BIM4EEB

BIM based fast toolkit for
Efficient rEnovation in Buildings

D1.5 Report on societal impact RP1

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D1.5 Report on societal impact RP1

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EXECUTIVE SUMMARY

BIM4EEB is a project introducing a BIM-based toolkit for efficient renovation. The aim of the project is to ease the process of building energy renovation, which provides benefits for many stakeholders such as owners, tenants, designers and many other third parties. Through a BIM Management System (BIMMS) and its interfaces, the actors of the process can interact with the building models, sensor data and construction information. Owners mainly benefit from the digitalized management of building data, and the tools of energy and cost analysis or scenario simulator. Tenants have the possibility to manage and give feedback about the thermal and indoor air quality (IAQ) conditions, besides following the construction process and getting custom information. Designers can access more data in a most efficient way, and the BIMMS allows them to inform all the other participants about changes or other issues.

The effect of an intervention on the built environment can be categorized in three main impacts, i.e. environmental, economic and social impacts. While the first two ones are relatively easy to assess with quantitative analysis, also sustained by BIM-oriented technologies, it is much different to assess impacts on individuals and the society. Social Impact Assessment (SIA) is a recognized field of research studying strategies to measure and manage impacts of planned interventions. Starting from the USA regulations in the 1970s, evaluation methods have been studied and applied in many fields of infrastructure and built environment and they have been implemented in regulations all over the world to assist community managers in decision-making processes. Nonetheless, the field of application is limited either to large-scale interventions or to expensive infrastructures. Also, the low quality of data sources makes such measurements less efficient and time-consuming.

This document aims at defining the methods, the indicators to be measured and their evaluation strategy of the impacts to all the social stakeholders involved in the project. In this context, the priority is to maximise an efficient use of data collected by the BIMMS and its integration with SIA methods analysed from literature. The outcome of this document will be used for an analysis whose results will be published in D1.8 *Report on societal impact RP2*.

PUBLISHING SUMMARY

BIM4EEB is a project introducing a BIM-based toolkit for efficient renovation. The aim of the project is to ease the process of building energy renovation, which provides benefits for many stakeholders such as owners, tenants, designers and many other third parties. Through a BIM Management System (BIMMS) and its interfaces, the actors of the process can interact with the building models, sensor data and construction information. The effect of an intervention on the built environment can be categorized in three main impacts, i.e. environmental, economic and social impacts. While the first two ones are relatively easy to assess with quantitative analysis, also sustained by BIM-oriented technologies, it is much different to assess impacts on individuals and the society. This document proposes a Social Impact Assessment (SIA) method to measure the effect of BIM4EEB on the stakeholders involved by it. This framework will be then used and validated at the end of the project.

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1 Introduction

BIM4EEB is a project introducing a BIM-based toolkit for efficient renovation. The aim of the project is to ease the process of building energy renovation, which provides benefits for many stakeholders such as owners, tenants, designers and many other third parties. Through a BIM Management System (BIMMS) and its interfaces, the actors of the process can interact with the building models, sensor data and construction information. Owners mainly benefit from the digitalized management of building data, and the tools of energy and cost analysis or scenario simulator. Tenants have the possibility to manage and give feedback about the thermal and indoor air quality (IAQ) conditions, besides following the construction process and getting custom information. Designers can access more data in a most efficient way, and the BIMMS allows them to inform all the other participants about changes or other issues.

The effect of an intervention on the built environment can be categorized in three main impacts, i.e. environmental, economic and social impacts, also known as the three dimensions of sustainability. While the first two ones are relatively easy to assess with quantitative analysis, also sustained by BIM-oriented technologies, it is much different to assess impacts on individuals and the society. Social Impact Assessment (SIA) is a recognized field of research studying strategies to measure and manage impacts of planned interventions. Starting from the USA regulations in the 1970s, evaluation methods have been studied and applied in many fields of infrastructure and built environment and they have been implemented in regulations all over the world to assist community managers in decision-making processes. Nonetheless, the field of application is limited either to large-scale interventions or to expensive infrastructures. Also, the low quality of data sources makes such measurements less efficient and time-consuming.

The document is structured as it follows: Section 2 introduces an analysis of SIA methods at the state of the art, including examples from other H2020 projects and references from standards; Section 3 presents the features of the BIM4EEB project, the actors involved and the demonstration sites, besides the performance indicators -KPIs-defined for the project objectives; in Section 4 the methodology for SIA of BIM4EEB is presented and, finally, Section 5 shows the future development of this framework of evaluation.

1.1 Relevance to other BIM4EEB deliverables

This document refers mainly to WP2 deliverables describing actors and their data requirements. D3.5 *Measurement and Verification* protocol has been referenced for the Key Performance Indicators (KPIs) and their measurement method. D8.1 *Report on management of real Best Practice Examples* is the reference for the demonstration site information.

The outcome of this deliverable is a SIA method for BIM4EEB project. The results of the measurement and evaluation with this framework will be published in D1.8 *Report on societal impact RP2*, at month M40.

1.2 Reference to other research projects

The aim of this document is to report the activities of social impact assessment of the BIM4EEB project. The effectiveness and the originality of the project is evaluated considering social, economic, environmental and technical aspects of the outputs of this research project. Also, BIM4EEB relates to other present or past H2020 projects with similar scope.

The references to the other H2020 projects analysed are listed in Section 2.2, with their full name, acronym and website link. Further documentation or other references have been listed in the bibliography. The final draft has been checked with an antiplagiarism checking tool (PlagScan), with a final plagiarism percentage of 11.5% considered acceptable as most of the words highlighted by the tool are not complete sentences and referred to other BIM4EEB deliverables.

1.3 Innovative results and progress

This document aims at defining the methods, the indicators to be measured and their evaluation strategy of the impacts to all the social stakeholders involved in the project. In this context, the priority is to maximise an efficient use of data collected by the BIMMS and its integration with SIA methods analysed from literature. This document also aims at proposing a framework for adapting generic quantitative KPIs to SIA-oriented evaluation methods. The methodology proposed will be validated at M40 and the results reported in D1.8.

2 State of the art

In this chapter, the definition of Social Impact Assessment is introduced, highlighting contributions from research, standardization organizations and European H2020 projects.

Social Impact Assessment (SIA) is an activity aimed at measuring societal impacts of projects. According to the definition given by Vanclay (Vanclay, 2003), SIA is about "the processes of managing the social issues associated with planned interventions". This definition comes from the principles written by the International Association for Impact Assessment (IAIA), which is an organization aiming at representing the professionals of social and environmental impact assessment. Although the fields of social and environmental assessment have differences, in the history of impact assessment these two aspects have been considered as interlinked.

From the point of view of institutional regulators, concerns about environmental impact of human activities inspired the development of regulations since the start of the1960s. Starting in USA, the first national policy regarding is the National Environmental Policy Act (NEPA) and it represents the first legislative effort considering environmental damages (Luther, 2008). This law is different from the ones introduced before in USA or other countries, as it does not have a regulatory statute, but it prescribes the basic framework for evaluation of environmental impacts without providing details on how to accomplish the goal.

Approved in July 1969, updated versions of NEPA included explicit requirements for environmental impact assessment, referred to as the environmental impact statement (EIS). A new federal agency, the Environmental Protection Agency (EPA), was established with the goal of examining and propose changes to EISs and consequently to the NEPA. Despite NEPA was originally generated mainly starting from the idea of managing the use of natural resources, the act considers the topic of environmental protection from different point of views, as confirmed by the principles listed below:

- "Fulfil the responsibilities of each generation as trustee of the environment for succeeding generations" ;
- "Assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings";
- "Attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences";
- "Preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity, and variety of individual choice";
- "Achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities";
- "Enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources". (White, 1970)

As it is possible to understand from the above cited principles, EIS is founded on a modern concept of sustainability considering impacts of human activities both on the environment and on its accessibility by people.

From a practical point of view, NEPA requires the assessment of environmental impacts, the proposal of alternatives to the proposed action, short and long-term commitment consequences evaluation, and analysis for optimization of irreversible use of resources. Examples of application of these policies can be found in significant projects of the scale of mining activities; flood control and water resources management projects; dam, oil and gas, highway, bridges but also affordable housing blocks construction, or renovation of existing housing units, etc.

Also, the European Commission, starting from the early 1970s, has brought on different actions, developing a directive for environmental impact assessment (EIA) in 1985 (EC, 1985). The main difference between the first European legislation and NEPA is that EIA directive aims at considering environmental issues before licensing public or private work of a certain scale. Depending on the type of intervention, the Commission mandates the assessments as mandatory (e.g., for nuclear power reactors or chemical treatment plants), while states can decide criteria and thresholds for each project under the scope of the directive. Although it mainly considers the conservation of the environment and the prevention of pollution of air, soil and water, in its latest drafts it also includes refers to the protection of architectural, aesthetics and heritage value, besides the quality of human life and of its populations on a bigger scale.

The EIA directive has been revised in order to include more socio-economic aspects in the assessments, align it with other existing regulations and ease the impact assessment procedures. The process of regulation renewal started with a report about the effectiveness of the directive, in 2009. After one year, in 2010, the European Commission (EC) launched a public consultation about the quality of the EIA process and its reach compared to other EU policies. This step, then brought to the proposal for a new directive in 2012, led to a new version of the EIA directive in May 2014 (EC, 2014). On the overall, changes have been justified according to three specific classes of objectives: (1) to specify the context and the contents of EIA reports; (2) to adjust the directive to emerging environmental issues like climate change, biodiversity, resource efficiency and their impact on populations; (3) to enhance policy coherence and procedures. One of the main actions towards these goals is the definition of time frames for each step of the Impact assessment process: the directive sets time thresholds for consulting and decision stages of EIAs (e.g. 90 days is the timing threshold for decision after the submission of required information from planners). Considering the object of assessments, what is most important is the broadening of the boundaries of the investigation towards more socio-economic impacts, with focus on hazard about accidents and disasters, besides significant effects on population and *human health* (*human health* replaces *human being*, including reasoning about the quality of life). An extra point of view on the impacts on the economy of local small and medium enterprises (SMEs) is introduced in the new version of the directive. Single countries apply these principles ruling the different assessments and their field of application.

The European Commission also foresees new horizons for the legislation as new technologies are introduced in the European market. The main report is the Digital Transformation in Transport, Construction, Energy, Government and Public Administration published by the Joint Research Centre of EC (EC, 2019).This document reports the context in which the European Commission plans the research efforts for different sectors, analysing the barriers and the requirements from both an economical and a societal point of view.. An overview of digital transformation in the construction sector has been presented considering digital transformation enablers and barriers in construction. Impacts of digital transformation on construction also have been presented considering economic impacts, digital start-ups in the engineering and construction sector, platform business models, innovation, business models and skills. Moreover, Social impacts have been considered covering employment and digital transformation in the construction sector, Potential implications of Digital Transformation on construction workers in the EU (Potential implications of DT on specific occupations, Potential impact of DT on migrant workers) and Safety.

The regulation framework suggests that methodologies for assessment have been studied starting from large-scale interventions. As a matter of fact, processes of SIA have been used to understand effects of large infrastructural projects like dams (Kirchherr & Charles, 2016), recycling systems (Aparcana & Salhofer, 2013) or city-scale projects (see Chapter 2.2). Aside from legislative acts, it emerges that social impact assessment methods have been developed in order to be effective in generic contexts, in particular in absence of regulatory frameworks (Vanclay, 2003). Though, the process of evaluating the projects has been studied in other specific context. Housing is recognized as a human right (UN, 1948) and every intervention on public or private housing generates implications on human lives and society. In the particular case of public housing there are some examples of application of SIA methods, mainly focused on the quality of procurement processes (Montalbán Domingo, 2019) or the feedback from tenants (Liu, et al., 2018) (Gan, et al., 2019). The satisfaction of public housing inhabitants, as investigated by Gan (2019), depends on factors of different nature, from neighbourhood causes to features of the architecture and disposition of spaces, to the technical performance of buildings. Renovation projects focus on the enhancement of this last issue, which causes energetic and environmental saves, but they also contribute to the enhancement of Indoor Environmental Quality (IEQ). The technological performance of the building has proved to be crucial for tenants (Zalejska-Jonsson & Wilhelmsson, 2013).

Besides the causes of satisfaction of housing projects, researchers have been studying the impacts on a larger public than the tenants, trying to understand societal effects of large public housing project. Li et al. (Li, et al., 2014) proposed an ex-post analysis of the impacts of large housing projects, introducing 24 indicators in three categories, as in Table 1. These indicators were then networked with the Analytic Network Process (ANP), measuring the weight of each category and indicator according to the relative relevance. This framework has been tested and validated on an existing housing facility in Nanjing, eastern China. Mixing qualitative and quantitative analysis, this research offers one of the most relevant examples of ex-post evaluation of social impacts of housing projects, providing a framework for the evaluation of both existing facilities and future projects.

Table 1: SIA indicators for Li et al. (Li, et al., 2014)

Category	Indicator
Socio-economic effects (SE)	SE01: Employment rate of local residents
	SE02: Income growth rate of local residents
	SE03: Crime cases around the project under investigation
	SE04: Poverty population among local residents
	SE05: Coverage rate of medical insurance of local residents
	SE06: Per capita living space of local residents
	SE07: Average price of nearby lands
	SE08: Ratio of students to of local residents
	SE09: Occupancy rate of the project under investigation
Mutual adaptabilities (MA)	MA01: Support degree of local governments
	MA02: Satisfaction degree of the developer
	MA03: Perfection degree of electricity supply
	MA04: Perfection degree of water supply
	MA05: Perfection degree of communication facilities
	MA06: Degree of public participation

	MA07: Regional air condition
	MA08: Regional water quality
	MA09: Local residents' acceptance to the project under investigation
	MA10: Compliance degree with national policies
	MA11: Compliance degree with local development
Social risks (SR)	SR01: Satisfaction degree of relocated people for the project under investigation
	SR02: Satisfaction degree of occupiers in the project under investigation
	SR03: Frequency of mass incidents about the project under investigation
	SR04: Public satisfaction degree on the threshold of affordable housing

2.1 Standards

Sustainable development of the construction sector, defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (CIB, 1999). It entered the European programs of development because of the importance of the construction sector for European economy. The International Organization for Standardization started developing a suite of standards providing specification and requirements for the assessment of sustainability performance of buildings. These standards are developed by the ISO/TC 59/SC 17 *Sustainability in buildings and civil engineering works* standardization group. The work is coordinated by the French organization AFNOR which published the CEN/TC 350 program containing 11 active standards and 4 under development standards at the moment[1].

CEN divides the standards, as visible in Figure 1, in Framework level, Building level and Product level standards. The presented framework is intended to support the decision process through a voluntary method of sustainability assessment. The general framework for sustainability assessment is presented in EN 15643-1 (ISO 16309, 2014), while the framework for social sustainability assessment is referred at EN 15643-3, as visible in Figure 1. All the methods are life-cycle based, which means that they consider the asset in every phase of its life, from conception and design to disposal and demolition. Social sustainability assessment methods differ from economic and environmental ones mainly because they need both qualitative and quantitative indicators. This framework applies to both new and existing buildings. EN 16309 does not provide thresholds, levels, classes or evaluation methods, but it defines the social performance categories for the evaluation as it follows:

1. accessibility;
2. adaptability;
3. health and comfort;

[1] Accessed on 14/05/20 at: https://www.iso.org/committee/322621.html

4. impacts on the neighbourhood;
5. maintenance;
6. safety and security.

