BIM4Ren

BIM and Renovation:

Innovation for a better future

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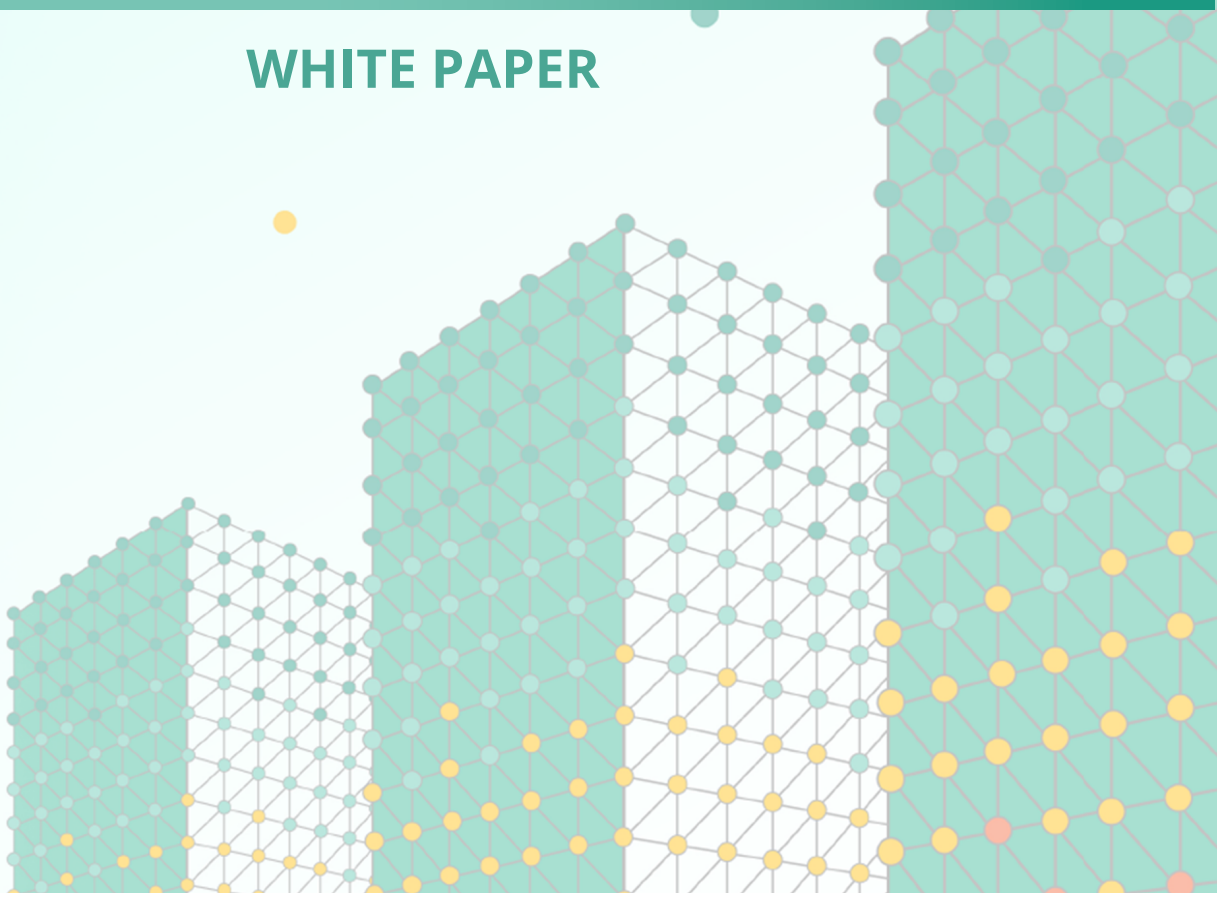

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BIM4Ren
Project EU

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1 EXECUTIVE SUMMARY

In the context of rising energy prices, reliance on fossil fuels, global warming and geopolitical conflicts, there is a need to reduce the total energy consumption of European buildings. Policies and technologies that encourage energy efficiency in buildings are underpinning a shift towards a sustainable built environment.

The European Union (EU) has proposed building renovation strategies to cut carbon emissions in half by 2030, including energy emission regulations, funding, and technical assistance focused on optimizing building energy performance. There are, however, major inefficiencies in the current renovation methods, which prevent these goals from being achieved. Examples, such as changes in specifications, unforeseen events, and lack of communication are some of the main causes of waste of time, cost losses and lower performance.

Existing and widely available technologies such as Building Information Modelling (BIM) can contribute to overcoming these barriers especially in the areas of communication and technology, which are critical in renovation projects. BIM adoption will help the construction sector's productivity, and Europe has shown strong commitment to facilitating the use of BIM to decarbonize its building stock. However, many European construction companies are still not using this technology in their commercial renovation projects. This is partially due to a lack of specific tools, little feedback and existing prejudices about what BIM is and how to implement it. Moreover, small and medium-sized enterprises (SMEs), the backbone of the European construction sector, are not enough digitalised. Several obstacles remain in this process, including the financial and technical accessibility of these tools, but also linguistic barriers. SMEs could become a prime market, and with adequate training and accessible tools, deliver more efficient renovations.

The BIM4Ren project, funded by the European Commission's Horizon 2020 program me, proposes a working methodology to improve the overall efficiency of building energy renovation. It involves all stakeholders in an information-centered process, through the elaboration of a modular collaborative workflow supported by digital tools, all accessible from a single platform dedicated to building energy renovation.

2 A GLOBAL CALL FOR CHANGE

...and the need for renovation

Europe must reduce its greenhouse gas (GHG) emissions and dependency on fossil fuels while mitigating rising energy costs to become carbon neutral by 2050 and meet the objectives set forth in the 2020 European Green Deal[1].

The EU building stock is considerably old and energy inefficient with buildings that are:

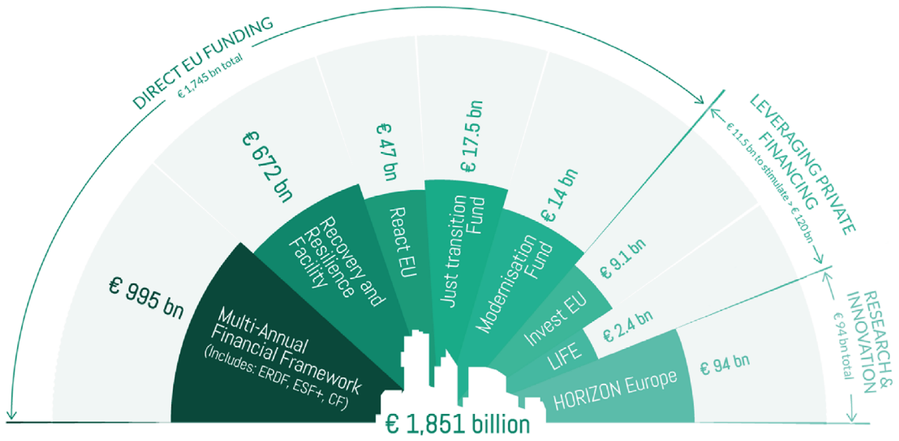
- responsible for **40%** of the EU's **total energy consumption** and 36% of GHG emissions2;
- **85% built before 2001** (more than 220 million building units), and mainly heated using fossil fuels;
- **35%** with an **energy performance certificate** (EPC) rating **worse than D**.

