements. Beside different national renovation standards and laws, conditions of building stock could vary together with calculation methods for assessing energy performances, market situation for energy audit products and funding programmes and national incentives.

The following questions were considered to investigate and collect useful data for service companies:

- Which are the services to be taken into consideration?
- Who will be the main users of digital logbook?

- Which are the main interests of service companies in renovation processes?
- Which are the main sources of information?
- Which kind of information need to be stored in a digital logbook?

Specifically, energy analysis and audits, energy management, project design and implementation, maintenance and operation, monitoring and evaluation of savings, property/facility management, energy and/or equipment supply, provision of service (space heating, lighting, etc.) are the considered services within the project and about which information are collected.

The main stakeholders and users as well as their benefits derived from the digital logbook have been explained in the first chapter and are reported in a comprehensive outline in the figure below.

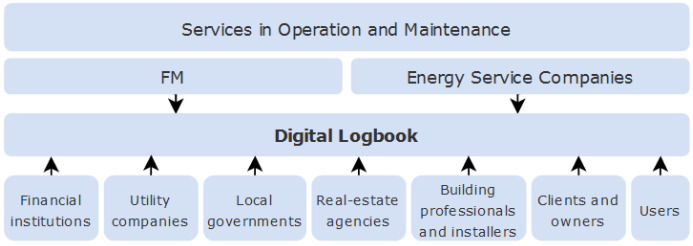

Figure 1. Stakeholders using digital logbook and taking advantage of it.

About the major interests of service companies in renovation processes several aspects must be considered as renovation policy impact, impact on energy demand, investment requirement, impact on comfort, impact on real-estate value, environmental protection policy, CO_2 savings, recommended timeline, health and safety, fire safety issues, connection with building automation system, visualisation such as work orders, how and where maintenance actions will be done, installation instruction, etc.

According to the literature, the building logbook should contain data such as building type and age, property plans and obligations, periodic synthesis data resulting from sensors continuously monitoring indoor climate (air temperature, air relative humidity), indoor air quality (CO_2 concentration, VOC content) and thermal comfort (PPD and PMV), information about energy consumption and energy cost, main significant interventions of executed maintenance (e.g. boilers replacement), etc. However, compared to the literature the BIM4EEB logbook concept has a different view of users and their access to it, factor that makes it unique in comparison to the other developed logbooks.

In fact, within BIM4EEB the logbook would become a tool for in-depth information on building relevant data and actions taken on it available to facility managers, but also to owners and clients, public authorities, occupants, designers and installers through the BIM Management System (BIMMS).
In this way building owners could be supported in investigating renovation options. Other stakeholders could access the same information for improving building performances or for updating requirements during building lifecycle.

The digital logbook is not only a management tool but it is also characterised by an operating feature: building operators could access the digital logbook and contribute actively to it reporting - if maintenance interventions for instance are considered - the most important actions, reserving the other executed maintenance operations for the planned O&M program.
Several kinds of data, which have to be updated during building lifecycle, are collected regarding different sources of information as building permits, properties, localization and legislation; agreements between stakeholders; agreements related to building use and operation; reports and certificates or data directly collected around the building.

3. The structure of digital logbook

The digital logbook has been structured with the aim to overcome issues related to the lack of information and partial knowledge about building conditions. The developed structure follows a certain flexibility to serve both national/regional needs but also to be integrated into a wider European approach.

To obtain the final structure of the digital logbook, the guidelines of the renovation roadmap managed by iBRoad project have been partly followed, but, unlike the iBRoad renovation roadmap, the digital logbook has been conceived as a synthesis of the most relevant building information from several points

of view and not as a customised and long-term renovation plan. Even if, in this moment, it is a mainly a descriptive repository, in the future it can be extended with an evaluation of the current state of the building in the form of score given by the stakeholders themselves in order to have a major and numerical feedback.

The proposed BIM4EEB logbook framework is subdivided into five macro areas to facilitate the distinction between different topics. The first group contains the *general and administrative information* about the building and its units, users, and owners. In the *Building construction information* group, there are all the technical information and data about the building asset and its components. Information related to energy consumption and performance belong to the group *Building energy performance*. Maintenance activity for the building and its parts are collected within the *Building operation and use* group. Lastly, data connected to the building or its surrounding infrastructure through information and communication technologies (ICT) are placed in *IoT information*.

In addition, it is fundamental to define different levels to classify the information on the type of collected data. Therefore, the digital logbook is characterised by six fixed levels of information, as follows: *Subgroup of information*; *Information*; *Source of information*; *Stakeholders providing the information*; *Stakeholders requiring the information*; *Use of information in O&M*.
Since the information content for each category is very considerable, it is not possible to show in this scenario the whole developed logbook. Consequently, one of the most significant section related to the facility management has been represented in the figure below.

Subgroup of information	*Information*	*Source of information*	*Stakeholders providing the information*	*Stakeholders requiring the information*	*Use of information inO&M*
Energy consumption and production	Energy source Metering system information	Energy bills; Smart metering; Energy certification; Design/As-built documentation (drawings and report)	Building professionals and installers; Energy Auditors; Building User; Energy sector-Business	Building user/Building owner; Facility managers; Financial institutions; Energy auditors; Design team (Energy expert, Building Service designer), when making the "As is" simulation model before the renovation measurements; Public authorities	Building check/Assessment; Economic/Financial evaluation; Renovation; Retrofitting
Energy generation	Energy source Metering system information	Smart metering; Mechanical metering; Design/As-built documentation (drawings and report); EPC	Building professionals and installers; Energy Auditors; Building User; Energy sector-Business	Building user/Building owner; Energy auditors; Design team (Arch, Struc, Elec, Building service designer) before renovation; Public authorities	Building check/Assessment; Economic/Financial evaluation; Renovation; Retrofitting
Maintenance	Electrical/HVAC/ Firefighting system & Other "Special" Walls/Roofs/ Floors/Windows/ Doors	Maintenance plan; Assessment report; Laws and regulations; Warrantee documents; Design/As-built documentation (drawings and report); EPC	Building professionals and installers; Building user; Owner	Facility management team; Public authorities; Building user	Building check/Assessment; Economic/Financial evaluation; Renovation; Retrofitting; Statistical data for comparison purposes
Indoor conditions	Intended use	Smart metering; Laws and regulations; Control/Assessment	National public authorities; Building user; Inhabitant	Building professionals	Definitions of alternatives about how to improve indoor conditions of occupants
Climate data	Weather data	Weather reports; Laws and regulations	Energy Auditors; National public authorities; Building user; Inhabitant	Building professionals	Definitions of alternatives about how to improve indoor conditions of occupants giving the climate data

Figure 2. BIM4EEB digital logbook framework concerning building operation and use

4. Conclusions

The paper has been developed in the context of the EU founded project BIM4EEB. It proposes the structure of a digital logbook to overcome communication and information management issues that are typical in renovations.

Starting from an overview on the building logbook concept in Europe and focusing then on the digital logbook developed by the BIM4EEB project, some important conclusions can be outlined:

- monitoring regularly data collected from buildings, it is possible to reduce the divergence between building operation and building design
- inhabitants and occupants could understand better which is the design intent and buildings performance, their comfort, satisfaction and productivity could improve too
- data from digital logbooks can also improve the commissioning and handover process
- a better management and operation of buildings results in lower costs and in a reduction of CO_2 emissions.

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