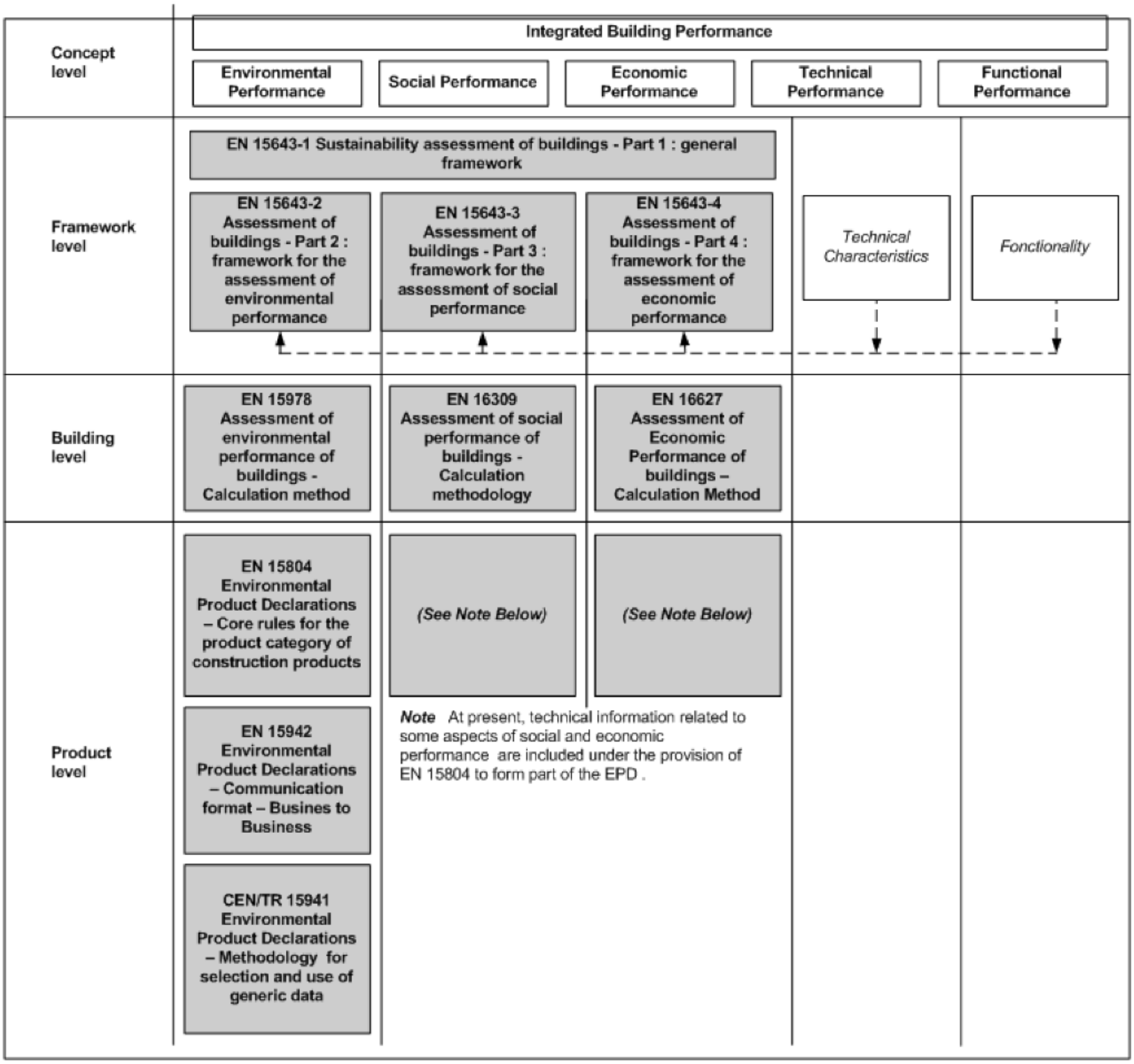

Figure 1: Work program of CEN/TC 350 (ISO 16309, 2014)

The purpose of the analysis, the object and the scenarios are defined according to a specified method in EN 16309. The main purposes cover the need for assistance in decision making process, documenting social performances of buildings or supporting policy development. This process allows the comparison between scenarios or projects on the basis of functional equivalents (ISO 16309, 2014), i.e. functional or technical requirements allowing the comparison between building objects.

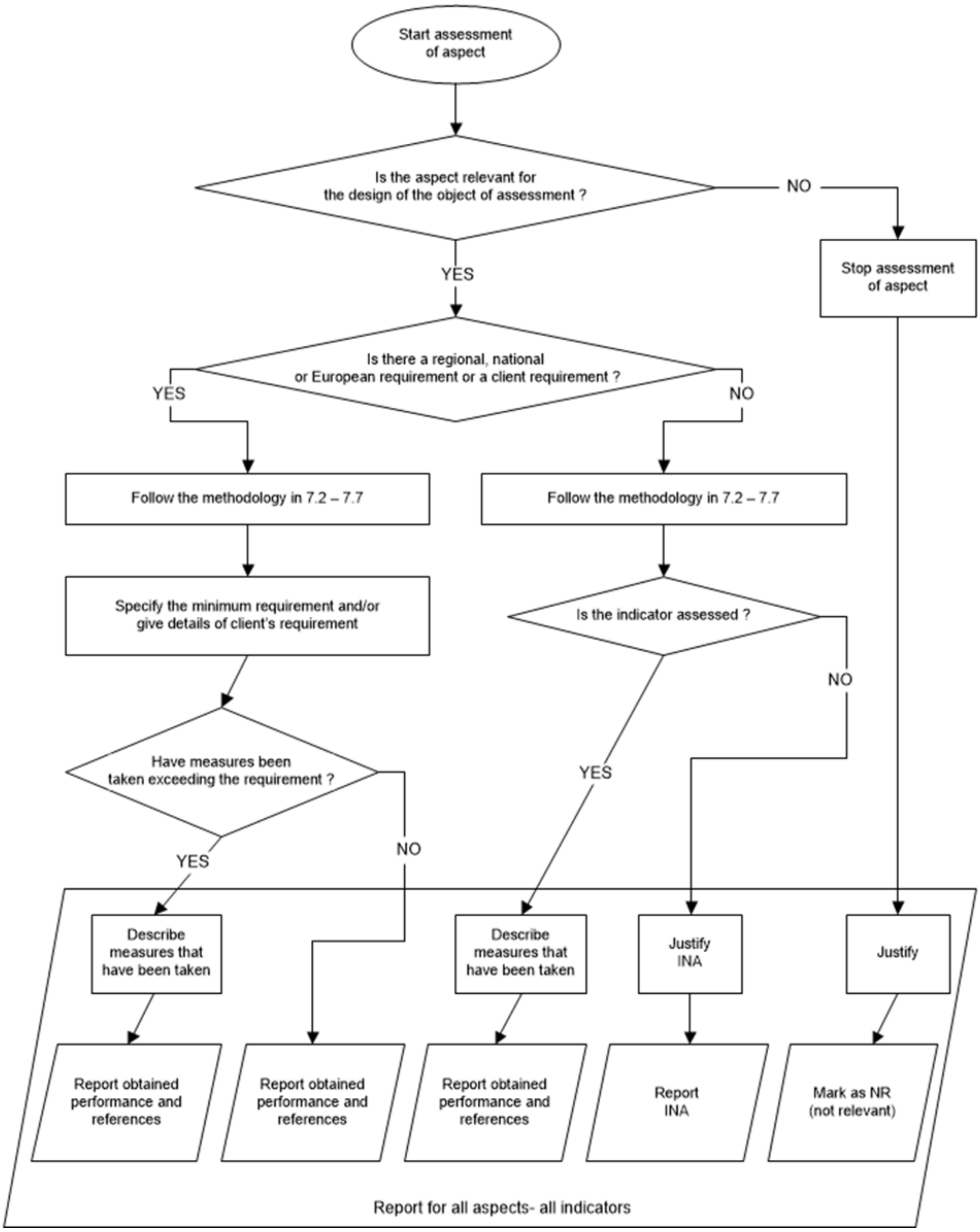

Figure 2: Concept of social performance assessment of buildings (ISO 16309, 2014)

The other parts of the standards provide a list of basic quantitative indicators of assessment and requirements for reporting in a transparent and retrievable way.
More indicators can be added to the framework proposed in EN 16309 and reported in Figure 2, but context based qualitative indicators are out of scope for this standard.

2.2 H2020 projects

Social impact is a key aspect to evaluate the efficiency of research projects involving residential buildings.

In this section, some EU funded research projects have been presented. Examples have been chosen for their relevance to the scope of this document and the affinity to the features of BIM4EEB project. Also, the context of both the call of this project and the call themed Digital Twins have been considered. Assessment methods have been aligned according to the goals of LC-EEB-02-2018 call and to those of the projects with public deliverables on SIA.

2.2.1 Analog H2020 projects

2.2.1.1 DREEAM: Demonstrating an integrated Renovation approach for Energy Efficiency at the Multi-building scale

A group of partners in the DREEAM[2] (DREEAM, 2017) project lead by Open Domo, Savills & SinCeo2 developed a specific digital platform dedicated to building owners and the tenants involved in the renovations. The key added value of this platform has been presented by showing the impact of the DREEAM renovations on the energy efficiency performance of the buildings, and proposing optimal solutions to building owners in the context of the DREEAM renovation scenarios;

More specifically, the DREEAM platform is able to:

- Inform the building owners about the energy usage in the common areas and on the building level to evaluate a potential for different scenarios of energy reduction strategies;
- Recommend very specific actions for energy optimisation, which will range from identifying the quick wins (low hanging fruit) in the demand shifting to comprehensive renovation strategies;
- Incorporate the renewable energy monitoring and the overall energy supply management.

In this project, the methodology developed for the sociological evaluation has targeted two types of actors involved in the DREEAM renovation process: Building managers' employees and a selected group of tenants in the 2 pilot sites in UK and Italy. Different thematic approaches have been taken into considerations during the qualitative questionnaire development process such as *socio-economical* context of the pilot site and households structure, mapping of the life quality of tenants inside their dwellings (thermal comfort, access to energy, fuel poverty situations, water consumption, renovations expectations, collective feeling in the building with neighbours, relations with the building owner) and the pilot site area and mapping of the level of tenants with electric and electronic devices in the domestic area.

2.2.1.2 HEART

HEART[3] project aims to provide a multifunctional toolkit which integrates several components to transform existing buildings into energy efficient smart buildings. It is also a quick decision-making tool which utilises advanced data analysis to predict and guarantee energy efficiency. While HEART is developed with a focus on existing buildings, the concept can be extended to new residential and commercial buildings. This project aims to lead us towards the future of sustainable building renovation and drive the transition towards smart cities.

The core of HEART is a cloud-based computing platform developed to address and support specific energy-related needs and choices. The HEART toolkit utilises components such as ICT, BEMS, HVAC, BIPV, and Envelope Technologies. These cooperate organically to achieve high levels of energy efficiency and allow for an effective interface with the Smart Grid. The system is driven by this cloud-based platform which supports decision-making in the planning/design phase and optimises energy performance in the

[2] DREEAM https://dreeam.eu/ Accessed 11/12/2020
[3] https://heartproject.eu/ Accessed 07/04/2020

operational one.

This project also aims to define alternative business models for exploiting the market potential of HEART. In order to find the best solution, the strategy has been chosen to evaluate both the economic sustainability of the models and their pros and cons. Also, support materials are expected to be provided with the definition of guidelines for the implementation, the integration of new components and the definition of a technology roadmap, with the aim to facilitate HEART's European market penetration.

This project aims to be tested in two different case studies. The buildings are large residential buildings, one Italian and one French. Before the interventions, a large energetic analysis is planned to define the *baseline energy performance and current users' behaviour*. Finally, specific surveys and interviews have been set up focusing on buildings *users' acceptance and satisfaction*, starting from the beginning of the retrofit intervention until the end of the project.

2.2.1.3 ReCO2ST: Residential Retrofit assessment platform and demonstrations for near zero energy and CO2 emissions with optimum coST, health, comfort and environmental quality

The roadmap of this project[4] goes from the *user awareness to the user acceptance* by defining an awareness rising plan and a social adoption campaign where a set of 12 external communication tools have been defined in terms of their duration, target group and timing.

Finally, two sets of indicators have been defined and recommended:

1. Social indicators based on project goals, legislative and regulatory aspects;
2. Energy, environmental, economic and health indicators.

The following social indicators are recommended in order to assess the impact of the whole project progress in terms of dissemination and communication:

- Number of unique visitors to the Website(Google Analytics)
- Number of references to the project in other websites
- Number of multimedia material downloads from the website
- Number of subscribers to the newsletter
- Number of followers on social networks
- Number of scientific publications in peer-reviewed journals and/or conferences
- Number of posts on social network
- Number of workshops co-located at international conferences
- Number of events attended on behalf of the project
- Number of press releases delivered to media
- Number of events with general public attendance
- Number of public awareness events

To facilitate owners who aims to renovate large residential buildings or large stock of residential buildings with a view of drastically reducing their carbon footprint RECO2ST has developed a Business Model KIT. A test of the developed business model kit has been carried out at early adopter sites and the developed

[4] ReCO2ST https://reco2st.eu/ Accesssed 11/12/2020

technologies have met the expected performance indicators set out in the project.

As all the approaches defined in RECO2ST including the Renovation Assessment Platform, the Retrofit-Kit, the Integrated Project Delivery method, the Intelligent Energy Management System and the Business Model-Kit has been implemented in renovation projects, it is expected that the impact will be:

• Energy consumption will be reduced by at least 60% in order to reach the target of near zero energy compared to the values before renovation, while enhancing indoor environmental quality
• Installation time will be decreased by at least 30% compared to typical renovation process for the building type.
• a high replicability potential and of large market uptake capacity.
• Affordability considering all costs involved, with a payback period below 15 years.
• New generation of skilled workers and SME contractors in the construction sector capable of applying a systemic approach to renovation.

2.2.2 H2020 projects from LC-EEB-02-2018 call

LC-EEB-02-2018 Building information modelling adapted to efficient renovation 5s the H2020 call for projects funding the BIM4EEB project. The research action aims at developing BIM based tools for existing building management. Projects are asked to (1) deliver harmonised common data exchange formats on building components, (2) integrate GIS and environmental data to the energy modelling, (3) connect different purpose models (acoustics, energy, economic evaluation, etc.), (4) develop solutions to integrate the users' feedback and (5) cooperate with standardization bodies to validate BIM platforms. On the overall, the goals are to reduce the renovation working time of at least 15-20% compared to traditional practices, accelerate the market spread of such solutions and to provide best practices examples for the construction industry.

The methods and the results of the project in this call will be a major reference in order to calibrate and validate the method proposed by this deliverable.

2.2.2.1 BIM-SPEED: Harmonised Building Information Speedway for Energy-Efficient Renovation

Since it is necessary to renovate the building stock considering both the impact on the environment and the users comfort conditions, BIM-SPEED[5] has the aim to exploit the Building Information Modelling for developing tools and methods to support and sustain building renovation. The project constituted by a multidisciplinary team of 22 partners spread across 9 countries, focuses on achieving at least 60% energy savings and reducing by 30% the renovation time. In order to accomplish this challenge, the project will develop:

- an open BIM-platform for harmonizing digital information across all phases in the life-cycle of a renovation project.

- a set of BIM-based tools.

-a standardized methods for acquiring, modelling and simulating as built data.

The approach based on process, ICT and social innovation pays a strong attention to the stakeholders involved in the renovation process.

BIM-SPEED will demonstrate the developed solutions in 12 real demonstration sites, in particular residential buildings built between 1945 and 1970, in Italy, Bulgaria, Poland, Romania and Spain.

[5] BIM-SPEED https://cordis.europa.eu/project/id/820553 , BIM-SPEED | Home (bim-speed.eu). Accessed 09/12/20

D6.4: Evaluation and recommendations of BIM data security, privacy, social and ethical aspects of BIM-SPEED will be compared to assess the strategies for the market uptake of the solutions of BIM4EEB and BIM-SPEED.
BIM-Speed also aims to provide advanced methods for building performance analysis to support choosing the most energy efficient and financially viable renovation option that will optimize the comfort of a building's occupants after renovation.

2.2.2.2 BIM4REN: Building Information Modelling based tools & technologies for fast and efficient RENovation of residential buildings

BIM4REN[6], a H2020 funded project, involves 23 partners across 10 countries focusing on the exploitation of BIM for the energy renovation of existing buildings. It wants to offer innovative and accessible BIM tools for each construction stakeholder taking into consideration the following phases of the renovation process:

-data collection to characterize the existing building into digitalized data;

-data management and consolidation creating a BIM model and organizing data;

-data driven design analysing technical and economic potential and generating renovation scenarios.

The main developed or in development aspects of the project are:

-creation of BIM based workflows about the residential building's renovation;

-services are integrated and accessible to each different actor from a single common platform;

-project pilots will be used to test and validate the methodology and tools developed.