Therefore, there is significant potential for improving the energy performance of existing EU buildings.[3]

The European Commission's policy framework to decarbonise the EU building stock and support the green transition for the construction value chain includes instruments such as:

- the **Renovation Wave strategy**, and the **Fit-for-55 package** for reducing net GHG emissions by 55% before 2030[4] which includes a revision of the Energy Efficiency Directive,
- the introduction of a new **Emissions Trading Scheme** for buildings and transport,
- the recast of the Energy Performance of Buildings Directive **(EPBD)**[5] particularly i. a revision of the **framework for EPCs**, ii. the introduction of **Building Renovation Passports** and **Digital Building Logbooks**, iii. and perhaps most importantly the introduction of mandatory **Minimum Energy Performance Standards** (MEPS), which are expected to render compulsory the energy renovation of the worst performing buildings.

At the same time, the EPBD recast directive mandates Member States to develop National Buildings Renovation Plans (NBRP) with a view of mobilising financing and triggering the necessary reforms and investments[6]. NBRPs will be integrated into National Energy and Climate Plans, to ensure comparability and tracking of progress.



EU Funding for Energy Renovation of Buildings 2021-2022

Figure 1: EU Funding for Energy Renovation of Buildings overview for 2021 to 2027. [7]

A. THE BUILDING SECTOR

…its current state, its role in global warming and the strategic next steps

The construction sector plays a vital role in the European economy:

- it includes around 3 million enterprises and a total direct workforce of around 18 million people;
- it generates approximately 9% of the EU gross domestic product,
- SMEs account for more than 80% of total employment in the EU construction sector with micro-enterprises with less than 10 employees representing the majority of the sector,
- 70% of the turnover of SMEs construction companies is from the residential market, with 75% of the European building stock made up of residential buildings.

It is therefore clear that a sustainable and renovated built environment cannot be reached without the participation of SMEs in the construction sector.

Reducing the negative environmental impact of existing buildings is a crucial challenge for a sustainable future.

At the current rate, 80% of the buildings in which we will live by 2050 are already built. As per EU ambitions, the annual renovation level of existing building stock must be increased from 1% to at least 3%.

B. MAIN CHALLENGES IN BUILDING ENERGY RENOVATION

…and the barriers to achieving the strategic goals

Most EU countries have standards, directives and building codes on energy efficiency that focus on new construction projects. However, these regulations are not always suitable for building energy renovation. This is mainly due to the lack of standardisation of the renovation processes and the fact that the technical challenges are different from the ones in new buildings. The conjunction of a European building stock with poor energy performance, with increasing energy costs make this context especially ripe for energy retrofitting.

Currently, the energy renovation approach in the EU is based on the following 3 main targets:

- The **need for decarbonization** of the current building stock at European and local levels through policies and fundings,
- The **huge potential of employment** considering the vast building stock that will need to be renovated in the next decades,
- The **rising costs of energy** within a context of global uncertainty, which leads to reduced energy consumption and, to a certain extent, to reduce the dependency to fossil energy.

In spite of these drivers, there are significant barriers to overcome in order to reach the desired renovation rate in Europe. While the volume of renovation projects is growing in the construction sector, their effectiveness doesn't compare to new construction in terms of cost, time, and quality. Moreover, renovation projects have a higher level of risks and uncertainties unlike new construction[8]. The most significant difference between renovation and new construction lies in the **unforeseen nature of the design choices, namely due to the lack of knowledge about the existing building**[9]. Therefore, the changing framework of a renovation project, which evolves as far as the information becomes more accurate, requires a strong effort to keep the building information updated. Here a new opportunity for BIM arises, as a technological instrument for helping with data management, collaboration, and information centralization.

Generally speaking, construction is known to be one of the less productive economic sectors[10]. Renovation activities in particular suffer from specific issues related to the uncertainty about the existing building, the diversity of buildings and clients' requirements, which results still in manual execution procedures, that can strongly impact the progress of a project. Nevertheless, the enabler technologies are slowly changing the paradigm of the inconvenience and high cost of building renovation, which seem to be the major problem to date.

The majority of publications in the field of renovation digitalisation refers to technologies for data acquisition such as laser scanning photogrammetry, but little literature exists about the challenges of carrying out energy renovation projects with respect to BIM opportunities. However, these digital technologies for renovation cover mainly the data gathering phase, whereas technologies should encompass the whole building renovation lifecycle to be most useful.

A survey carried out in the frame of the BIM4Ren supports this analysis.*

In conclusion, the main challenges of building renovations are:

- **defining processes specific to renovation** and not just adaptation to new buildings practices,
- **managing the handover** between the design phase and the construction phase, especially considering the technical integration with the existing building,
- efficiently **gathering the information** about the existing building,
- **improving communication** between the multiple stakeholders

BIM, as a collaborative data-centred process, can help overcome those challenges.

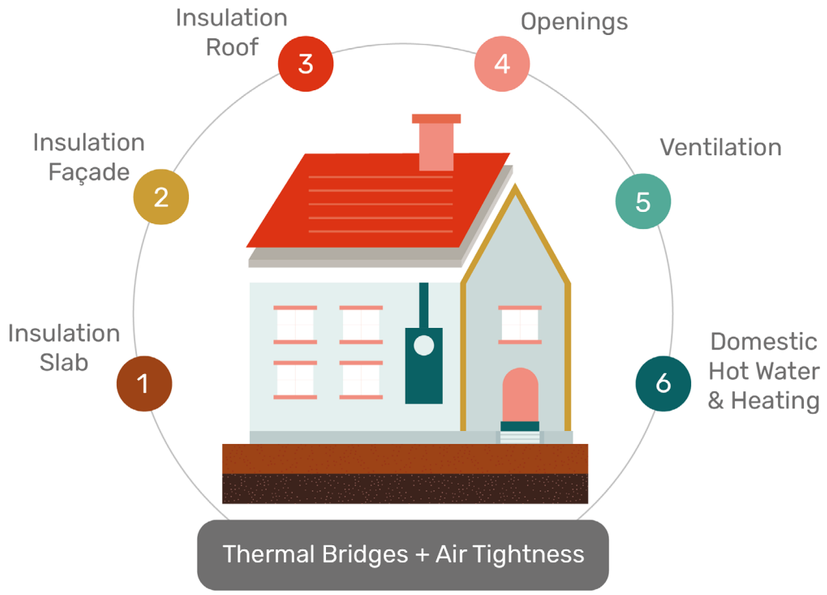


Figure 2: The performance aspects of building energy renovation[11].

C. NEW OPPORTUNITIES

...and how they facilitate the urgent need for increased building energy renovation

The challenges in renovation projects are many and complex, yet with the rise of emerging technologies, there are many opportunities to be found in the light of the unprecedented scale of expected renovation projects. And BIM can be a key player!

* The survey was answered by more than 300 respondents related to AEC sector all over Europe, as well as interviews conducted in the framework of the project "Survey about BIM implementation in renovation processes"

The digital transition in the construction sector and the adoption of BIM for building renovation can unlock benefits for all stakeholders, especially SMEs. Digitalisation as an enabler of change could help create a new positive and modern image of the construction sector, more attractive to the millennials, underrepresented groups such as women, or talent from other business areas. Some countries are even making the use of BIM mandatory in public procurement, with companies having the obligation to manage a better compliance with legal requirements.

With BIM adoption, there is real potential to enhance communication, trust, and cooperation along the whole construction value chain. Cost-efficiency would then become a central element in construction works, saving time in the execution phase and increasing productivity. At the same time, digitalisation could help alleviate heavy, burdensome, and repetitive tasks for construction professionals and present the possibility to use virtual environments when applicable. Significant improvements could be achieved when it comes to project management, operation and maintenance throughout the whole lifecycle of a building. Eventually, all this could lead to the facilitation of higher energy efficiency and lower lifecycle costs of buildings.