The project approach focuses on "Living Labs", namely real case studies used to have a feedback from the pilot case stakeholders; in particular, the pilot sites chosen are in Paris, San Sebastian and Venice. Through them it will be possible to show the quality of developed tools and to offer a demonstration site for the retrofitting sector.

BIM4REN aims at demonstrating how the delivered methodology can improve the renovation process in terms of cost and delays reduction, and quality improvement through the development of the BIM4Ren platform and the demonstration on pilots.

2.2.2.3 BIMERR: BIM-based holistic tools for Energy-driven Renovation of existing Residences

With 18 partners involved across 10 European countries, the BIMERR[7] project started in January 2019 is committed to develop a set of BIM-based tools to support stakeholders involved in the renovation process.

The effectiveness of these tools will be verified exploiting 4 residential buildings in 3 European countries: a pre-validation phase on two existing buildings in Greece, where the renovation interventions will not take place, will precede the validation phase carrying out in Poland and in Spain.

Among the main objectives, the project wants:

-to boost the renovation rate addressing the EU policy objectives;

-to set semantic interoperability between the different standards in the construction sector proposing the results to standardization bodies;

-to develop tools and methods to support the (semi-)automated creation of enriched digital building models of existing buildings and to facilitate the renovation efficiency for all actors.

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[6] BIM4REN https://cordis.europa.eu/project/id/820773 , https://bim4ren.eu/. Accessed 09/12/20
[7] BIMERR https://cordis.europa.eu/project/id/820621 , https://bimerr.eu/. Accessed 09/12/20

The methodology for the assessment of *user acceptance* KPIs described in D3.3 of BIMERR (BIMERR, 2019) introduces the three principles of *functionality, interoperability/compatibility and ease of use* of the User Interface (UI). These factors combined will measure the ease of use, perceived safety and the usefulness of the toolkit. With this methodology, BIMERR introduces 26 KPIs for User acceptance.

During the first period, progress has been made through the foreground work to achieve the social, economic and environmental impacts set for the project. It is predicted that a wide uptake application of the BIMERR solutions will lead to significant annual energy savings, emissions reduction, real state value increase of the EU building stock. BIMERR also aims to contribute to tackling the energy poverty problem in the EU and to create jobs.

2.2.2.4 ENCORE: ENergy aware BIM Cloud Platform in a COst-effective Building REnovation Context

ENCORE[8] is an EU funded project started in January 2019 involving 12 partners from 9 European countries with the main aim to boost the renovation among European countries and in the world through BIM based tools in order to obtain better levels of comfort and energy efficiency.

For the project the involvement of several stakeholders of the renovation process as architects, designers, public administration, FM, etc. is expected; the exchange of information could become more efficient and effective thanks to a common platform accessible by all actors.

Among the involved actors the inhabitants are considered too: they are involved by providing them mobile instruments to capture images and other information inside the apartment.

ENCORE is developing a BIM Cloud based solution to supply services such as acquisition of data, surveys and photogrammetry, end users' feedback by AR/MR, energy efficiency simulation exploiting BIM models, etc. to the actors of renovation process.

As well as other projects involving the development of services and tools, ENCORE will validate and test what has been developed in two demonstration sites ("Baseline" and Experimental" buildings). The first one will be used as a reference and the second one to evaluate different Renovation scenarios and measure their validity. Even inhabitants and owners could help validating the project through on-site solutions via AR or MR or online.

Moreover, several dashboards have been developed to strengthen EnCORE's ease of use. A roadmap has been set up to advance EnCORE to TRL-9, key technical risks has been analyzed and the mitigation actions have been established.

2.2.3 H2020 projects from LC-EEB-08-2020 call

LC-EEB-08-2020 Digital Building Twins (RIA) is a call for proposal oriented to the development of solutions for Digital Building Twins exploiting the most recent digital technologies. Considering digitalization developments, one of the last technologies that construction sector should focus on and exploit is the Digital Twin. The Digital Building Twin differs from Building Information Modelling because it considers the collection and processing of real time data retrieved from the asset through the use of specific tools.

By digital twin a more efficient construction sector can be obtained. Real time behaviour of the built asset and its activities could be monitored and the connection between as-designed and as-build models could allow monitoring real progress with respect the initially BIM-based planning.

The aim of the programme is to create a digital building twin trying to achieve an improved scheduling

[8] ENCORE https://cordis.europa.eu/project/id/820434 , http://encorebim.eu/easyconsole.cfm/id/898/lang/en. Accessed 09/12/20

forecast by 20%, improving the safety on construction sites and enhancing the resource and equipment usage, reducing the cost by 20% on construction sites.

2.2.3.1 BIM2TWIN: Optimal Construction Management & Production Control

BIM2TWIN[9] is an ongoing Horizon2020 project from LC-EEB-08 started in November 2020, coordinated by Centre Scientifique Et Technique Du Batiment (France), that has the aim to build a Digital Building Twin (DBT) platform for construction management providing a knowledge about the current situation of the built asset. The project who sees involved a multidisciplinary team will apply and test the developed Digital Building Twin platform on three demonstration sites in Spain, France and Finland. Among the main objectives we find reducing operational waste, costs and carbon footprint, cutting down schedules, improving quality and safety.

The project will focus on the following topics:

-investigating deeply data, information and knowledge about the Digital Building Twin;

-creating a common platform to acquire, gather and interpret data stream coming from the building and supply chain in order to form real-time project status in a Project Status Model (PSM);

-exposing the PSM to a set of construction management applications (e.g., for monitoring of schedule, safety, quality and impact from an environmental point of view) through an application programming interface (API) and to users through a dashboard;

-representing PSM built on property graph linked to the BIM and project management data.

The output of this project is particularly valuable for its impact towards the construction industries as it aims at enhancing data management throughout the construction process.

2.2.3.2 Ashvin: Assistants for Healthy, Safe, and Productive Virtual Construction Design, Operation & Maintenance using a Digitial Twin

Among the ongoing H2020 project belonging to the call for proposal LC-EEB-08, Ashvin[10], namely Assistants for Healthy, Safe, and Productive Virtual Construction Design, Operation & Maintenance is a financed project using a Digital Twin, involving 14 partners from 11 European countries with the starting date in October 2020. The scope of the project is to achieve an improved productivity by a better use of resources and maximization of equipment, reduced costs and increased work safety for the construction sector by developing an open-source digital twin platform providing a digital representation of the construction asset, collecting real time data and integrating IoT technology. In order to test the efficiency of the platform and tools developed, a validation and test procedure will be applied to 10 real-world construction projects across Europe

The developed platform will allow to collect real time data stream during the life cycle of the product in order to monitor and check the environment and the production process and will exploit the integration with IoT and a set of specified tools. Concerning the features of the project, consider the following:

-merging of video and sensor data,

-integration of geo-monitoring data,

-provision of multi-physics methods of simulation to digitally illustrate the product behaviour,

-designing for productivity and safety by evidence-based methods,

[9] BIM2TWIN https://cordis.europa.eu/project/id/958398. Accessed 09/12/20
[10] Ashvin http://www.ashvin.eu/. Accessed 09/12/20

-providing methods for the 4D simulation and visualization of building processes,

-developing a planning process with the support of real-time data.

Thanks to the Ashvin project developments it will possible to get through worker protection and privacy questions related to the tracking of the construction life.

2.2.3.3 BIMprove: Improving Building Information Modelling by Realtime Tracing of Construction Processes

Starting in September 2020 e with a collaboration of 12 European partners from Norway, Spain, Germany, Switzerland and Finland, the EU-funded BIMprove[11] project has the following main objectives: reducing costs in construction projects by 20%; speeding up construction operation by enhancing the ability to forecast scheduling, by automating progress and quality reporting; making safer the construction site reducing accidents.

The project is developing a cloud-based service-oriented system where exchange information and process data by APIs, improving the 3D-based BIM systems with the digital twin technology providing a more dynamic system based on real time data and behaviour of the building. The users could have an easy access to the information and data by customized interfaces (e.g., wearable technology for alerts, VR visualization for site managers, etc.)

To verify the compliance of developed and provided services with standards three pilot cases will be taken into consideration: BIMprove will be exploited to identify risks connected to fire through a continuous updated building that can be adopted by the emergency plan for fire brigades; the reduction of common accidents can be guaranteed thanks to construction site schedules outlining the eventual changes in safety barriers for workers; a better scheduling could be achieved by notification and visualization processes according to which the involved actors can be advised regarding changes in the plan avoiding conditions contributing to delays.

The effectiveness of the safety measures and the methods to measure it will be a relevant reference for D1.8 at month M40.

2.2.3.4 COGITO: COnstruction-phase diGItal Twin mOdel

COGITO[12] (COnstruction-phase diGItal Twin mOdel) is an ongoing Horizon2020 project started in November 2020 aiming at fast tracking the lean construction to reach the so-called Construction 4.0.

The project wants to develop an interoperable Digital Twin platform, exploiting real-time based tools capable to provide information about the actual state and behaviour of the construction site. The main characteristics of the project are:

-The use of multi-source data stream pre-processing services will handle big data streams in order to inspect data coming from drones or satellite images giving information about the actual behaviour of the built asset and resources and workers involved.

-In order to avoid eventual accidents, the service concerning Health and Safety will investigate the nD BIM to identify hazards and carry out alerts exploiting real time data from the construction site.

-An automated quality control examination, based on a correlation between as-is to as-designed BIM elements, will be allowed by the Geometric and Visual Quality Control service.

-the digital twin will represent the 3D of the model considering as-designed BIM, as built BIM and

[11] BIMprove https://www.bimprove-h2020.eu/. Accessed 09/12/20
[12] COGITO https://cordis.europa.eu/project/id/958310. Accessed 09/12/20

information about asset, machinery and workers locations.

To validate the project and the developed services, COGITO tools will be tested in three demonstration sites: respectively in one lab facility in Austria and in two construction sites in Spain and Denmark. The application of Health and Safety measures through digital tools on the demo cases represents a solid reference for the measures of social impacts.

3 BIM4EEB social context

BIM4EEB is a project aiming at refurbishing residential buildings taking into account the presence of building occupants and asking them to cooperate in some activities. This aspect amplifies the impact of the renovation activity compared to a traditional workflow. This chapter describes the stakeholders involved in the project, their activity and the features of the toolkit proposed. In the second part of this section the methods for performance evaluation are presented. Referring to what has been declared in the Grant Agreement and in previous deliverables, the social impact of the BIM4EEB goals are identified and, consequently, indicators are co-produced and aligned.

All the data collected and elaborated in the project has been treated according to GDPR European regulations, ensuring privacy of all the people involved in the project, especially tenants. More details about this topic are available in the Ethics deliverable.

3.1 Actors involved

Here, the list of actors involved in the project activity is presented. Namely, tenants, owners, designers and site workers.

The involvement of stakeholders is one of the first aspects to be addressed when we talk about "social impact". Following this statement, this chapter will show the results of deliverables from D2.1 to D2.5 containing information on who are the actors involved in a renovation process and which are their needs.

Specifically, questionnaires were implemented and distributed to understand the needs of construction companies, owners and inhabitants (D2.3, 2019; D2.5, 2019).

To estimate the social impact of project based on the perception of stakeholders influencing or influenced by the project, three questionnaires respectively for occupants, construction companies - Facility Managers, and designers are presented in Annex I. Then, this chapter will present the connection between the so called “social impact” and the developed questionnaires. The social impact has been organised at the level of process stakeholders. In order to outline the level of company’s size (Micro enterprises, SMEs, Large enterprises, etc.) a specific filter has been introduced within the questionnaires.

3.1.1 Definition of relevant activities and involved stakeholders in actual and efficient renovation processes

The output of the needs and requirements study carried out in Deliverable D2.1 (BIM4EEB, 2019), which had the main goal of outlining the relevant stakeholders of renovation process, is used.

The main involved actors and stakeholders in a renovation process, including both small and medium enterprises (SMEs) and large enterprises, have been identified as follows:

- Inhabitant/End-user
- Client/Owner
- Client adviser
- Technical adviser
- Project leader
- Surveyor (site, quantity)
- Designer (lead, architectural, structural, building services, fire safety, landscape, interior, lighting)
- Consultant (cost, access, acoustic, planning)
- Adviser (health and safety, facility management (FM), security, sustainability)

- Cladding specialist
- Information manager
- Landscape architect
- Master planner
- Contractor
- Sub-contractor
- Supplier
- Maintenance planner
- Construction lead
- Contract administrator
- Operational lead
- Party wall surveyor
- Local authority
- Tenderer

In the D2.1 the workflows of the main activities, according to private and public sectors, are defined highlighting the principal differences. In the D2.2 there are some additions inherent to the designers.

The details at each activity are presented following the structure defined in the EN 16310:2013 (Figure 3).

N.	WHO	MAKES	WHAT	SHORTCUT

Figure 3: Table structure

3.1.2 Digital logbook

The output of the deliverable D2.4 consists in defining service companies' needs and requirements to be collected for the digital logbook development (BIM4EEB, 2019). Considered as an archive of all information regarding the building, the digital logbook will see the storage and the continuously update of the essential information, like the previous interventions made on the building itself.

During the renovation process many factors could be considered barriers or potential obstacles that might hinder the success of the operation. Among these there are the lack of information or a deficient or inadequate awareness of building information. Consequently, the structure of a digital logbook was defined in D2.4 to be used by facility managers, energy service companies, users and owners in order to, respectively, define activities which will be proposed for renovation, delineate impacts of different solutions on energy demand and get a full idea about the condition of their own buildings.

Users, clients, owners and authorised third person – the latter including energy experts, utility companies, facility managers, financial institutions and public authorities - are the principal stakeholders who can make a contribution and/or benefit when accessing the digital logbook.

Specifically, clients, in contact with design team, work to guarantee a logbook of good quality and they benefit given their knowledge about the building. The lead consultant designer instead is responsible for the development of digital logbook, he has to ensure that the client's requirements are set out during the process and that the actual design intent is passed to the facilities manager. The facility manager has the role to finalize the logbook thanks to his awareness of the building and to generate a historical register of it. In addition to having access to design, commissioning and energy consumption information, facility managers can allow fine tuning of the building. Regarding occupants and users, they could understand how to better use their space improving levels of comfort and energy efficiency by the digital logbook. Finally, also financial companies and real estate operators could benefit of digital logbook: in fact, they need information about the current building structure, materials and systems, consumption, etc. in order to perform their own due diligence and produce an audit on the investment risks of renovating a particular asset.

Logbook information

The information within the logbook have been organized in: General and administrative information (summary of main building services plant, overview of controls/building energy management system, occupant information); Building construction information; Building energy performance; Building operation and use; IoT information.

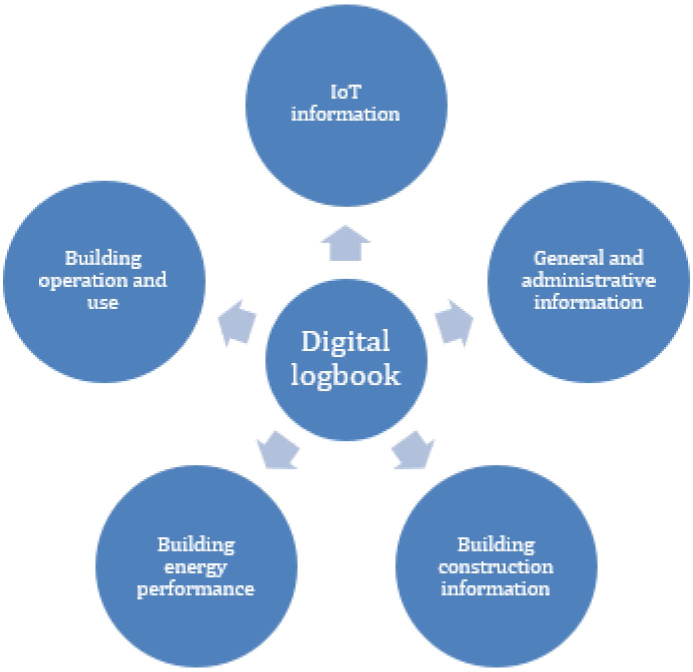

Figure 4: Group of information considered for the development of BIM4EEB digital logbook

For a clear and effective reading, in the deliverable D2.4 the information within the several groups have been organized in tabular form (Figure 5).

Subgroup of information	Information	Source of information	Stakeholders providing the information	Stakeholders requiring the information	Use of information in O&M

Figure 5: View of table fields

3.1.3 List of construction companies' needs and requirements (BIM4EEB, 2019)

Technology and the relative innovation have brought changes among several industrial sectors and even the construction sector (AEC), one of the less developed sectors from the digitalization point of view, has faced some changes and its productivity can grow more if the sector become more digitalized.

In order to have a complete awareness of which were the construction companies' needs, a questionnaire, characterised by general and specific questions, was created and then sent to European companies.

The general questions - highlighted in paragraphs 4.1 of D2.3 (BIM4EEB, 2019).- are about company information and the construction trade and supply chain management (SCM). The questionnaire is further divided into the following sub-sections:

- Company Information;
- BIM for Supply Chain Management;
- Checklist;
- Documents;
- Scheme;
- As-built drawings;
- Management of the data.

Regarding the specific questions section of the questionnaire, a series of categories to the attention of the respondents was introduced and among all those the following four were chosen: Structural element, External vertical closure, Window and Hot sanitary water system.

Moreover, in order to influence as little as possible the respondents, empty tables were created.

Among the objectives of the survey, there are:

- knowing in which phase the single attribute was defined or modified;
- Knowing the person responsible of this definition or modification;
- Identifying the documents containing the aforementioned information;
- Identifying the amount of information provided.

The phases, where the respondent has to indicate when the attribute in question is defined for the first time, are numbered from 1 to 7 and are reported below.

1. Initiative (concept)
2. Initiation
3. Design
4. Procurement
5. Construction
6. Use
7. End of life

Then, the respondent has to indicate who is responsible for defining the attribute:

CL	Client
D	Designer
CC	Contractor
S	Supplier

Figure 6: Actors of the process (BIM4EEB, 2019)

Finally, was asked also where it is possible to find the information and if could be other further attributes related to Ordinary Maintenance, Extraordinary maintenance, Restoration and/or Renovation.

Category															
ID	Sections	Name	Description	In which phase?							By whom?				
				1	2	3	4	5	6	7	CL	D	CC	S	NO

Figure 7: Structure of the table

To see the information contained in each table according to each category, see tables from 3 to 6 of deliverable D2.3 (BIM4EEB, 2019). The total number of companies collaborating to the survey is 27. In Figure 8 details about answering companies are visible.

The graphs of the most significant results are shown below.

Figure 8: Profile of respondent companies (BIM4EEB, 2019)

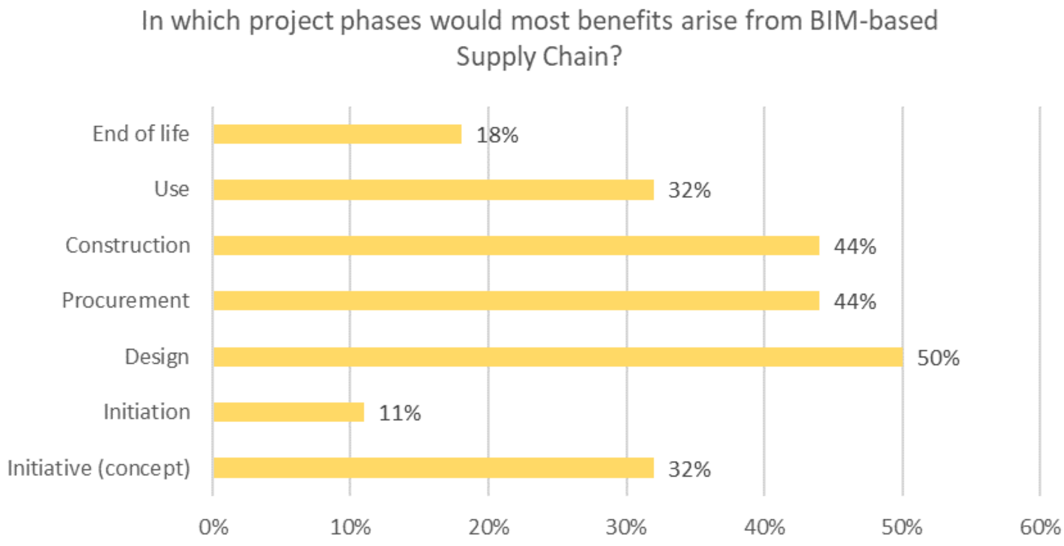

Figure 9: Questionnaires results from D2.3 (BIM4EEB, 2019) (1)

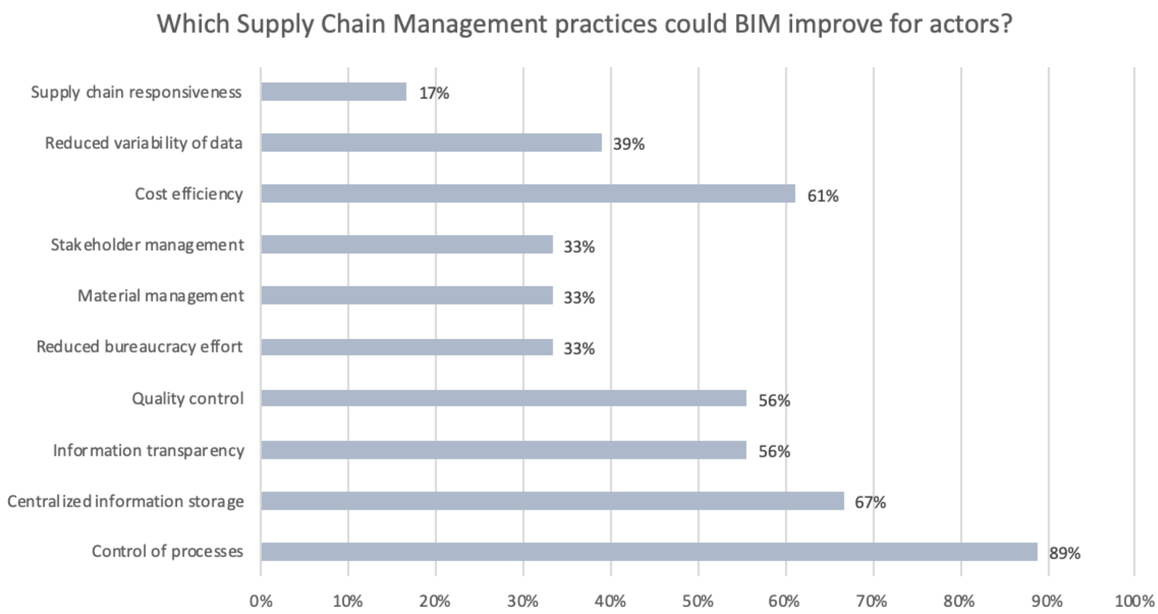

Figure 10: Questionnaires results from D2.3 (BIM4EEB, 2019) (2)

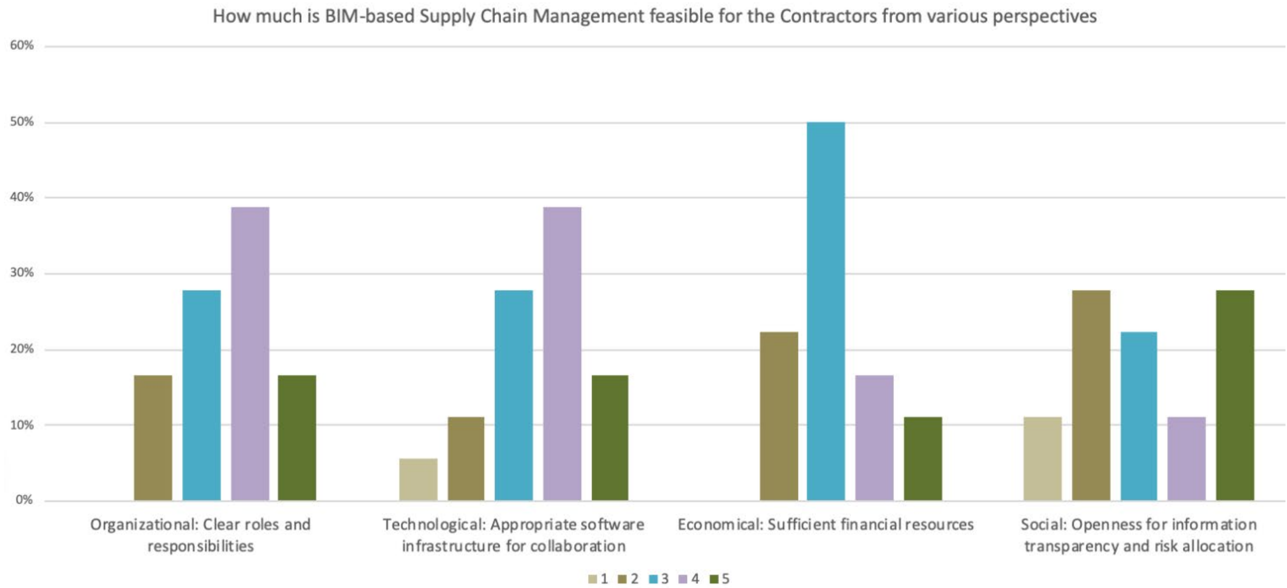

Figure 11: Questionnaires results from D2.3 (BIM4EEB, 2019) - Feasibility contractors [1 (low feasibility) - 5 (high feasibility)]

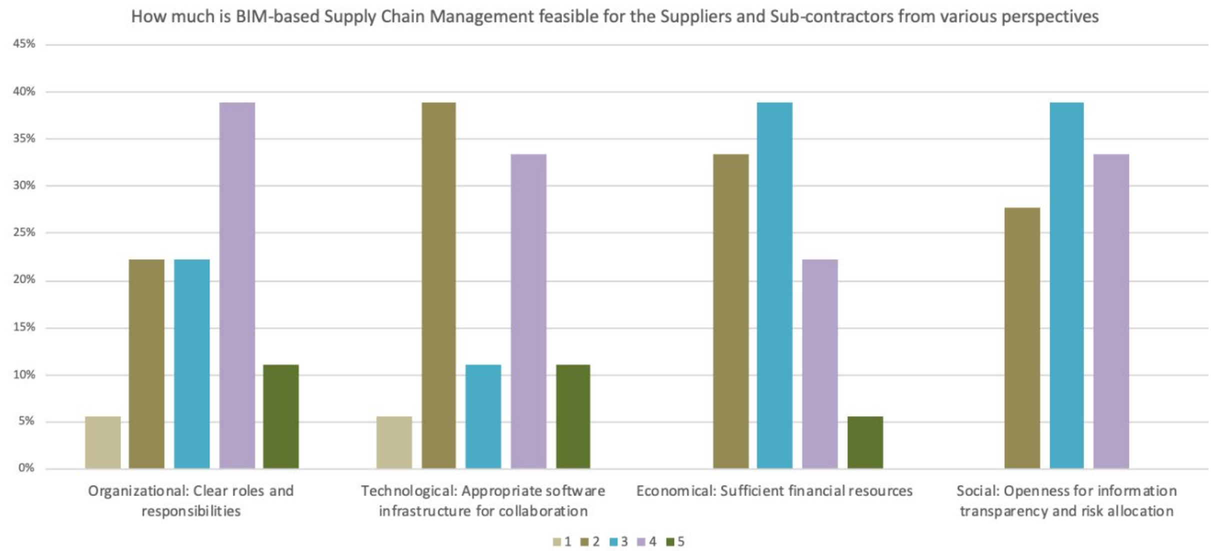

Figure 12: Questionnaires results from D2.3 (BIM4EEB, 2019) - Feasibility supplier/sub-contractors [1 (low feasibility) - 5 (high feasibility)]

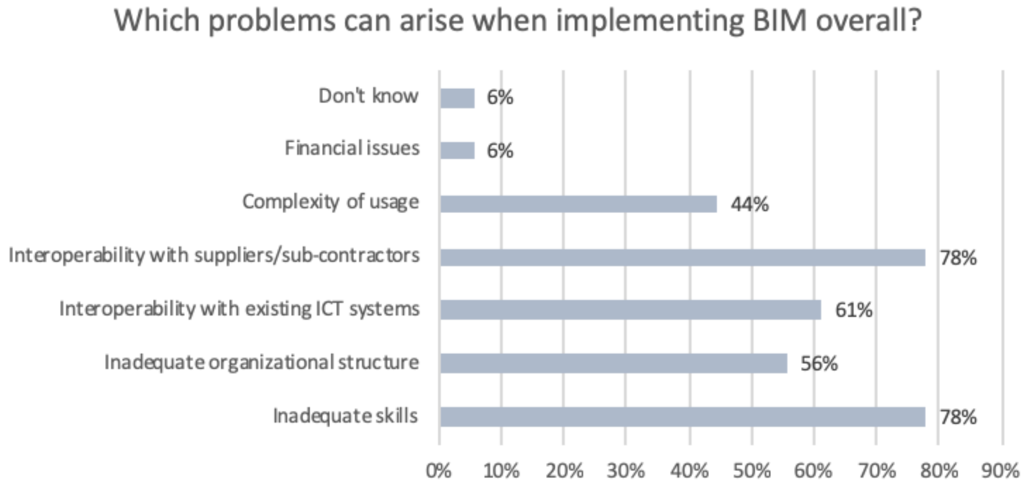

Figure 13: Questionnaires results from D2.3 (BIM4EEB, 2019) (3)

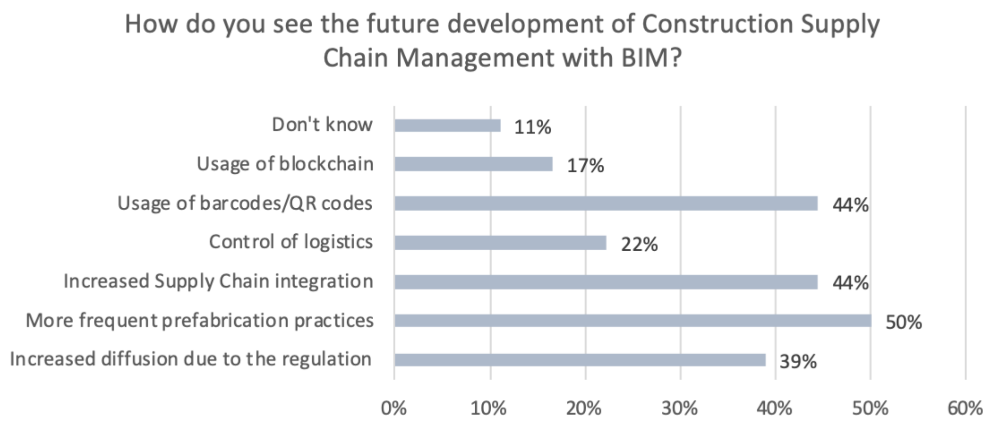

Figure 14: Questionnaires results from D2.3 (BIM4EEB, 2019) (4)

The results of each section were discussed in detail in chapter 5 of deliverable D2.3.

In general according to the output of the data analysis, it is possible to say that the companies needs to introduce software for the data management in order to guarantee a continuous update of information and drawings for the entire life cycle of the project.

Principal companies requirements
Improved interoperability with the stakeholders information systems
Improved interoperability with existing ICT systems used within the organization
Improved ICT skills
Accurate As-Built drawings for projects of restoration and renovation

Figure 15: Information exchange, main requirements (BIM4EEB, 2019)

Principal companies requirements
Greater clarity on the source where the information is located (which documents)
More clarity about the phase where the attributes would be defined
More clarity about who is the responsible for the definitions of the attributes

Figure 16: “structural element”, main requirements (BIM4EEB, 2019)

The results of the analysis of D2.3 confirm the trends outlined by various researchers (Lam, 2017) (Hosseini, et al., 2016) (Bosch-Sijtsema, et al., 2017) representing that most of the companies working in the construction sector can be considered small or medium enterprises (SMEs). As declared in the DoA, BIM4EEB aims at contributing to the development of SMEs by accelerating the market uptake of BIM-oriented tools. Also, renovation sector is estimated to produced an indirect positive effect of 0.00096 jobs created for every squared meter of deep renovated envelope of a European building (BIM4EEB, 2018). Latest reports reveal that overall numbers of BIM users are growing, but the trends see a ratio of BIM adoption for micro enterprises (one or two people enterprises) which is half of those which have over fifty employes (NBS, 2020). BIM4EEB introduces within its toolkit technologies aiming at a Level 3 of maturity of BIM, which ease interoperabilty and communication issues but at the same time it can represent an obstacle for SMEs as highlighted by NBS (i.e. the lack of in-house expertise).