The digitalisation of the building energy renovation process will allow practitioners to reach a deeper knowledge of the existing buildings such as the use of 3D scanning technology to capture data about the building's shell, since the facade replacement is typically the most demanding intervention. Additionally, the use of technologies such as BIM will enable collaboration between stakeholders, including occupants, which is one of the most common causes of building energy renovation inefficiencies. Finally, digital tools allow stakeholders to follow the onsite process even if they're offsite, updating constantly the information of the execution vs. planning phases.

Digital solutions such as BIM make sense and can present great benefits if they are affordable, easy to use, and bring a real added value to construction SMEs' daily activities. For massive digitalisation, the cooperation of the whole construction value chain is essential and can be mutually beneficial for all stakeholders. Appropriate participation of SMEs in all relevant political, technical, and educational forums to discuss the digitalisation of the construction sector will be crucial for the uptake of digital tools and processes. At the same time, it is essential that the tools, training and the entire relevant debate is made available in as many languages as possible; this is of central importance, knowing that most construction professionals and SMEs work primarily in their national languages and most of them do not speak English. Implementing a gradual roadmap and appropriate transition phases from traditional to digital methods for SMEs is key. In this sense, guaranteeing that digital tools are financially bearable for SMEs is major factor. The facilitation of the exchange of good practices and the creation of networks at the European, national, and local levels, as well as targeted financing and training schemes adapted to SMEs, can make the difference and unblock any bottlenecks of the digitalisation process. processes. Implementing a gradual roadmap and appropriate transition phases from traditional to digital methods for SMEs is key. In this sense, guaranteeing that digital tools are financially bearable for SMEs is major factor. The facilitation of the exchange of good practices and the creation of networks at the European, national, and local levels, as well as targeted financing and training schemes adapted to SMEs can make the difference and unblock any bottlenecks of the digitalization process.

Luca Del Favero
BIM Coordinator – CMB Carpi

"As for new construction, using BIM in renovation remains the way to reduce management risk and to improve the quality of the project."

3 BIM IN RENOVATION PROJECTS

...and its adoption in Europe

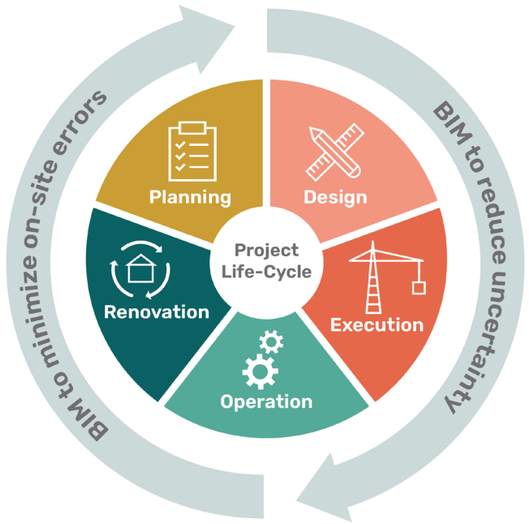


Figure 3: The benefits of using BIM throughout the building life-cycle [12]

A BIM 'model' is composed of objects (such as floors, doors, and other building elements) containing relevant information, rather than being drawn using lines and meshes as done in the preceding approach of computer aided design (CAD). BIM does not only change how building drawings and visualizations are created, but it also dramatically alters all of the key processes involved in putting a building together along its full life cycle (e.g., how multiple team members collaborate on a design, within a single discipline as well as across multiple disciplines; how the building is actually constructed, including the fabrication of different components by sub-contractors; and how, after construction, the building facility is operated and maintained).[13]

While many European and national directives are pushing for the use of BIM, it is still not widely adopted for a variety of reasons. The very fast evolution and complex development of digitalization has created difficulties for construction SMEs to adapt. This has often taken the form of a lack of suitable tools adapted for the onsite work of construction SMEs, including oftentimes the lack of availability of the said tool in the respective national language(s). This heterogeneity of digital tools creates compatibility and interoperability issues, while the lack of representation of construction SMEs in the research and development (R&D) and standardisation processes also hinders widespread BIM adoption. Shifting roles and responsibilities when it comes to liability and reluctance of insurers, and the question of data protection and ownership also points towards the risk of a monopoly and dependency on large players.

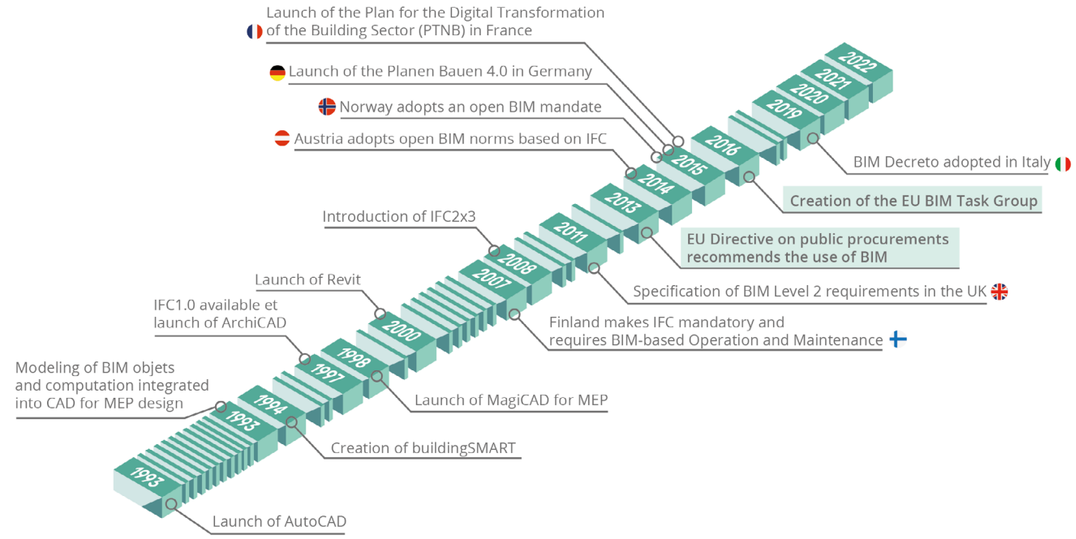


Figure 4: BIM Evolution in Europe Source: https://fr.mum.ch/wp-content/uploads/2020/04/Adoption-du-BIM-en-Europe-Un-livre-blanc-02042020.pdf [14]

The adoption of BIM for renovation faces two main issues. First of all, digital construction software often focuses on newly built stock; in particular the digitalization of existing building is still not at a market level. Secondly, while renovation is the main market for SMEs, the limited size of those leads to difficulty in affording the considerable up-front investment for the acquisition and training on software.

The European Commission has funded over €100 million in BIM for building energy renovation innovation actions in the past 10 years.[15] This demonstrates Europe's strong commitment to facilitating the use of BIM to decarbonize its building stock. However, many European construction companies, 90% of which are SMEs, are still not deploying this advanced technology in their commercial renovation projects due to lack of reliable BIM pilot results guiding implementation.[16] [17]

A. BIM MISCONCEPTIONS

...and the common excuses causing the lack of BIM adoption in building energy renovation projects

Since the introduction of BIM, there has been confusion about what exactly it is and how to successfully implement it on projects and within entire organizations. The common misconception is that BIM is simply a 3D model of a structure, while it is in practice way more than that, constituting a shift in the entire process of creating and managing all information required in the design, construction, and maintenance of a building project.