For these reasons this deliverable introduces an evaluation method capable of measuring the impact on construction companies according to their size and their turnover. This is made possible through the fields of the Questionnaires B and C as in ANNEX I, allowing to assess the social impact of the project on the involved actors. Especially, a filter has been introduced as input to define the dimension of the company the interviewee is part of, indicating the range of employees constituting the enterprise (i.e. 1 to 9 employees, 10 to 50 employees, etc.).
After the data collection that will be visible in Deliverable D1.8, it will be clear the type of company where the interviewed actor works in. Then, information retrieved from the questionnaires could be separated and filtered according to the company size feature.
Considering the different questions, a comparison of the level of social impact between the SMEs and other enterprises is possible. Consequently, based on the results of the questionnaire, the social impact of the project on SMEs with respect to micro and large enterprises can be investigated.
Despite the data collected and the results of the questionnaires will be shown in D1.8 as stated above, it is considered necessary and appropriate to present through an example the relation between the questionnaire and the social impact taking into consideration the involvement of SMEs.

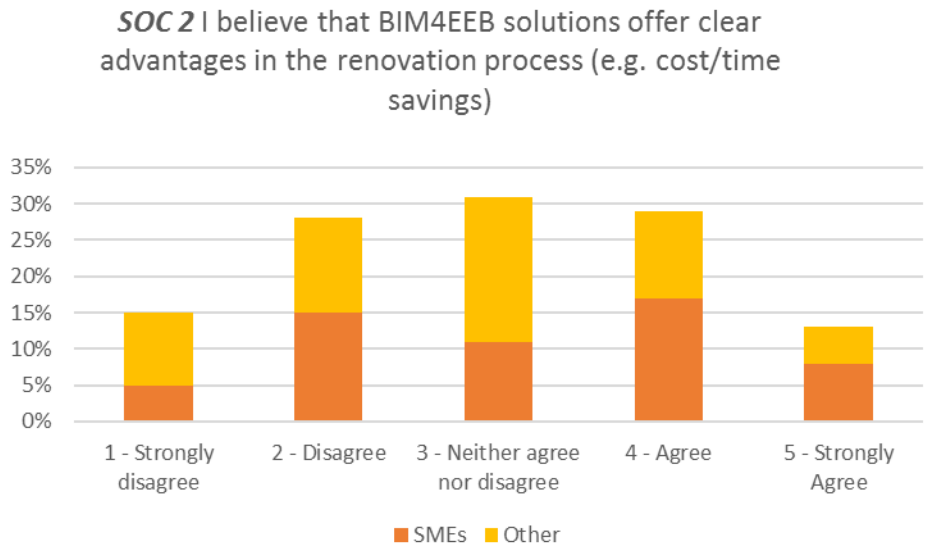

Figure 17: Example of questionnaire results, filtered by companies' size.

The difference in percentage will enable us to outline the social impact on SMEs with respect to the other type of companies.

3.1.4 List of owners' and inhabitants' needs and requirements (BIM4EEB, 2019)

As explicitly stated in the DoA, "a participatory perspective will be even considered as a measure for public and societal engagement, ensuring an active participation of different stakeholders"

Building owners' and inhabitants' involvement in the project's activities is a necessary starting point to define their needs and requirements for the development of BIM4EEB's tools and methodologies.

Building owners and inhabitants are not as familiar with the renovation process and its specificities as AEC business stakeholders (i.e. Construction companies, Service companies, Designers) who have a deep knowledge about such processes. Therefore, in order to ensure an active participation and guarantee the useful contribution, owners and inhabitants have been subjected to appropriate questionnaires and at a later stage in semi structured interviews with the pilot site representative partners.

Figure 18: Buildings owners and inhabitants engagement methodology (BIM4EEB, 2019)

This stage of the project included two different questionnaires, one for the owners and one for the inhabitants.

As defined in the deliverable D2.5, the type of information gathered from the end users is classify into the following groups:

- Profile information;
- General knowledge and familiarity with the tools that will be implemented and questions to Owners

and Inhabitants about their level of information inherent in their buildings/premises;

- The needs of the owners and inhabitants who will be implemented in the BIM4EEB tools.

The templates of the questionnaires can be found in Annex I of the D2.5 and a detailed presentation of the questionnaire results can be found in Annex II of the D2.5 (BIM4EEB, 2019).

In addition to the questionnaires, the owners and inhabitants were subjected to semi-structured interviews that allowed to identify and examine new ideas and additional technical requirements aimed at safeguarding ethical and legal barriers presenting the different demonstration sites.

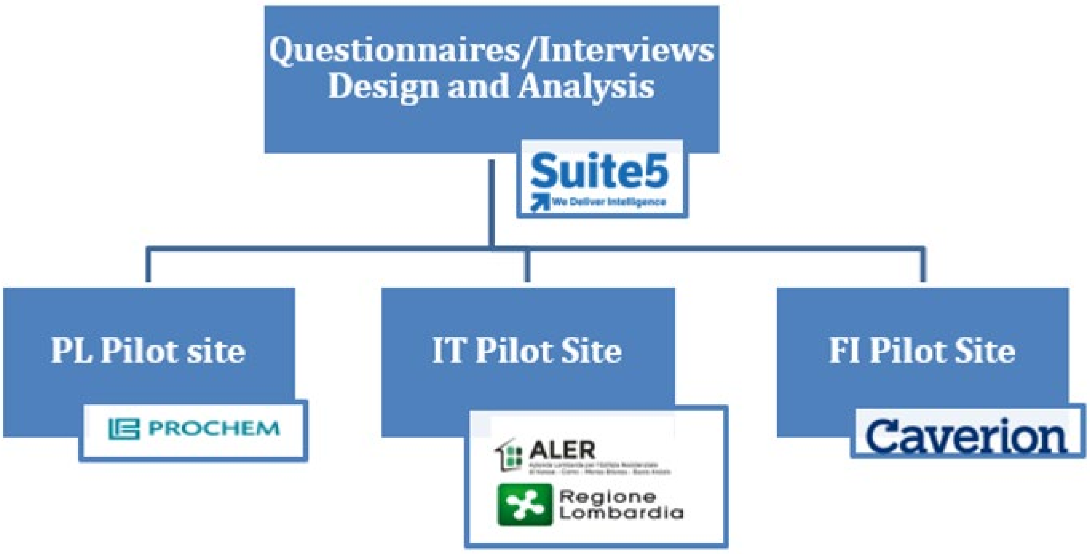

Figure 19: Questionnaires work allocation

Goal of the semi-structured interviews		
1. To shape the final list of Usage Scenarios addressing the owners and inhabitants needs	2. To cross check the results from questionnaire analysis towards the extraction of the final list of owners and Inhabitants requirements	3. To gather any regulatory and legal requirements as part of the overall requirements definition phase at the different pilot sites

In the chapter 6 of the D2.5, building Owners and Inhabitants' needs and requirements are showed. (Table 8, 9 and 10 of the D2.5). All this information is structured in tabular form, and they have been organized according to the following attributes:

- Requirement ID: This attribute gives an identification code to the requirement;
- Description: This attribute is useful to explain the specification of a requirement;
- Renovation Phase: This attribute represents the phase of construction that the requirement

addresses;

- Priority: This attribute represents the importance of the requirement for the construction process.

3.2 Project KPIs

In the context of the analysis of social impacts, in this section the project KPIs implemented to date will be shown. The amount of KPI is increased compared to what was stated in the initial phase. This increase is due to what emerged from the questionnaires and interviews with stakeholders and from the tools being developed.

3.2.1 Project KPIs structure and content

BIM4EEB has structured the KPIs into six macro categories as described below:

Table 2: BIM4EEB's macro categories

Social-Users	Assessing the impact of BIM4EEB based on the perception of the stakeholders directly affecting or affected by the project
Renovation Process	Associated to the specifics of the renovation process, e.g. time, cost for renovation process
Energy	Assessing the energy requirements and performance of the renovated buildings such as energy consumption, energy savings, Life cycle assesment parameters etc…
Comfort	Assessing the impact of BIM4EEB in regard to factors like occupants thermal and visual, building acoustics comfort
Economic	Assessing the economic feasibility of a building's renovation in regard to cost, Life cycle cost, project profitability, LCC assessment, etc.
Environmental/safety	For evaluating the environmental impact of BIM4EEB solution deployment. These include indoor CO_2, CO, Particulate Matter (PM), Volatile Organic Compounds (VOCs) focusing on Indoor Air Quality indicators that quantify occupants' health risks' pollutants

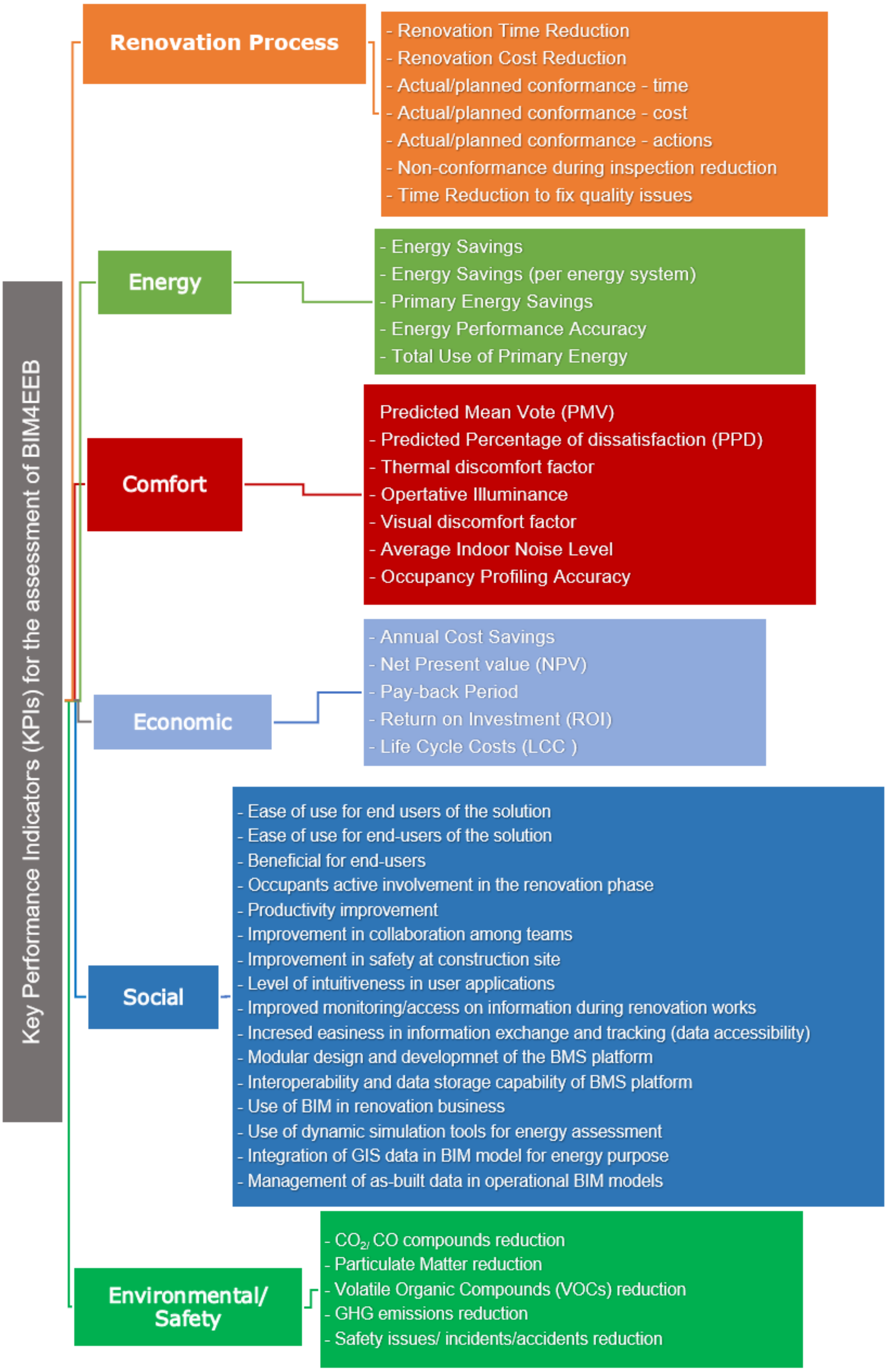

Figure 20: BIM4EEB Key Performance Indicators categories (BIM4EEB, 2019)

The KPIs grouped for categories are collected in the following tables (see paragraph 5.2 of the D3.5)

Table 3: Proposed KPIs for the evaluation of the Renovation category

KPI	Name	Description	Unit
REP 1	Renovation Time Reduction	This is the time saving performed during the renovation process based on the better management of the renovation activities; compared to the baseline/traditional process. A multi-vectoral analysis should be considered addressing the different steps of the renovation process (e.g. audit time, data retrieval, renovation actions etc.,)	%
REP 2	Renovation Cost Reduction	This is the cost saving performed during the renovation process based on the better management of the renovation activities; compared to the baseline/traditional process	%
REP 3	Actual/planned conformance - time	Better accuracy of the renovation process time considering the design phase; compared to the baseline/traditional process	%
REP 4	Actual/planned conformance - cost	Better accuracy of the renovation process cost considering the design phase; compared to the baseline/traditional process	%
REP 5	Actual/planned conformance - actions	Better accuracy of the renovation process time, considering the share of actions completed on time as on the design phase; compared to the baseline/traditional process	%
REP 6	Non-conformance Issues during inspection reduction	Number of non-conformance report items: #qualityIssues; compared to the baseline/traditional process	%
REP 7	Time Reduction to fix quality issues	Reduction of time required to fix quality issues	%

Table 4: Proposed KPIs for the evaluation of the Energy category

KPI	Name	Description	Unit
ENE 1	Energy Savings	Calculating the percentage difference between measured and baseline consumption data within a predefined period	%
ENE 2	Energy Savings (per building component)	Calculating the percentage difference between measured and baseline consumption data within a predefined period for different building components (e.g. HVAC, lights etc…)	%
ENE 3	Primary Energy Savings	Calculating the percentage difference between measured and baseline primary energy consumption data within a predefined period	%
ENE 4	Energy Performance Accuracy	Deviation between predicted and actual energy use by comparing predicted and real energy consumption	%
ENE 5	Total Use of Primary Energy	User of primary energy expressed as the indicator Cumulative Energy Demand during the lifecycle of the project (considering the different phases)	MJ or %

Table 5: Proposed KPIs for the evaluation of the Comfort category

Subcategory	KPI	Name	Description	Unit
Thermal Comfort	COM 1	Adaptive Predicted Mean Vote (PMV)	Adaptive PMV (based on PMV) predicts the mean value of the overall thermal sensation of a person as a function of environmental parameters: air temperature, mean radiant temperature, air velocity, and air humidity.	Numerical (-3 to +3)
	COM 2	Predicted Percentage of dissatisfaction (PPD)	Percentage of the people who felt more than slightly warm or slightly cold.	%
	COM 3	Thermal discomfort factor	Assessing the people's satisfaction with the thermal environment.	Probability (0-1)
Visual Comfort	COM 4	Operative Illuminance	Assessing the people's satisfaction in terms of illuminance compared to a reference value.	lux
	COM 5	Visual discomfort factor	Identifying the feeling of visual discomfort defined from sensing and actuation data.	Probability (0-1)
Acoustics Comfort	COM 6	Average Indoor Noise Level	The level of noise in the building environment compared to reference values.	dB
Occupancy	COM 7	Occupancy Profiling Accuracy	Deviations about real and predicted occupancy schedules	%

Table 6: Proposed KPIs for the evaluation of the Economic category

KPI	Name	Description	Unit
ECON 1	Annual Cost Savings	Reduction of cost due to the renovation activities; compared to the baseline values	%
ECON 2	Net Present Value (NPV)	Calculated based on nominal costs and discount rate based on the projected actual future costs to be paid, including general inflation and deflation.	€
ECON 3	Pay-back Period	The period required to recover the funds expended in an investment on renovation.	Time (years)
ECON 4	ROI - Return on Investment	Assessment of the energy measures for the whole building by using the overall investment costs and the saving in running costs energy.	%
ECON 5	Life Cycle Cost (LCC)	LCC defines the business framework for renovation activities, by comparing the investment costs with the economic savings achieved due to the energy conservation measures introduced in during the renovation. LCC analysis considers all cash inflows and outflows over the useful life of the project, reducing each flow to its present value.	€