Misconception 1 - BIM is just a 3D model: BIM is a collaborative process that can be supported by digital tools, and in particular by tools that deliver a BIM model, i.e.: a digital model of the building. One can be involved in a BIM process by simply using the required information. For instance, a painter may only need quantity take-offs, which could be in the form of an Excel document that the BIM manager extracts from the BIM model. The richness of a BIM model resides in the availability of information in the model, not necessarily on the accuracy of the 3D geometry.**

Misconception 2 - BIM is expensive: While indeed BIM can be expensive, it more so depends on the user's needs and the specific tools used. Some actors can work in BIM with simple, familiar office software. In addition, ever more software applications and tools are available on the market, with a variety of license costs. The scientific and open-source community is also growing, offering some free*** and/or open-source tools**** which can be useful for BIM projects. Companies need to identify the right tools (and processes) for their own needs, and this concept demonstrates the democratization of BIM for all stakeholders.

Misconception 3 - BIM is only for the design phase: There is an increase of software applications and tools that are being marketed to cover the construction and operation and maintenance phases. The potential of BIM is high to identify discrepancies between design and reality, to evaluate potential on-site waste, to perform audits, to assist facility managers, and much more. The entire construction value chain is increasingly becoming aware of BIM potential. Therefore, the number of BIM projects are increasing and BIM specifications are becoming adapted to the desired usage. (see Figure 5).

Misconception 4 - BIM is only for new construction: BIM offers some great potential for building renovation. Creating a BIM model of an existing building provides valuable data points which helps to explore different renovation scenarios, and to facilitate the circular economy. The main value behind BIM is that it offers stakeholders a common process and repository for data exchange, and this is equally applicable to both new construction and building renovation projects.

Misconception 5 - BIM is only for large projects: BIM is a collaborative methodology which improves communications between stakeholders of all project sizes, not only large projects. The digitalization of building assets is a major advance for the operation and maintenance of individual buildings large and small. For instance, the amount of valuable time that can be gained by using a digital model of a building to be renovated is massive, time which can assist engineers in their preliminary studies, or construction workers in avoiding time-consuming mistakes onsite.

Misconception 6 - BIM is too complex: Using BIM can be as simple as creating or making use of an information model in any type of software application or tool that supports a BIM-workflow. The perceived complexity is due the wide scope of benefits and different applications in all the phases of the building lifecycle. Various stakeholders see the benefits of using BIM in construction and are ready to share their BIM implementation journeys and best practices in order to speed up BIM implementation and digitalization in the whole value chain.

** In 2012, the UK adopted a new norm (COBIE) for BIM in which no 3D data is modelled

*** EveBIM or BIMVision are examples of free BIM viewers

**** See the OSArch website (https://osarch.org/) for a list of such tools

B. BIM COSTS AND BENEFITS

... when using BIM for building energy renovation

BIM optimizes stakeholder collaboration during a building energy renovation project by enabling stakeholders to exchange information more fluently through a digital model of the building. In the context of the Renovation Wave and the goal of improving energy performance, a single-step deep renovation delivers better results than a renovation performed in multiple steps[18] 17. However, a single-step renovation process requires a wider variety of interdisciplinary professionals to work together, from façade specialists to HVAC technicians and architects. The use of BIM can also foster occupant and building owner involvement which in turn reduces inefficiencies in construction.

BIM models of existing buildings provide invaluable information required before renovation begins. This allows professionals to spend more time on gathering information prior to the work, while lowering potential delays due to misconceptions once the renovation work starts. This could reduce both cost and onsite nuisance for owners and occupants alike. In addition, the BIM model could be used to facilitate the building maintenance and future planned interventions.

Academics and practitioners alike would agree that the use of BIM-based workflows brings numerous benefits throughout the different stages of construction. Some of which are summarized as follows:

↑ Boosts productivity (less re-work, conflicts and changes)

BIM workflows allow for faster processing of design changes as all data, drawings and documentation are linked and generated from a central information model.

↑ Enhances stakeholder collaboration and communication

BIM models that are shared in the design and construction processes facilitate improved communications during those processes. To ensure interoperability, the use of open standards such as Industry Foundation Classes (IFC), are of paramount importance as they allow all stakeholders to view the shared models through their own independent software platforms.

↑ Improves project quality and performance

By providing an up-to-date design and construction model to the entire building energy renovation team, a BIM workflow helps detect design and construction mistakes early in the process by facilitating multidisciplinary integrated design. In addition, the use of open standards for model integration can enable the consolidation of all design input into a so-called federated model.

Martin Osa
Engineer – Kursaal BIM

"As an SME, we observe that more and more BIM-based solutions on the market are easy to use and affordable. At Kursaal, BIM helps us better evaluating the amount of material to buy and reducing the amount of wast."

Reduces waste

The use of BIM workflows and technologies provide a better overview of the building energy renovation project activities before the start of any construction work, which allows for more prefabrication and reduces waste on unused materials. For example, prefabricated elements can be easily bolted in place rather than created onsite. Apart from cost savings, this brings about the additional benefit of reducing environmental impact during construction.

Speeds up project delivery

Using BIM, construction companies can generate planning and construction simulations early in the building energy renovation design process before the start of any construction activities (with cost, time and safety benefits). This in turn speeds up the decision-making process.

Reduces construction costs

With the net effect of the aforementioned benefits (i.e., higher productivity, better communication, waste reduction, and faster delivery), cost reduction is an inevitable side effect. In addition, using BIM-supported workflows to promote closer collaboration between stakeholders can lead to reductions in tender risk premiums, lower insurance costs, fewer overall variations and change requests, and fewer opportunities for claims.

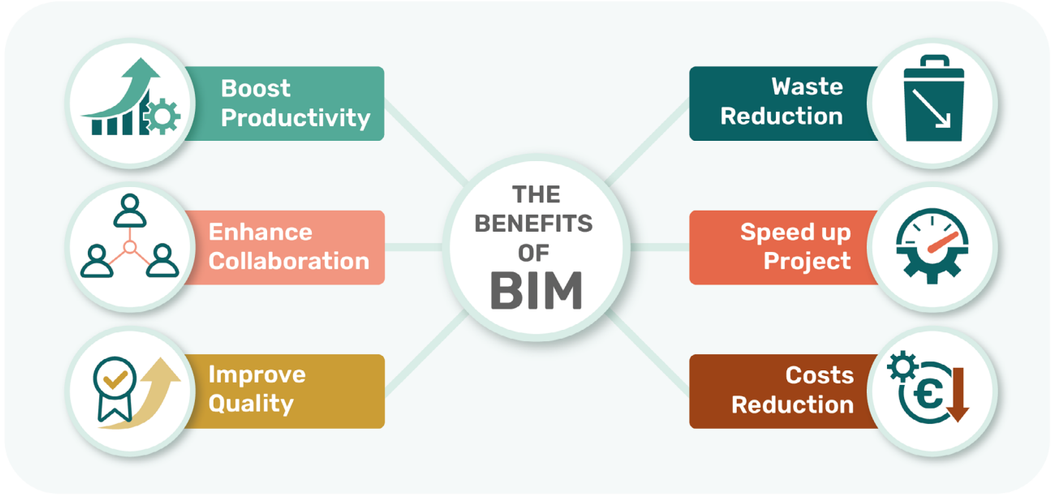


Figure 5: The main benefits of using BIM in building energy renovation

A necessary investment. The cost of BIM implementation can be expressed in both tangible and intangible investments for companies on both organizational and project levels.[19] Successful BIM implementation requires changing the three domains of an organization: people, process and technology.
The main investment costs for BIM implementation are related to the acquisition software applications and tools and the corresponding hardware and trainings required for the creation and use of BIM models.[20]

Focus on the needs. Construction SMEs can benefit in many ways from using BIM-based technologies and processes. An important starting point before purchasing any software or hardware is to identify the key aspects of existing processes that the SME would like to improve. This will help define the main BIM goals and uses (such as improved scheduling, estimation, and risk analysis) and therefore the appropriate technological processes and organizational changes.

The importance of sharing Best Practices. However, the best way to implement BIM is through practice and getting acquainted with information models and their benefits, for example by using freely available online model viewers or mobile applications and collaborating with front runners who already own software that supports BIM-based workflows.

Training. Training for these BIM applications is readily available, including instructor-led courses, online training, and self-paced tutorials. Depending their choice, users can validate their skills with certification programmes, get expert guidance at an authorised training centre, or dive into a recommended training guide.

The European Commission has recently developed an interactive handbook[21] which includes recommendations on how to further digitalise construction SMEs. Its purpose is to support the digitalisation of SMEs in the sector, foster their growth, enhance their productivity and efficiency, and prepare them for the challenges of an increasingly connected and digitalised world.

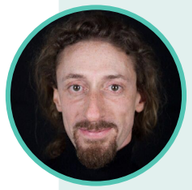
4 BIM4Ren: A JOURNEY TO BUILDING ENERGY RENOVATION

Demonstrating how BIM for building energy renovation unlocks value for construction SMEs

BIM is gaining traction with construction actors, evidenced by the fact that the BIM market in Europe is expected to reach €2.38 billion by the end of 2023[22]. Nevertheless, the main BIM adopters remain big companies even if SMEs make up 90% of the sector as already mentioned, and meanwhile BIM is mainly being used only for new and complex construction projects[23] but not for building energy renovation. The main difficulties in extending the use of BIM for this application is the lack of tools and (semi)-automated procedures to model building assets, and the legal and organizational barriers of the renovation process[24]. However, the use of BIM in renovation helps to avoid mistakes and time loss, deliver clearer explanations to building owners and occupants, and simulate different renovation scenarios on a virtual model for an informed final choice[25]. Moreover, for companies involved with EPCs, BIM can deliver accurate energy consumption estimations.

The BIM4Ren EU-funded project, was dedicated to the elaboration of BIM methodologies, as well as the development and testing of digital tools dedicated to building energy renovation actors. The focus of the project was the digitalization and design phases of residential building stock in Europe.

The main outputs of the project are presented in the following sections.



Andrea Vanossi
BIM Manager – CMB Carpi

"A good BIM process needs well-defined requirements, the digital common platforms are the bases to set up a comprehensive design and construction workflow"

A. BIM METHODOLOGY FOR RENOVATION

... from data gathering to data-driven design

Figure 6: Stakeholders in a BIM-based renovation project

Every building is different, and every renovation project is different. In this context, it is complex to elaborate a working methodology for building energy renovation that could apply to all building typologies and any renovation project ambition. The BIM4Ren project elaborated a modular collaborative workflow supported by digital tools, all accessible from a single platform dedicated to building energy renovation as shown in Figure 8. The workflow can be split into the following steps:

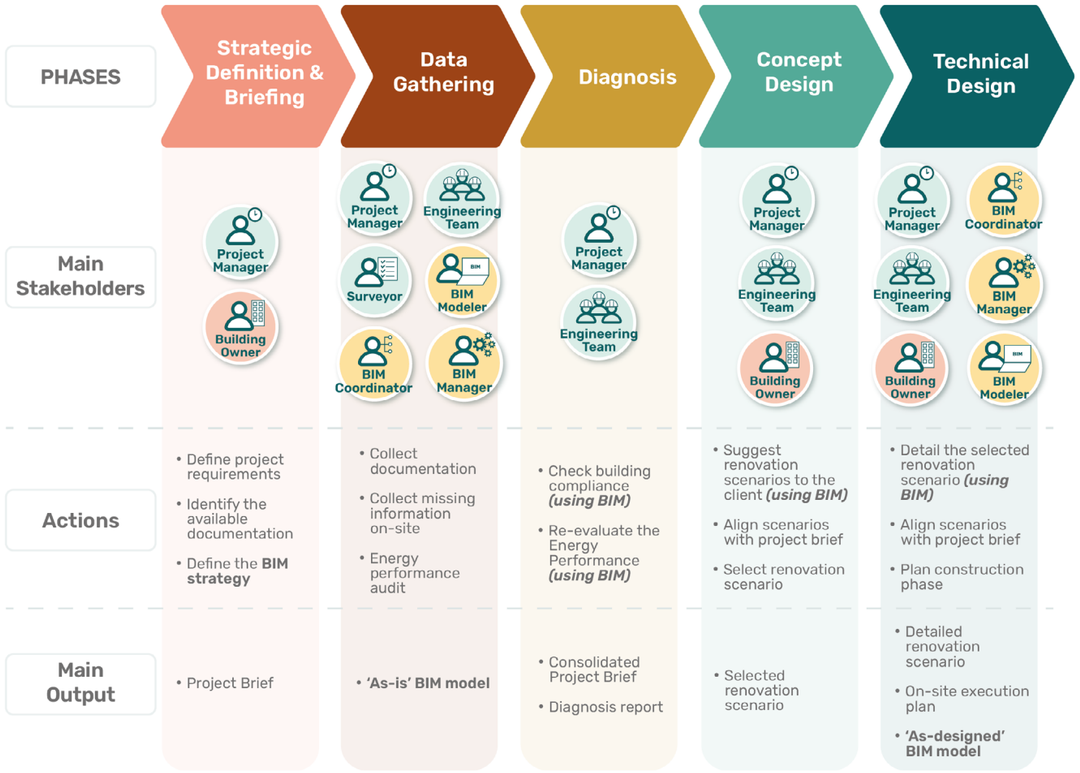


Figure 7: A collaborative workflow supported by digital tools for building energy renovation

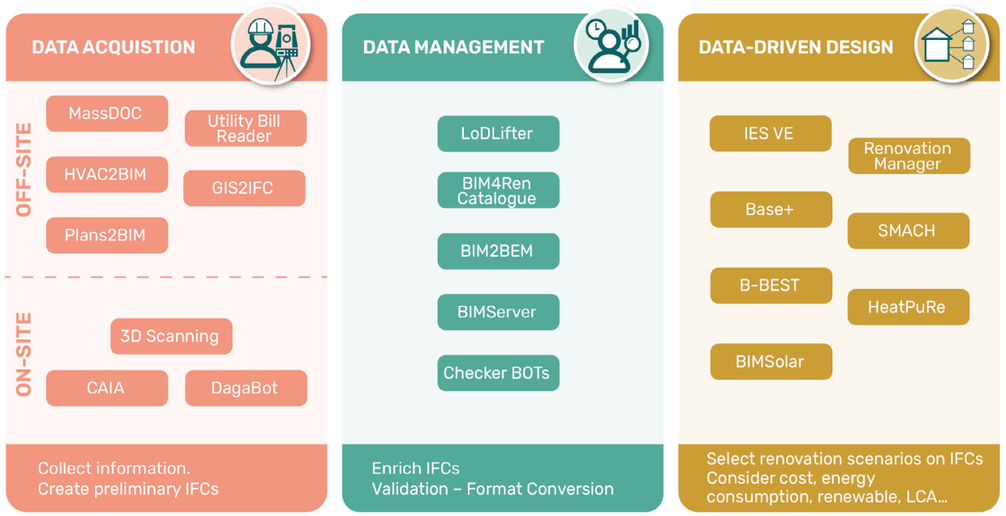


Figure 8: Overview of the BIM4REN tools and their workflow

1. The strategic definition & briefing phase: In this initial phase, the project manager collects the main information from the building owner, to better evaluate the feasibility of the renovation project. The information can be related to the building (localization, year of construction, bills, past audits, past renovations, materials, envelope characteristics if known...) and to the project (budget, environmental targets...). All this data can be used to draft a first non-geometrical BIM model of the building, as well as a project information model. The project manager then discusses the feasibility of the renovation project with engineers (if needed). If agreed, a contract is signed at the end of this phase between the team and the building owner. A BIM specifications document can also be signed to ensure the delivery of the BIM model that will be used in the future operation and maintenance of the building.