Table 7: Proposed KPIs for the evaluation of the Social category

KPI	Name	Description	Units
SOC 1	Ease of use for end users of the solution	It provides the means for assessing the acceptability of the framework from BIM4EEB end user (i.e. Construction Companies, Designer, FMs, Occupants).	Likert scale (1-5)
SOC 2	Beneficial for end-users	The extent to which BIM4EEB offers clear advantages for end users (i.e. Construction Companies, Designers, FMs, Occupants). Advantages can vary from cost savings, improved quality and increased comfort. It is presumed that solutions which have a higher level of advantages to end users will be more likely to be adopted than solutions which have negative or no advantages	Likert scale (1-5)
SOC 3	Occupants active involvement in the renovation phase	The extent to which occupants have been involved in the renovation process.	Likert scale (1-5)
SOC 4	Productivity improvement	The extent to which BIM4EEB improves the productivity of its users (i.e. Construction Companies, Designer, FMs), during the various stages of the renovation.	Likert scale (1-5)
SOC 5	Improvement in collaboration among teams	The extent to which BIM4EEB can improve the collaborations among its stakeholders (i.e. Construction Companies, Designer, FMs, Owners)	Likert scale (1-5)

SOC 6	Improvement in safety at construction site	The extent to which BIM4EEB can improve the H&S on site during the renovation works for Construction companies, FMs and Occupants.	Likert scale (1-5)
SOC 8	Improved monitoring/access on information during renovation works	The extent to which BIM4EEB provides improved monitoring capabilities of the renovation works for Construction Companies, FMs and Occupants.	Likert scale (1-5)
SOC 9	Increased easiness in information exchange and tracking (data accessibility)	The extent to which BIM4EEB improves tracking and information exchange among its various stakeholders (i.e. Construction Companies, Designer, FMs, Occupants)	Likert scale (1-5)
SOC 10	Modular design and development of the BMS platform	The extent to which BIM4EEB can be expanded to address additional types of requirements from the business actors (i.e. Construction Companies, Designer, FMs, Occupants)	Likert scale (1-5)
SOC 11	Interoperability and data storage capability of BMS platform	The extent to which BIM4EEB incorporates standards-based data models to ensure interoperability among the different tools and data reusability of the platform to large scale applications	Likert scale (1-5)
SOC 12	Use of BIM in renovation business	The extent to which BIM utilisation in the renovation industry can alleviate typical process, financial and technical barriers by reducing costs of building information acquisition and generate more accurate energy savings forecasts, as declared by the BIM4EEB stakeholders involved or Advisory Board (construction / renovation companies, /service companies)	Likert scale (1-5)
SOC 13	Use of dynamic simulation tools for energy assessment	The extent to which utilising enriched BIM models can speed up the market uptake and move towards data collection for digital built environment, as declared by involved stakeholders or (building managers and energy managers involved in the Advisory Board)	Likert scale (1-5)
SOC 14	Integration of GIS data in BIM model for energy purpose	The extent to which connecting BIM and GIS towards can enhance the accuracy of building energy models; as declared by involved BIM4EEB stakeholders or Advisory Board (construction/renovation companies, service companies)	Likert scale (1-5)
SOC 15	Development of digital logbooks for renovated building; management of as built data in operational BIM models	The extent to which use of enriched BIM model with detailed as-built data orderly stored in digital logbooks can accelerate the market uptake of BIM; as declared by involved stakeholders (designers, construction/renovation companies, inhabitants, clients, service companies)	Likert scale (1-5)

For the assessment of the social KPIs, questionnaires were provided for each stakeholder utilising the system usability scale (SUS) approach (Madison, 2017). The questionnaires can be found in ANNEX I. Social KPIs can be discussed also taking into consideration small and medium enterprises and the related impact. For example, Social KPI 1 “Ease of use for end users of the solutions” aims at assessing how easy to use is the system for construction companies, FMs and designers, as well as Social KPI 2 “Beneficial for end users” evaluates the level of advantages in renovation process such as cost and time savings according to construction companies, FMs and designers. Moreover, Social KPI 12 “Use of BIM in renovation business” proposes to assess to construction and renovation companies the degree of improvement that BIM can offer in renovation projects.

Table 8: Proposed KPIs for the evaluation of the Environmental/Safety category

KPI	Name	Description	Unit
ENV 1	CO_2/ CO compounds reduction	Assessing the level of pollutant emissions (CO_2/CO) compared to a reference value	ppm
ENV 2	Particulate Matter (PM) reduction	Assessing the level of pollutant emissions compared to a reference value.	mg/m^3
ENV 3	Volatile Organic Compounds (VOC) reduction	Assessing the level of pollutant emissions compared to a reference value. VOCs can impact severely the IAQ and may have effects ranging from internal conditions	mg/m^3
ENV 4	GHG emissions reduction	The amount of GHG emissions produced due to the energy consumption of the building can be measured by monitoring the consumption type and multiply for the respective conversion factor	Tonnes of CO_2 eq. or %
ENV 5	Safety issues/ incidents/accidents (during inspection) reduction	Reduction of the number of non-conformance report items: #safetyqualityIssues; compared to the baseline/traditional process	%

3.2.2 Categorization of KPIs

In this section, a clear allocation of the KPIs according to the different tools is presented, in order to show the direct impact of them to the performance objectives of the project. Prior to the mapping of the KPIs, a brief description of the intended BIM4EEB tools as identified in the DoA is provided. Then, the KPIs will be categorized according to the different demo sites located in Italy, Poland and Finland.

3.2.2.1 Presentation of Tools

- ***Fast Mapping of Buildings Toolkit***

The BIM4EEB Fast Mapping of Buildings Toolkit aims at easing the process of scan-to-BIM on existing buildings. This toolkit also uses a device exploiting Augmented Reality (AR) for the real time visualization of hidden building elements such as wall studs, water pipes, and electrical ducts. It is directed to Building surveyors, technicians, architects, engineers, construction workers. It creates an IFC file starting from the point clouds obtained in scanning, it elaborates them and it exchanges models with the BIMMS, as shown in Figure 21.

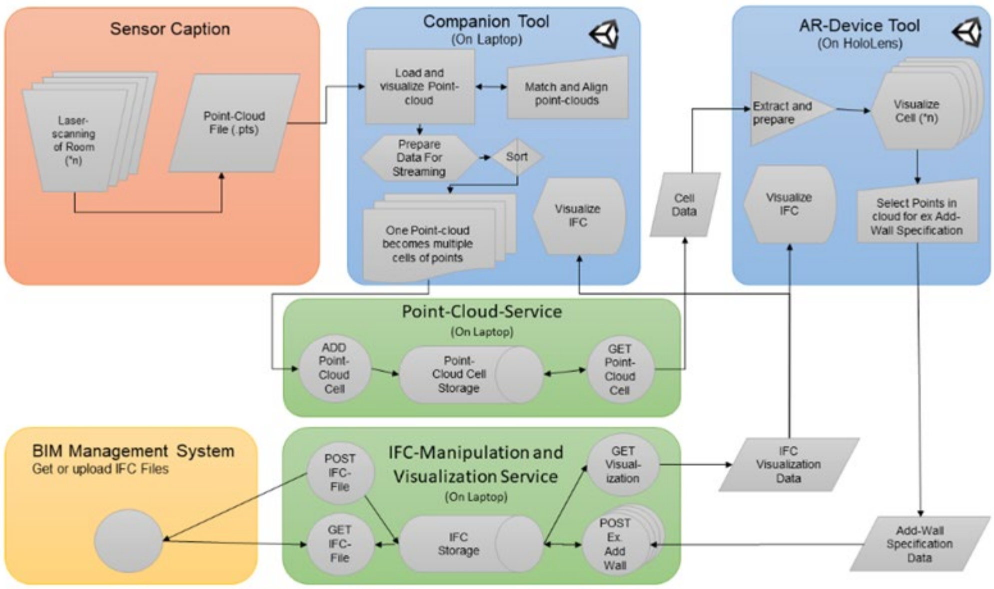

Figure 21: The fast mapping of buildings toolkit

- ***BIM4EEB BIMeaser tool***

This tool aims at helping decision makers in creating and evaluating energy refurbishment scenarios from different point of views. It allows engineers, architects and energy consultants to integrate the features of energy simulation tools with BIM information about costs, life cycle and other requirements for decision making processes, through the use of Linked Data from the BIMMS.

It allows a fast reconstruction of the *as-is* energy and indoor building model on which renovation scenarios can be applied on. The integration of tools allows a better modelling of the indoor conditions, which greatly influence costs and performances. An important feature is the possibility of setting and managing the Owner Project Requirements (OPRs), needed for the scenario validation process.

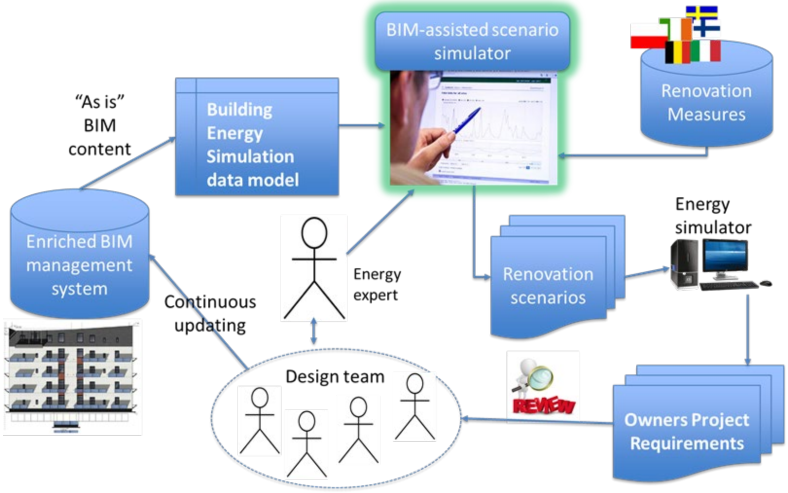

Figure 22: General architecture of the BIMe Simulator tool

- ***BIM4EEB BIM4Occupants***

As the name suggests, BIM4Occupants is a web-based user-friendly application for building inhabitants which connects them with the building information managed in the BIMMS. It is oriented towards the needs of both owners and tenants and it provides on one side general information about the buildings and their systems, their performances and their operation; on the other side it allows a personalized visualization of consumption, comfort and profiling data.

The application consists of two main features:

- *Occupants 2.0*: This application is oriented to the occupants providing access to personalized data about indoor and outdoor environmental conditions (temperature, relative humidity, illuminance, Indoor Air Quality (IAQ)) and allowing occupants to give their feedback about comfort conditions;
- *Building 2.0*: This application is oriented to both the owners and occupants as it allows the collaboration for the update of the models with the most updated as-is conditions by collecting occupants contents. Also, occupants can schedule together with the owners activities of maintenance, receive notification about the Health and Safety (H&S) alerts or report issues occurring during maintenance works.

- ***BIM4EEB Auteras***

This tool is designed to support Room Automation System in a BIM-based environment. The implementation of Room Automation System is a consequence of the use of sensors and of a Building Automation Systems, controlling hygro-thermal, acoustic and IAQ parameters in all the rooms of a building. It works processing IFC models and integrating it with functional requirements of the automating system. Then, it generates automatically room specific automation schematics, saving time to system designers and system integrators. The output of the tool can be used to form bills of quantities for procurements.

- ***BIM4EEB BIMcpd***

BIMcpd is a toolkit providing support for the design of HVAC, lighting and fire systems. It is designed to provide the most suitable solution for the placing of buildings systems, avoiding losses of time, resources and money. It exploits the potential of regular both BIM models and Linked Data technologies to analyse performances of building systems, compare results and evaluate them according to the measurement and verification protocol used in the project, the International Performance Measurement and Verification

Protocol (IPMVP).

The user-friendly interface of BIMcpd allows architects, engineers, M&V practitioners, energy auditors and facility managers to access data in various formats, both tabular and graphic, and to upload and map data for specific energy calculation.

It is divided in three parts, whose initials compose the name *BIMcpd*:

1. Constraint checking tool
2. Performance evaluation tool
3. Data management tool

The first one, Constraint checking tool, includes features that help the design and placement of ducts and cables, switches, sockets, fire detection and control systems and other devices. The Performance evaluation tool is made of a data viewer and an integration of M&V projects, whose results can be exported in different formats (e.g. CSV, Excel, PDF, PNG, JPG). The Data management tool allows the mapping of data with the most common data schema used in AEC, such as IFC, besides its validation and sharing.

- ***BIM4EEB BIMplanner***

BIMplanner is the tool allowing collaboration and information about the progress of site operations, by linking familiar desktop tools for activity planning and BIM models with Linked Data. The main user is the owner and the contractors and sub-contractors of maintenance works. It allows the scheduling and planning of activities and sub-tasks on a weekly basis, enriching such information with geometrical data from the web-based 3D-interface. It relates to the BIMMS thanks to the Linked Data platform developed for BIM4EEB.

3.2.2.2. Categorization of KPIs according to BIM4EEB demonstration sites

In this chapter the project demonstration sites are introduced, and for each of them the KPIs that will be measured will be shown in tabular form.

- ***Italian demonstration site***

Table 9: Italian demonstration site information

Country	Italy
City	Monza
Building	Public housing
Composition	65 apartments on 8 storeys
Year	1981

Figure 23: Italian demonstration site

Table 10: Italian site interventions and elicited KPIs (BIM4EEB, 2019)

	Tools					
	BIM Management System	Digital tool for Fast mapping of buildings	BIM-assisted energy refurbishment assessment	Human machine interface	Tool for connecting BIM models and BACS	Fast tracking tool for renovation operations
	KPIs					
Italian Site	REP 1	REP 1	REP 1	COM 1	REP 1	REP 1
	REP 2	REP 2	REP 2	COM 2	REP 8	REP 2
	ECON 1	REP 3	REP 3	COM 3	ENE 1	REP 3
	ECON 2	REP 4	REP 5	COM 4	ENE 2	REP 4
	ECON 3	REP 5	REP 8	COM 5	ENE 3	REP 6
	SOC 1	REP 8	ENE 1	COM 6	ENE 4	REP 7
	SOC 2	ECON 1	ENE 2	COM 7	ENE 5	REP 8
	SOC 4	SOC 1	ENE 3	COM 8	COM 1	SOC 1
	SOC 5	SOC 2	ENE 4	SOC 1	COM 2	SOC 2
	SOC 6	SOC 4	ENE 5	SOC 2	SOC 1	SOC 4
	SOC 7	SOC 5	ECON 4	SOC 3	SOC 2	SOC 6
	SOC 8	SOC 6	ECON 4	SOC 4	SOC 4	SOC 7
	SOC 9	SOC 7	SOC 1	SOC 5	SOC 7	SOC 8
	SOC 11	SOC 8	SOC 2	SOC 7	SOC 9	SOC 9
	SOC 15	SOC 9	SOC 4		ENV 1	
	ENV 5	SOC 12	SOC 7		ENV 2	
		SOC 14	SOC 12		ENV 3	
		SOC 15	SOC 13		ENV 4	
		ENV 5				

- ***Polish demonstration site***

Table 11: Polish demonstration site information

Country	Poland
City	Chorzow
Building	Residential building
Composition	5 floors, 12 apartments and 3 commercial areas
Year	1902

Figure 24: Polish demonstration site

Table 12: Polish site interventions and elicited KPIs (BIM4EEB, 2019)

	Tools			
	BIM Management System	Digital tool for Fast mapping of buildings	Human machine interface	Tool for connecting BIM models and BACS
	KPIs			
Polish Site	REP 1	REP 1	COM 1	REP 1
	REP 2	REP 2	COM 2	ENE 1
	ECON 1	REP 3	COM 3	ENE 2
	ECON 2	REP 4	COM 4	ENE 3
	ECON 3	REP 5	COM 5	ENE 4
	SOC 1	ECON 1	COM 7	ENE 5
	SOC 2	SOC 1	SOC 1	COM 1
	SOC 4	SOC 2	SOC 2	COM 2
	SOC 5	SOC 4	SOC 3	SOC 1
	SOC 6	SOC 5	SOC 4	SOC 2
	SOC 7	SOC 6	SOC 5	SOC 4
	SOC 8	SOC 7	SOC 6	SOC 7
	SOC 9	SOC 8	SOC 7	SOC 9
	SOC 11	SOC 9	SOC 8	(ENV 1)
	SOC 15	SOC 12	(ENV 1)	(ENV 2)
	ENV 5	SOC 14	(ENV 2)	(ENV 3)
		SOC 15	(ENV 3)	ENV 4
		ENV 5		

- ***Finnish demonstration site***

Table 13: Finnish demonstration site information

Country	Finland
City	Tampere
Building	Residential building
Composition	Two buildings of 5 storeys each, with a total of 52 apartments
Year	1998

Figure 25: Finnish demonstration site

Table 14: Finnish site interventions and elicited KPIs (BIM4EEB, 2019)

	Tools			
	BIM Management System	Digital tool for Fast mapping of buildings	BIM-assisted energy refurbishment assessment	Fast tracking tool for renovation operations
	KPIs			
Finnish Site	REP 1	REP 1	REP 1	REP 1
	REP 2	REP 2	REP 2	REP 2
	ECON 1	REP 3	REP 3	REP 3
	ECON 2	REP 4	REP 4	REP 4
	ECON 3	REP 5	(ENE 1)	REP 5
	ECON 4	(COM 6)	(ENE 2)	REP 6
	SOC 1	SOC 1	(ENE 3)	REP 7
	SOC 2	SOC 2	(ENE 4)	COM 7
	SOC 4	SOC 4	(ENE 5)	SOC 1
	SOC 5	SOC 5	COM 1	SOC 2
	SOC 6	SOC 6	COM 2	SOC 3
	SOC 8	SOC 7	COM 3	SOC 5
	SOC 9	SOC 8	COM 4	SOC 4
	SOC 11	SOC 9	(ECON 5)	SOC 6
	SOC 15	SOC 12	SOC 1	SOC 7
		SOC 14	SOC 2	SOC 8
		SOC 15	SOC 4	SOC 9
		ENV 5	SOC 5	ENV 5
			SOC 7	
			SOC 12	
			SOC 13	
			(ENV 1)	
			(ENV 2)	
			(ENV 3)	
			ENV 5	

3.2.3 Evaluation of User Acceptance (ANNEX IV D3.5) (BIM4EEB, 2019)

The BIM4EEB framework wants to provide appropriate tools to be used for improving productivity of its users (i.e. renovation stakeholders). In order to increase the overall user acceptance of the tools and increase their business value, these instruments have to be firstly accepted and then used by framework's users.

In the literature, the assessment of user acceptance of a system - including aspects such as perceived usefulness, performance expectancy, effort expectancy, social influence, etc. – can be done in different way. In this case, data necessary for the measurement and evaluation of user acceptance have been collected through questionnaires.

As mentioned in the deliverable D3.5, two known models for the evaluation of user acceptance are the Technology Acceptance Model(TAM). and the Unified Theory of Acceptance and Use of Technology (UTAU). The application of these models is shown in the Annex IV D3.5 (BIM4EEB, 2019).

4 Social Impact Assessment for BIM4EEB

4.1 Methodology

Starting from the context described in chapter 2, the methodology for BIM4EEB social impact assessment is here proposed.

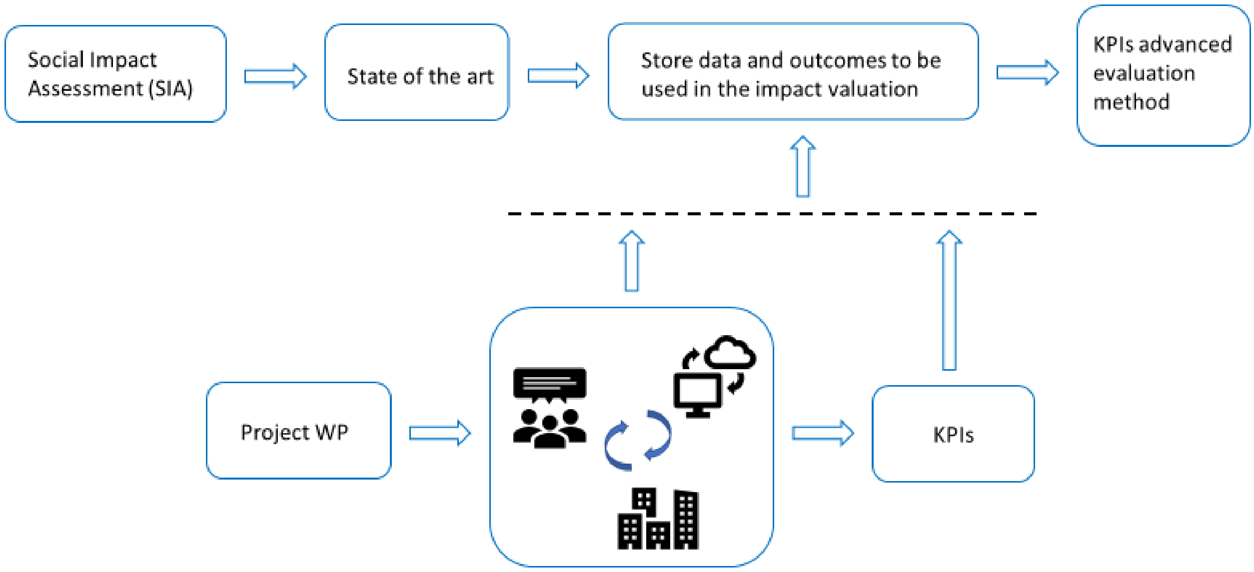

Figure 26: BIM4EEB methodology

4.2 Indicators

The social impact assessment, in view of the evidence and the results obtained or expected, wants to ensure a feasibility study. These results will be used to define objectives, to guide decisions and improve projects at national and international level.

The method that will be shown in this chapter is divided into two parts.

In this first phase, we want to give those in charge of the decision-making process the opportunity to define the project objectives. Claiming that these are the same for each context is wrong. For this reason, the framework presented allows a calibration of the indicators towards general project goals, in a context-based assessment of social impact. In the case of BIM4EEB, major goals are defined at project level and shared by the three demo-cases of continental, northern and Mediterranean climate: the framework allows a partial or total differentiation of project objectives on the same measurement basis, as theorized in *A methodology for ex-post assessment of social impacts of an affordable housing project* (Li, et al., 2014).

Social impact measurement is useful for:

- the organization that acts the intervention, to understand its own logical model, to set goals and because all the internal stakeholders directly involved know what the change is to aim for;
- external parties, mainly lenders, to understand the effectiveness of their intervention and the possible continuation / interruption / revision of the support;
- public entities where interventions have goals that involve the community.

The social impact indicator of the group is requested according to the Likert scale (decimals can also be used), as shown in the following figure. The reason for the use of this scale is to weight and compare the relative importance of KPIs measured in categories outside SOC category.

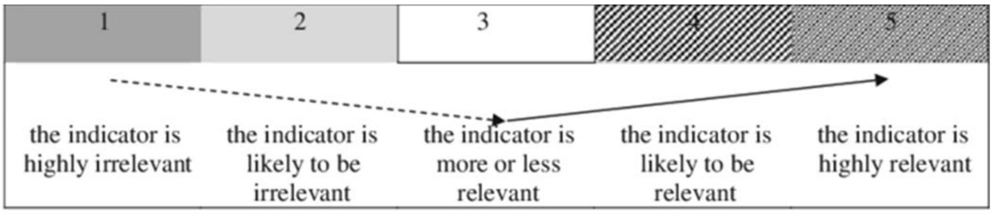

Figure 27: Likert scale (Hugé, et al., 2010)

Table 15: Social Impact indicators per groups

KPI	Group	Social Impact group' Indicators	Units
SOC	Social-Users		Likert scale (1-5)
REP	Renovation Process		Likert scale (1-5)
ENE	Energy		Likert scale (1-5)
COM	Comfort		Likert scale (1-5)
ECON	Economic		Likert scale (1-5)
ENV	Environmental/safety		Likert scale (1-5)

SIA indicators are introduced to integrate SOC indicators measured according to the Measurement and Verification (M&V) method described in D3.5 (BIM4EEB, 2019). This allows the consideration of more aspects than those highlighted and directly measured by the questionnaires. The following table shows an example of this methodology.

Table 16: Example of equivalence of the name and description of the SO and SIA KPIs

KPI	Name	Description	Units
SOC 1	Ease of use for end users of the solution	It provides the means for assessing the acceptability of the framework from BIM4EEB end user (i.e. Construction Companies, Designer, FMs, Occupants).	Likert scale (1-5)
SIA 1	Ease of use for end users of the solution	It provides the means for assessing the acceptability of the framework from BIM4EEB end user (i.e. Construction Companies, Designer, FMs, Occupants).	Likert scale (1-5)

The proposed method aims to offer the possibility of carrying out an accurate analysis of the social impacts referring to all the project KPIs, through the attribution of a value from one to five (Likert scale) for each result obtained or expected, effectively enabling one to see the different levels of project performance being measured, the results of these indicators and their respective social impact. By consolidating the results, this will allow to evaluate the social impact of the project in more detail, ensuring a clear understanding and analysis of the results and providing the necessary information to support the replicability of the project.

It is considered necessary to repeat the method for each demonstration site. This will allow to highlight the validity of the method and show its replicability already within the project.

SIA KPIs will be used to define the social impact of each project KPI, if measured and / or influential in determining the result.

With reference to the following table:

- KPI: All BIM4EEB KPIs to date;
- Name: Name of the KPI;
- Value: Values obtained or expected for each KPI;
- Units: Unit of measurement of KPIs;
- Reference value: Reference values used for the definition of KPI values;
- Units: Unit of measurement of reference values;
- SIA: Indicates the social impact value. Measured by likert scale (decimals can also be used) or '0' value if the relative KPI has no influence on the SIA KPI in question. This value must be identified by those involved in the decision-making processes of the project and will maintain the subjectivity which, for the reasons already explained, characterizes this method.

Table 17: Reworked view of the file to be compiled

Social Impact

(yellow)	Project results or Expected results if the replicability of the project is being evaluated
(pink)	Social Impact Indicators - Enter the most appropriate values
(green)	Results - Uneditable cells

						Social Impact Indicators - Likert scale (1-5), Insert "0" if is not relevant		
						SIA 1	SIA 2	SIA ...
						Ease of use for end users of the solution	Beneficial for end-users	...
KPI	**Name**	**Value**	**Units**	**Reference value**	**Units**	**SIA 1**	**SIA 2**	**SIA ...**
REP 1	Renovation Time Reduction		%					
REP ...	Renovation Cost Reduction	...	...					
ENE 1	Energy Savings		%					
ENE ...	Energy Savings (per building component)	...	...					
COM 1	Adaptive Predicted Mean Vote (PMV)		Numerical (-3 to +3)					
COM ...	Predicted Percentage of dissatisfaction (PPD)	...	...					
ECON 1	Annual Cost Savings		%					
ECON ...	Net Present Value (NPV)	...	...					
ENV 1	CO_2/ CO compounds reduction		ppm					
ENV ...	Particulate Matter (PM) reduction	...	...					
SOC 1	Ease of use for end users of the solution	3	Likert scale (1-5)			3	0	0
SOC ...	Beneficial for end-users	...	Likert scale (1-5)			0	...	0

Description of the example of Table 18: 2 are the years that are currently used for a renovation process, 23 % is the measured or expected percentage of time reduction of the BIM4EEB project and 3.8 a subjective social impact value for SIA 2. Such values are then compiled in the red cells of Table 17. Orange cells represent the measurement values of project KPIs while green cells are non-editable cells of the spreadsheet.

Table 18: Example of compilation

KPI	Name	Value	Units	Reference value	Units	SIA 1	SIA 2
REP 1	Renovation Time Reduction	23	%	2	years	0	3.8

It is underlined how the choice depends on:

- The objectives of the project, in terms of meeting the priorities of each stakeholder;
- Where the project site is located;
- The KPIs being measured.

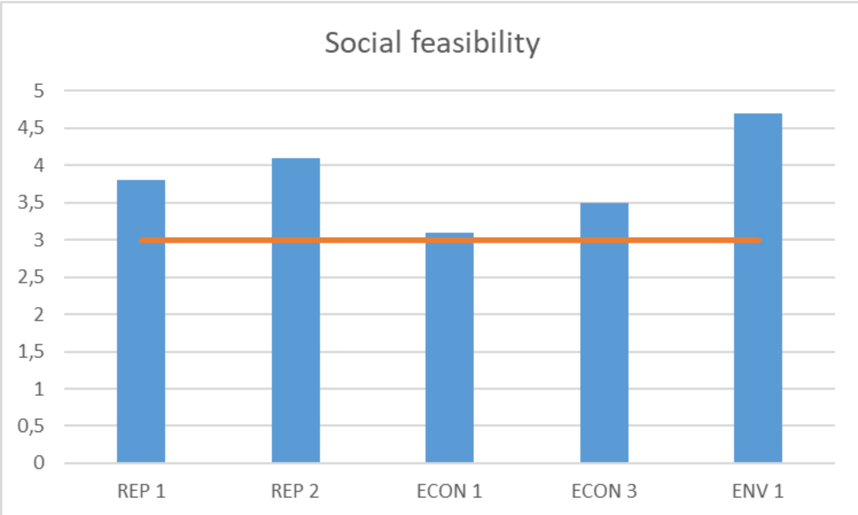

Figure 28: Example of social feasibility chart

Figure 27shows the graph representing the social feasibility for each analysed KPI.

The chosen method offers a first valid social feasibility analysis based on the social impact value of each KPI.

Once this part has been completed, all the data necessary for subsequent analysis are actually already present.

It will automatically generate a table with the following indices:

- Effective Value: Average of the values attributed to the individual KPIs;

$$Effective\ Value = \frac{\sum_{i=1}^{nKPI} SIA(KPI_i)}{nKPI}$$

- SOC: Average of the values attributed to the individual KPIs belonging to the "Social-Users" group;

$$SOC = \frac{\sum_{i=1}^{nKPI[SOC]} SIA(KPI[SOC]_i)}{nKPI[SOC]}$$

- REP: Average of the values attributed to the individual KPIs belonging to the “Renovation Process” group;

$$REP = \frac{\sum_{i=1}^{nKPI[REP]} SIA(KPI[REP]_i)}{nKPI[REP]}$$

- ENE: Average of the values attributed to the individual KPIs belonging to the “Energy” group;

$$ENE = \frac{\sum_{i=1}^{nKPI[ENE]} SIA(KPI[ENE]_i)}{nKPI[ENE]}$$

- COM: Average of the values attributed to the individual KPIs belonging to the “Confort” group;

$$COM = \frac{\sum_{i=1}^{nKPI[COM]} SIA(KPI[COM]_i)}{nKPI[COM]}$$

- ECON: Average of the values attributed to the individual KPIs belonging to the “Economic” group;

$$ECON = \frac{\sum_{i=1}^{nKPI[ECON]} SIA(KPI[ECON]_i)}{nKPI[ECON]}$$

- ENV: Average of the values attributed to the individual KPIs belonging to the “Environmental/safety” group;

$$ENV = \frac{\sum_{i=1}^{nKPI[ENV]} SIA(KPI[ENV]_i)}{nKPI[ENV]}$$

- Weighted value: Weighted value: Average of the values attributed to the individual KPIs multiplied by the relative social impact indicators of the group they belong to;

$$Weighted\ value = \frac{\sum_{i=1}^{nKPI} \frac{SIA(KPI_i) + Social\ Impact\ Goup'\ Indicator(KPI_i\ Group)}{2}}{nKPI}$$

- Feasibility value: Feasibility limit value.