2. The data gathering phase: is key in delivering a model of the existing building, as accurate as possible. The phase can be split into two sub-phases

a. Offsite data gathering: which consists of gathering all the documents provided by the building owner (2D plans, audits...) but also some open data (digital maps, incentives...). Various tools can facilitate the exploitation of this data such as Plans2BIM (developed by WiseBIM) which generates 3D BIM models semi-automatically from 2D layouts, or GIS2IFC (Tecnalia) to generate BIM models from GIS data.[26]

b. Onsite data gathering: the data collected onsite can be inaccurate, incomplete, or outdated. Therefore, an onsite visit is required to consolidate the data and the model of the building as-it-is. The visit needs to be well-planned to identify the information to collect. Tools such as DagaBOT (Tecnalia) or CAIA (RWTH) are helpful to associate data collected on-site to a BIM model.
At the end of the data gathering phase, a BIM model of the as-is building can be created, assembling geometric and technical information (through the LodLifter developed by CSTB)and will be the basis for the diagnosis and design phases of the building energy renovation project.

3. The diagnosis phase: can be executed to update the latest audits, and the project requirements (i.e., the project information model elaborated at the initialization phase, the feasibility for reaching the targets, etc.). At this phase, some preliminary renovation options can be evaluated on the BIM model created at the end of the data gathering phase. In the BIM4Ren project, this is done by considering generic objects in a BIM object library such as 14cm rock wool internal insulation, double glazed PVC window, etc. and running thermal simulations and cost evaluations in a BIM integrated design process (with the Renovation Manager tool developed by Nobatek/INEF4). The comparison of different renovation options has a strong pedagogic added value for the building owner.[27] At the end of this phase, a final renovation scenario, or a reduced set of possible scenarios should have been selected.

4. The concept and technical design phases: is the final phase of execution for the conception of the renovation, when the previously selected scenarios are further evaluated into technical details to ensure the feasibility, to deliver a detailed cost, and to guarantee an accurate performance of the renovation. While in the diagnosis phase, the study could be executed on an inaccurate BIM model (I.e., with low Level of Details – LoD), and based on generic BIM products, the technical design phase requires the use of accurate models and objects. In this phase, the BIM4Ren project offers the possibility of using detailed professional software such as IES VE (IES) for thermal simulation, or BIMSolar (EnerBIM) for solar installations assessment.

The project plan can then be delivered to the client. This takes the form of:

- a BIM model of the building as-is
- a BIM model of the building as-designed

All the tools developed in the BIM4Ren project are available from a single platform (OSAP, One Stop Access Platorm, developed by Ekodenge) to facilitate their usage. The OSAP can help in delivering additional information such as onsite planning to prepare the execution phase, the list of products to be installed and their technical descriptions, the global budget, or information that may help in elaborating an EPC.

B. USE CASES

... experiences BIM in real renovation projects

The methodology and tools described above were tested on real renovation projects in different countries. The demonstration pilots are all different in terms of climatic conditions, configuration of buildings, works planned, and energy ambitions.

■ Deep renovation in a social multi-dwelling building in France

FRANCE
Residencial (social housing)
4000m²
POLYLOGIS: SHO
Full renovation focusing on energy

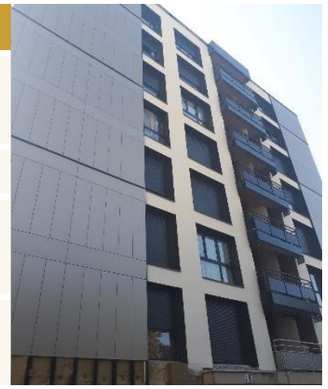


Figure 9: Use case in France: deep renovation in a social multi-dwelling building

Logirep manages more than 100,000 dwellings, and carries out more than 10 building renovations each year. The decision for the renovation follows an internal process, during which a quick evaluation of costs and energy performance is done. Nevertheless, those little informed decision impact dramatically the cost, the time and performance of the renovation.

This building located in the suburbs of Paris was planned to be deeply renovated in 2022. The energy renovation consists in the improvement of the envelope of the building by replacing the windows and adding external insulation with a ventilated cladding. The central gas boiler for heating and domestic hot water is also replaced.

Assisting in the renovation process, a preliminary BIM model was created offsite by using the online Plans2BIM tool. The model was then enriched with technical information on the envelope and HVAC elements, captured from an energy audit carried out by Nobatek/INEF4. The BIM model was then used to assess the technical and economic feasibility of installing PV and PT panels with BIMSolar. An energy model was created from the BIM model, and more than 1000 renovation scenarios were considered using Renovation Manager to be then presented to the building owner, i.e., the social housing organization Logirep, for them to select considering energy consumption, cost and indoor discomfort in summer.

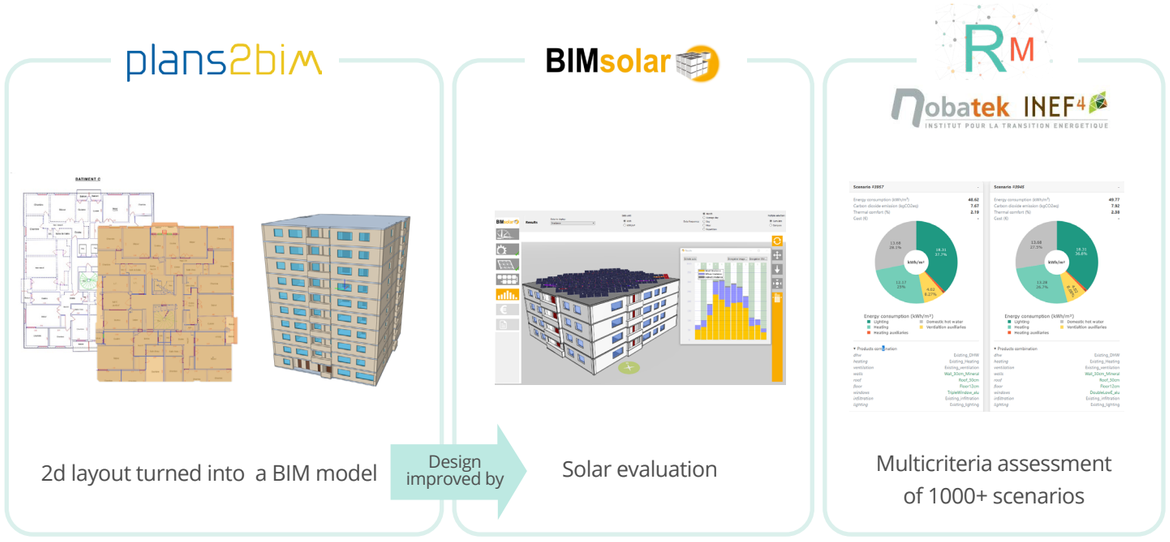


Figure 10: Detail of the workflow used for the French use case involving 3 separate complementary tools

The resulting process is manageable internally by the social housing organization thanks to the easiness of use of the tool and the low level of data required. It allows energy consumption, costs and occupants comfort to be taken into account at an early stage in an overall analysis. Full training of the tools would require 1 day, and the overall analysis 2 days.