The following tables show the results of a test proposed as an example

Table 19: Example of weight assignment per groups

KPI	Group	Social Impact group' Indicators	Units
SOC	Social-Users	1	Likert scale (1-5)
REP	Renovation Process	1	Likert scale (1-5)
ENE	Energy	4	Likert scale (1-5)
COM	Comfort	3	Likert scale (1-5)
ECON	Economic	5	Likert scale (1-5)
ENV	Environmental/safety	3	Likert scale (1-5)

Table 20: Example of results view

KPI	Name	Effective Value	SOC	REP	ENE	COM	ECON	ENV	Weighted value	Feasibility value
SIA 1	Ease of use for end users of the solution	3.6	4.0	2.5	4.2	3.0	5.0	3.8	3.3	3
SIA 2	Beneficial for end-users	3.6	4.0	2.5	4.2	3.0	5.0	3.8	3.3	3
SIA 3	Occupants active involvement in the renovation phase	3.6	4.0	2.5	4.2	3.0	5.0	3.8	3.3	3
SIA 4	Productivity improvement	3.6	4.0	2.5	4.2	3.0	5.0	3.8	3.3	3
SIA 5	Improvement in collaboration among teams	3.2	4.0	2.5	4.2	1.6	5.0	3.8	3.1	3
SIA 6	Improvement in safety at construction site	3.8	4.0	2.5	5.0	3.1	5.0	4.0	3.4	3
SIA 7	Level of intuitiveness in user applications	3.7	4.0	2.5	5.0	2.9	5.0	4.0	3.3	3
SIA 8	Improved monitoring/access on information during renovation works	3.2	4.0	2.5	5.0	2.9	1.8	4.4	3.1	3
SIA 9	Increased easiness in information exchange and tracking (data accessibility)	2.4	4.0	2.5	5.0	1.0	1.0	2.8	2.7	3
SIA 10	Modular design and development of the BMS platform	3.7	4.0	2.5	5.0	2.9	4.2	4.6	3.3	3
SIA 11	Interoperability and data storage capability of BMS platform	3.7	4.0	2.5	5.0	2.9	4.2	4.6	3.3	3
SIA 12	Use of BIM in renovation business	3.4	3.0	2.5	5.0	2.9	3.8	3.6	3.2	3
SIA 13	Use of dynamic simulation tools for energy assessment	3.4	3.0	2.5	5.0	2.9	3.8	3.6	3.2	3
SIA 14	Integration of GIS data in BIM model for energy purpose	3.2	3.0	1.4	5.0	3.0	3.8	3.6	3.1	3
SIA 15	Development of digital logbooks for renovated building; management of as-built data in operational BIM models	2.7	3.0	1.0	5.0	3.0	1.4	3.6	2.8	3

An additional view of the project results is available and, based on these, a feasibility chart will be shown. Unlike the previous one, a general perspective is shown without distinctions between the different SIA KPIs.

Table 21: Example of project results' general view

	Effective Value	SOC	REP	ENE	COM	ECON	ENV	Weighted value
SIA Social Impact Assessment	3.4	3.7	2.3	4.7	2.7	3.9	3.9	3.2
	Normal	Good	Bad	Very_good	Normal	Good	Good	Normal

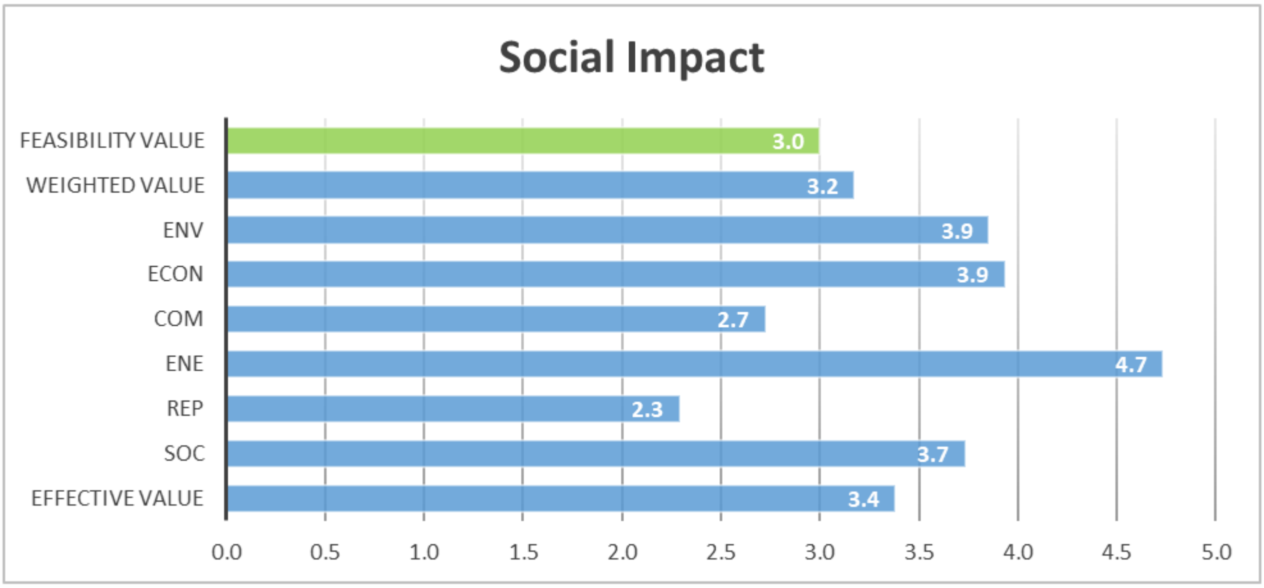

Figure 29: Example of summary chart of the results

5 Future steps

In this section, a monitoring procedure is highlighted, together with key activities inside a timeline considering all the project constraints.

The Social Impact Assessment process will be delivered following the steps highlighted in Figure 2, the workflow of EN 16309 standard. The results will be listed and reported according to EN 16309, as visible in the example in Figure 29, in D1.8 *Report on societal impact RP2*.

	Modules B2-7	Information modules (specify on the characteristics 1.1 to 22.3 for each module)			
	Module: ...B2...	title module: .....maintenance..........	1	2	3
	aspect	Indicator	provision / measure / activity [in the object of assessment as specified in B1, USE]	SCENARIO in B2-7 related to the provision/measure/activity ref. Clause 6.3	Impact in module B2-7 [specify what (SOCIAL) impacts the scenario has for the use and/or for the user of the building?]
specification of the scenario (NOT covered by the column 2) that have impact during B2 - maintenance ref. clause 6.3		*Building Interior:* *floors: cleaning 1 week beyond office hours - vacuum cleaning, solvent free stain removers, no further maintenance* *ceiling systems: no maintenance* *Building exterior:* *roof inspection: spring and autumn; gutters and drainages cleaning; overall leakage control of the roof* *glass facades: cleaning 1/ month - minimised water used - bio detergents* *Installations - appliances:* *airconditioning systems: cleaning filters 1 / month* *etc.*			
	Module: ...B2...	title module: ....Maintenance............			
1	Accessibility	7.2.1 Approach to the building			
	Impact = "X(=YES)","NO", "NR", or "INA" [as specified in "influence-allocation"] [copy the information from "influence-allocation" from the respective columns B2 to B7.]	The following measures (indicators) shall be assessed for improved accessibility in the approach to a building as a minimum list for the assessment. Additional measures can be used where appropriate:	provision / measure / activity [in the object of assessment as specified in B1, USE; copy the respective information from column "e" of the sheets "B1"]	SCENARIO in *B2 - maintenance* - related to the provision/measure/activity ref. Clause 6.3	Impact in module *B2 - maintenance* - [specify what (SOCIAL) impacts the scenario has for the use and/or for the user of the building?]
1.1	x	the number and distance (m) of dedicated drop-off and pick up points from the entrance for people with additional needs	heated geothermal-heatpump heated pavement and ramp	maintenance heatpump 1 / year during summer; included in maintenance plan	none
1.2	x	the number and distance (m) of allocated car-parking for users with additional needs	*see 1.1*	*see. 1.1*	*see 1.1*
1.3	x	the number and distance (m) kerb ramps to facilitate the setting-down of passengers close to the building	*not electric heated as in the Functional and technical demand description, but geothermal-heatpump heated pavement and ramp*	*see. 1.1*	*see 1.1*
1.4	x	distances to public transports	*choice of site location; existing facility of public transport Veolia*	"-"	"-"
1.5	x	the total number and proportion of electronically or mechanically operated entrance/exit systems (e.g. coin/card activated parking meters and other payment systems) designed for access by those with additional needs	*automated revolving doors operated by electronic badge card.* *Adjacent automated door for disabled persons controled by security service at the front desk*	*automated revolving doors: inspection 1 / month* *regular maintenance 1 day per year (manual operated entrances/doors during the time of maintenance)*	*low level of inconvenience*
1.6	x	the provision of appropriate tactile, visual and audio wayfinding systems	*in place acc. client's brief*	*inspection 1 / month maintenance : F.M.*	*ow level of inconvenience*
1.7	INA	other / additional indicators; specify here			
	Module: ...B2...	title module: ....Maintenance............			
	Accessibility	7.2.2 Entrance to and movement inside the building The following shall be assessed for improved accessibility at entrances/exits and continuity of access and movement inside a building as a minimum list for the assessment. Additional measures can be used		SCENARIO in B2 - maintenance - related to the provision/measure/activity ref. Clause 6.3	Impact in module B2 - maintenance - [specify what (SOCIAL) impacts the scenario has for the use and/or for the user of the building?]
1.8		the minimum width of doors			
1.					

Figure 30: Example of report of assessment (ISO 16309, 2014)

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ANNEX I – Questionnaires

Three different questionnaires for the different stakeholders are presented. The following questionnaires have been proposed in D3.5, in Annex II (BIM4EEB, 2019). Questionnaires B and C have been enriched with new questions useful to identify the type of organization (Micro enterprises, SMEs, Large enterprises, etc.), as cited in Section 3.1.3.

The results of these questionnaires will be used to evaluate the social KPIs of the project.

Based on TAM methodology, a series of questions is defined for all questionnaires for the evaluation of a technology component under specific criteria. In addition to the common questions, some stakeholders' specific questions are defined to address BIM4EEB project specific objectives and requirements.

A. Questionnaire for Occupants

Please rate the following statements according to the scale:
1 (Strongly disagree), 2 (Disagree), 3 (Neither agree nor disagree), 4 (Agree), 5 (Strongly Agree)

		1	2	3	4	5
№	**Statement**					
1	I found the system easy to use. (SOC 1)					
2	I believe that BIM4EEB solutions offer clear advantages in the renovation process (e.g. Increased comfort, quality, etc) (SOC 2)					
3	With BIM4EEB, it was easier for me to be involved in the renovation process, compared to a traditional renovation approach. (SOC 3)					
4	Through BIM4EEB it's easier for me to exchange information and collaborate with other stakeholders. (SOC 5)					
5	With BIM4EEB, the renovation of my residence caused me less discomfort than what is expected with the traditional renovation approach. (SOC 3)					
6	Using BIM4EEB makes me feel safer around the construction site. (SOC 6)					
7	I think that I would need technical support of to be able to use this system.					
8	I found the various functions in this system were well integrated.					
9	I needed to learn a lot of things before I could get going with this system.					
10	I find that the User Interface of BIM4EEB and its user application have intuitive design. (SOC 7)					
11	With BIM4EEB I can monitor easily the construction works during the renovation, compared to a traditional renovation approach. (SOC 8)					

12	BIM4EEB makes it easier for me to exchange/track information with other stakeholders. (SOC 9)					
13	I find that the use of a digital logbook, enables better management of the building information(SOC 15)					

B. Questionnaire for Construction companies - Facility Managers (FMs)

General questions

1. What is your role inside your company?
    a. Bank or third party financier
    b. Construction lead
    c. Contract administrator
    d. Contractor
    e. Facilities management (FM) adviser
    f. Security adviser
    g. Site surveyor
    h. Tenderer
    i. Work supervisor
    j. No response
    k. Other

2. What country is your company located in?

3. What is the size of the company related to the number of employees?
    a. 1 to 9 employees
    b. 10 to 49 employees
    c. 50 to 249 employees
    d. More than 250 employees

4. What is your annual turnover?
    a. Up to 2 million EUR
    b. From 2 million EUR to 10 million EUR
    c. From 11 million EUR to 50 million EUR
    d. More than EUR 50 million
    e. No response

Please rate the following statements according to the scale:

1 (Strongly disagree), 2 (Disagree), 3 (Neither agree nor disagree), 4 (Agree), 5 (Strongly Agree)

№	Statement	1	2	3	4	5
1	I found the system easy to use. (SOC 1)					
2	I believe that BIM4EEB solutions offer clear advantages in the renovation process (e.g. cost/time savings) (SOC 2)					
3	I believe that by using BIM4EEB I become more productive. (SOC 4)					
4	I think that BIM4EEB promotes a more collaborative work environment. (SOC 5)					
5	Using BIM4EEB makes me feel safer around the construction site (SOC 6)					
6	I find that the User Interface of BIM4EEB and its user applications have intuitive design. (SOC 7)					
7	With BIM4EEB I can monitor easily the construction works and schedules during the renovation, compared to a traditional renovation approach. (SOC 8)					
8	BIM4EEB makes it easier for me to exchange/track information with other stakeholders. (SOC 9)					
9	The modular design of BIM4EEB makes it easier to address other types of requirements from the various business actors (SOC 10)					
10	I find that the BMS platform offers increased data interoperability among the provided tools and data storage/reusability capabilities. (SOC 11)					
11	I believe that utilising BIM in renovation projects, provides the means to overcome typical barriers (e.g. financial, technical) identified in the traditional process, as well as produce more accurate energy savings estimates through simulation tools. (SOC 12)					
12	I believe that use of BIM enriched models can boost the renovation market uptake potential. (SOC 13)					
13	I believe that linking BIM models with GIS can enhance the accuracy of building energy simulations. (SOC 14)					
14	I find that the use of a digital logbook, enables better management of the building information and generally boost the renovation market uptake (SOC 15)					

C. Questionnaire for Designers

General questions

1. What is your role inside your company?
    a. Access consultant
    b. Acoustic consultant
    c. Architectural designer
    d. BREEAM assessor
    e. Building services designer
    f. Cladding specialist
    g. Client adviser
    h. Construction lead
    i. Cost consultant/quantity surveyor
    j. Electrical Designer
    k. Fire safety designer
    l. Health and safety adviser
    m. HVAC Designer
    n. Information manager
    o. Interior designer
    p. Landscape architect
    q. Lead designer
    r. Lighting designer
    s. Maintenance planner
    t. Project leader
    u. Structural designer
    v. No response
    w. Other

2. What country is your company located in?

3. What is the size of the company related to the number of employees?
    a. 1 to 9 employees
    b. 10 to 49 employees
    c. 50 to 249 employees
    d. More than 250 employees

4. What is your annual turnover?
    a. Up to 2 million EUR
    b. From 2 million EUR to 10 million EUR
    c. From 11 million EUR to 50 million EUR
    d. More than EUR 50 million
    e. No response

Please rate the following statements according to the scale:
1 (Strongly disagree), 2 (Disagree), 3 (Neither agree nor disagree), 4 (Agree), 5 (Strongly Agree)

№	Statement	1	2	3	4	5
1	I found the system easy to use. (SOC 1)					
2	I believe that BIM4EEB solutions offer clear advantages in the renovation process (e.g. cost/time savings) (SOC 2)					
3	I believe that by using BIM4EEB I become more productive. (SOC 4)					
4	I think that BIM4EEB promotes a more collaborative work environment. (SOC 5)					
5	I find that the User Interface of BIM4EEB and its user applications have intuitive design. (SOC 7)					
6	BIM4EEB makes it easier for me to exchange/track information with other stakeholders. (SOC 9)					
7	The modular design of BIM4EEB makes it easier to address other types of requirements from the various business actors (SOC 10)					
8	I find that the BMS platform offers increased data interoperability among the provided tools and data storage/reusability capabilities. (SOC 11)					
9	I believe that utilising BIM in renovation projects, provides the means to overcome typical barriers (e.g. financial, technical) identified in the traditional process, as well as produce more accurate energy savings estimates through simulation tools. (SOC 12)					
10	I believe that use of BIM enriched models produced by BIM4EEB improve the quality of my designs and generally can boost the renovation market uptake potential. (SOC 13)					
11	I believe that linking BIM models with GIS can enhance the accuracy of building energy simulations. (SOC 14)					
12	I find that the use of a digital logbook, enables better management of the building information and generally can boost the renovation market uptake (SOC 15)					