Aude de Brébisson
Innovation and EU programs manager – Polylogis

"The BIM4Ren experience helped better understanding how using BIM in renovation can help us improving the quality of a renovation project"

■ Façade renovation in a private residential building in Spain

Grupo Kursaal is a Spanish SME specialized in the renovation of existing buildings. The challenges in their day-to-day activities include the initial costs assessment, the estimation of quantity of building materials to avoid waste, the evaluation of the future performance and, the planning of the renovation work to reduce the time on site.

Two building pilots were selected to test some BIM4Ren tools. A 3D scanning of the building's envelopes was carried out to obtain a 1 mm accuracy of cloud points that allowed the generation of a BIM model, the accurate calculation of quantities of material required and the planning of the renovation work. In addition, other tools were tested such as PIECE and Base+ (Tecnalia) to evaluate the impact of different renovation scenarios; ARtoBuild (BIMEO) and Plans2BIM (WiseBIM) to quickly create geometric BIM models; CAIA (RWTH) and Dagabot (Tecnalia) for a digital BIM-supported diagnosis; and the Feedback tool (TNO) to gather energy performance related information post renovation works.

Figure 11 : Use case in Spain: façade renovation in a private residential building

A renovation project often presents several problems, the main one being the absence of accurate graphic documentation, which often results in unforeseen issues during the construction works and therefore a poor predictability of time and costs of the project. The tools tested in BIM4REN improved the quality of the existing graphic documentation. In addition, they have been very useful in centralizing and better managing communications between stakeholders and workers. It should be noted, however, that these tools are not specific to façade renovation, for which more accurate models are required, in particular for onsite work, rather than the ones generated by BIM4Ren, which are more generic and focus on early phases of renovation projects.

■ A rehabilitation with nZEB target in Romania

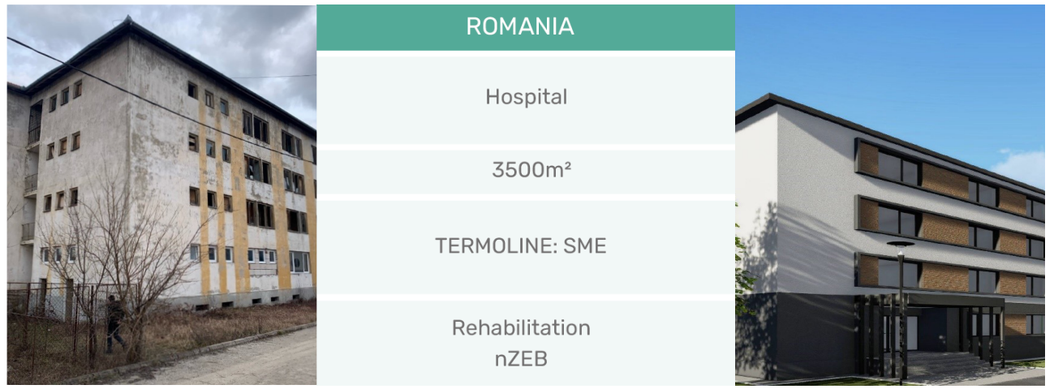


Figure 12: Use case in Romania: rehabilitation with nZEB target

Termoline is a Romanian company specialised in HVAC systems. The company was involved in the renovation of a student dormitory, built during the 80's, then turned into a hospital. The objective is to reach nearly zero energy consumption through an in-depth energy renovation consisting in the insulation of the envelope, new HVAC systems including a geothermal heating system.

Termoline used the Plans2BIM tool, developed by WiseBIM to generate a first BIM model of the existing building. It was then used in ArchiCAD for design purposes. The achieved quickness was particularly useful for the initial phase when the building owner's requirements are not fully defined, and the designer has to react with agility. In this very case, the opportunity to install a heat pump arose and the HeatPure tool, developed by IBP Fraunhofer, was used to assess the potential of such an installation. It allowed a quick comparison of different heating scenarios, either with a gas boiler or a heat pump, using characteristics provided by the manufacturers. An energy and economic analysis was carried out automatically and showed the benefits of installing a heat pump rather than a gas boiler.
Lastly, the potential for PV panels installation was assessed by importing the BIM model in the free BIMSolar tool and efficiently assessing the potential electricity production of a roof installation.

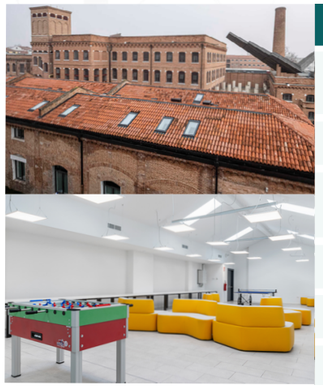
Horia Ban
Director – TermoLine

"The set of BIM4Ren tools proved to be really efficient in helping us to estimate the installation of heat pumps, and solor panels...and in few hours of trainings, we were able to use them hours"

The comparison between the use of the BIM4Ren tools and the business-as-usual approach showed great value, as those were quicker to use, while providing comparable outputs. It also key to note that these tools were pedagogic, easy to use, and require a short training period (less than half a day for all the three tools). Although the generated BIM model had a low-level of details, it was not a problem to carry out the studies in a preliminary phase of the renovation project.

■ Assessing the potential of digitalization in deep renovation: traditional vs. BIM-based

CMB Carpi as a large general contractor and ATI as an architectural firm are involved in two renovation projects for which BIM based tools were tested. First, a student dormitory building in Venice, serving as benchmark of traditional renovation activities. Second, "Gran Reno", a deep renovation project of a shopping mall in Bologna. The comparison of the two methods was used to assess both working processes. The challenge is the overall management of the renovation works that involve a large number of companies to monitor progress and quality.



ITALY	
Residencial (Student dormitory)	**Mall**
8000 m²	**100.000 m²**
Public + private owners	**Private owners**
AIT project	-
CMB Carpi	**CMB Carpi**
R2M / GBC	**R2M / GBC**

Figure 13 : Use case in Italy

The overall goal of the Gran Reno building renovation was to re-design the layout of the building, upgrading its systems. This goal included several objectives such as:

- Increasing the size of shops and common spaces
- Upgrade the overall energy efficiency of the building. Achieving BREEAM certification
- Improve fire safety

It required the creation of a detailed as-built BIM model detailing its architectural characteristics, HVAC systems and an energy analysis to ensure the achievement of BREEAM certifications.

Following the workflow define along the project, the initial acquisition of information required an important focus starting with:

- Data acquisition through digital scanning/point clouds with the testing of the Matterport solution to define the original status of the project different from what report in drawings.
- Data management was a key challenge due to the amount of information to be collected. The BIMQ Platform developed by AEC3 helped define a framework to organize the work to get a more efficient administration of BEP information and relative attachment, such as BIM rRequirements, in order to differentiate the modelling activity according to roles and, in the end, to be able to easily check the quality of the model information.
- On site quality checking by the using of Zutec platform and the testing of the beta version of Rialto to manage the snag list at the end of the construction phase.

The close follow up of the pilot sites highlighted that for such large and complex projects, it is required intensive planning, coordination and project management, as well as initial training and/or new qualified people to implement them. The investment in digital BIM-based tools helps lowering the risks of errors and miscommunications, and allows efficient workflows, teamwork, and traceability along the different phases.

In conclusion both the client and the contractor should be involved in the use of BIM based workflows and digital tools as it not only reduces risks throughout the project long but also leads to better quality results of the delivered asset.

5 LESSONS LEARNT AND RECOMMENDATIONS

…or the need to understand the requirements and constraints of a project as early as possible

The BIM4Ren project deals with preliminary phases of a building energy renovation project. We proved that with some simple, fast and efficient software, as well as models with low level of details, BIM can be useful in selecting different renovation options and discarding some irrelevant ones; while the renovation project progresses, more detailed models are required, and more domain or expert-specific software are necessary.

From our experience, we propose a series of recommendations to the different stakeholders:

Technical challenges for researchers

- **BIM for Energy Analysis**

  On the road towards a semi-automatic generation of energy simulation ready models created from an open BIM model. One challenge is to define the required level of details and potentially adapt it to the progress of the project, another is to extract the useful information from a potentially heavy BIM model. This would ease the collaboration between designers and energy consultants.

- **Digitalisation of the buildings**

  Although there are plenty of innovative tools, there is no one-fit-all solution and still a need for reliable, low-cost and easy to handle digitalisation tools. This represents a major opportunity to democratize the use of BIM in the construction sector, through the possibility of digitalizing the existing building stock and ensure a full digital continuity along the building lifecycle.

Tips for practitioners:

- **Don't be scared by BIM!**

  The comfort of continuing to operate with traditional ways should not prevent construction actors, from opening up to new methodologies and tools, which have a real potential to improve working conditions, but also the company's image and profits. Any transition requires taking the first step.

- **Start your project using BIM!**

  BIM being a continuous data generation & management process, by starting using BIM from the very beginning with reachable objectives in a renovation project, you will be on the path of greater efficiency.

- **Your needs are your drivers. Explore and choose wisely!**

  The model you create should answer your needs. While going too far could create a heavy, unusable model, and result in a less efficient process, focusing only on the basic functions of new tools can quickly cap potential improvements. Define your requirements, and select tools that answer to it.

- **Invest in training!**

  For a successful use, you need some BIM training. The necessary time to learn should be seen as a wise investment. Focus on general BIM training rather than on specific hard-to-use software. Testing is part of the training. Test and be an actor of the transition of your sector.

- **Collaborate with BIM!**

  By involving the other practitioners into a clear workflow, you will drive all collaborators, including the less skilled towards best practice, and incidentally improve the information flow and thus devote more time to fruitful actions.

For software editors:

- **Listen to the clients' needs!**

  Lots of issues hinder their practices, there is a lot of room for digital tools that will help them be more efficient in their daily activities.

- **Make it simple, it will be easier to market!**

  SMEs may have low capacity of investment, but there are numerous, and increasingly committed to digitising their activities, whether to rationalise costs, make their operations more efficient or meet regulatory requirements

- **Adopt openBIM!**

  By ensuring interoperability, you ensure the exploitability of your innovations.

- **Money remains the main driver**

  For the design tools, delivering energy or environmental indicators is necessary, but integrating costs, return on investments and other financial outputs will make the difference.

To push the use of BIM:

- **For policy makers,**
  - Similar to the Directive 2014/24/UE on public procurement for new buildings, the use of BIM should be encouraged for renovation works
  - Through an inclusive development of these tools, the integration of a **Building Renovation Passport** as an extension of a Digital Building Logbook will drive renovation in Europe.
  - Encourage the development and deployment of **local one-stop shops for energy-efficient building renovation**, so as to create a local hub of expertise that can guide and benefit property owners in their search for information on the best scenarios for their project, qualified specialists and public financial support.
  - Keep in mind that small and micro construction companies are mostly active in their local economy, with administrative red tape and linguistic limitations as strong obstacles to their digitalisation.
- **For building owners**, the integration of the delivery of BIM models in the tenders will ensure higher quality in the renovation works. The investment required is justified by the possibility of i. updating the model more easily, ii. reducing risks of future errors, iii. using the same model during the operational phases of a project.

Testimonials

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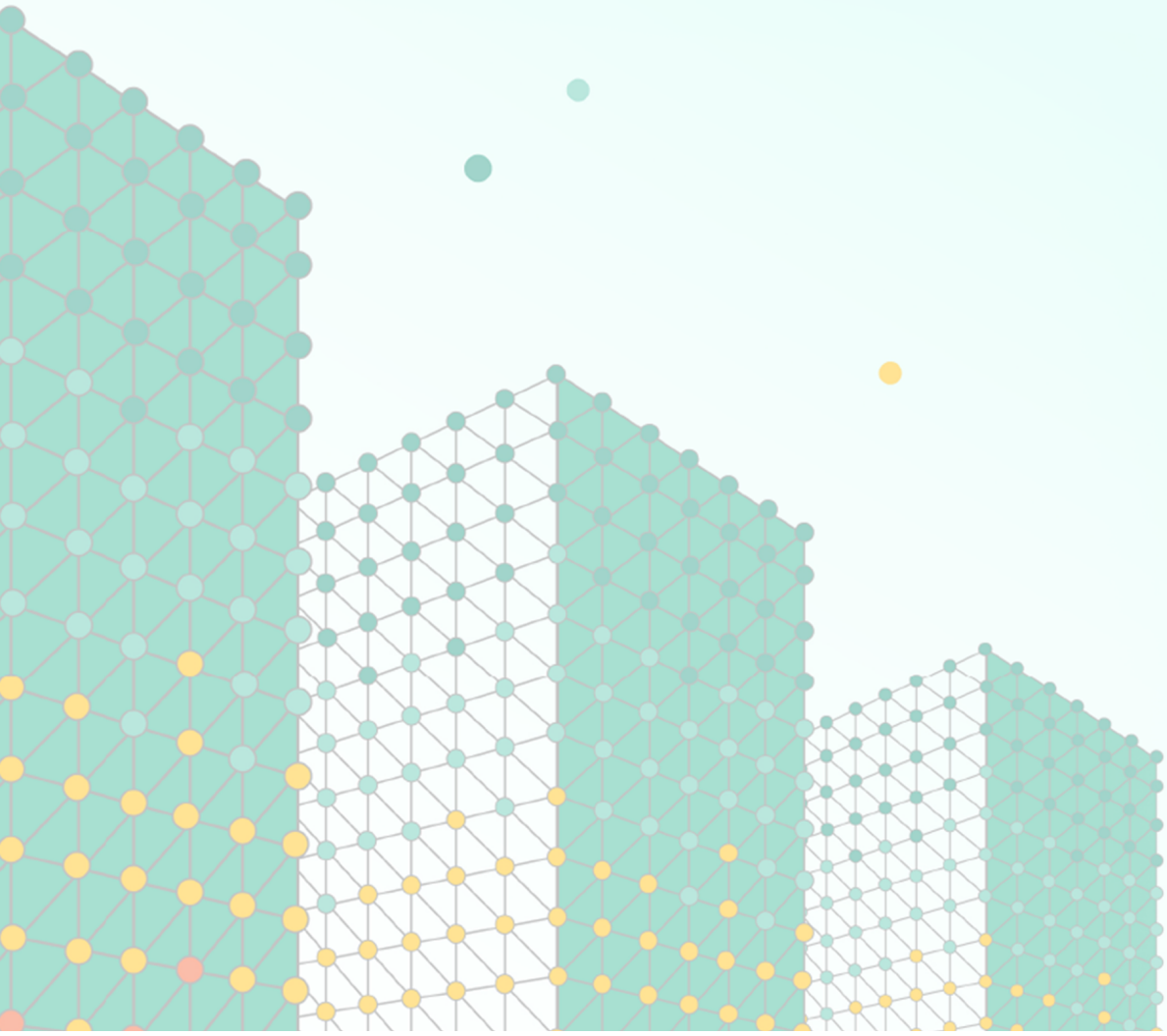

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