BIM SPEED

EU BIM guidelines, best practices and market uptake roadmap for renovation of residential buildings

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BIM-SPEED

Harmonised Building Information Speedway for Energy-Efficient Renovation

This research project has received funding from the European Union's Programme H2020-NMBP-EEB-2018 under Grant Agreement no 820553.

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Colophon

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Publishable executive summary

The main objective of this deliverable (EU BIM guidelines, best practises, and market uptake roadmap) is to ensure that the innovative knowledge of BIM-SPEED project, pilot experience, and set of BIM solutions offered are adopted by all value-chain actors in construction and renovation.

The initial EU-wide survey and its follow-up survey are aimed to understand the level of BIM adoption in the EU Member States among different stakeholders (architects, HVAC engineers, large construction companies, SMEs), what obstacles and barriers they face in renovation process, the reasons for not using BIM tools and what could be improved in the EU and national legislation to make the market access to BIM easier accessible. Both surveys are explained in Chapter 2.

Chapter 3 presents the conducted desk research on EU legislation and regulatory framework in Member States. Analysis was done on the most important EU legal acts and initiatives (EU BIM Task Group, Renovation Wave, Energy performance of buildings directive) and desk research covered legislation of nine European countries (France, Italy, Spain, Germany, Lithuania, Portugal, Belgium, the United Kingdom, Belgium) to examine to which extent Member States address BIM for renovation and help to understand the level of BIM usage across the EU.

Finally, Chapter 4 and 5 of the deliverable present main achievements and key steps of the roadmap of market uptake of the BIM-SPEED project, the approach and long-term impact developed tools could have in renovation process. Sub-chapter 4.2. offers a detailed overview on several tools, chosen as the most promising ones and having high potential to policy making. They include BIM-SPEED platform, Crow Data Collection (Inhabitants App), 3D Modelling of Existing Asset based on Point Clouds (Scan2BIM), BIM to BEM process, VR Safety Training.

Conclusions based on two surveys and performed desk research show that EU goals to double annual energy renovation in the next decade and reduce carbon emissions by half are not fully on track. Survey results reveal that adoption of BIM is still relatively low due to various obstacles (lack of skills and awareness among employees in the companies, lack of regulations and guidelines, budget restrictions). Analysis of legal frameworks in the EU Member States indicate that approaches to BIM implementation might differ from one country to another, therefore EU-wide approach could help to a higher BIM implementation. In addition to a common approach, BIM-SPEED project offered solutions could complement to achieve better energy performance and a higher renovation rate by offering a combination of methodologies and tools.

The type of this report is PUB (Public), being accessible to public audience with no restrictions.

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1. Introduction

1.1. Objectives of the task

The World Economic Forum predicts that the population in most urban areas in the world is increasing dramatically fast, i.e., 200 000 people each day.[1] Growing population across the globe is in great need of access to affordable housing, good living conditions, infrastructure and public transportation system. Recent changes in the work culture and the increased teleworking due to Covid-19 pandemic have drastically shifted our lives and people spend much more time at their homes. According to the statistics, 85% of the EU's building stock were built before 2001[2] and will still exist and will be occupied in 2050. Despite the fact that Europe has a diverse and rich historic variety of building across the whole continent, a huge part of the building stock is poorly heated and does not correspond to a current level of energy performance. In addition, the majority of the buildings in Europe are extremely old, they account for 40% of EU energy consumption and 36% of greenhouse gas emissions.[3]

Therefore, the industry requires essential changes that could be achieved by renovation. It is calculated that only 11% of the EU existing building stock undergoes some level of renovation each year. [4] Due to the fact that this number is abnormally low and would not allow to reach the main political objective of carbon neutrality by 2050, in order to tackle these challenges, back in autumn 2020 the European Commission launched the Renovation Wave initiative, which is supposed to double the renovate rate in Europe in the next decade. To reach climate neutrality and improve energy performance of the buildings, the EU has an objective to renovate 35 million energy-inefficient buildings by 2030[5]. However, in order to reach this goal, a lot has still to be done at all levels. It concerns upskilling the workers in all the Member States so that they have adequate skills, improving productivity and efficiency of companies, and most importantly - digitalise the sector.

Digitalization is the main key to ensure better communication and collaboration among all actors involved in the renovation process. It improves accuracy, quality of the works, reduces the financial costs, and above all helps to prevent a high number of errors. Among the technologies that help accelerating digitalization of construction we count drones, 3D printing, virtual reality, artificial intelligence, and BIM. In short, BIM allows all participants in the construction process (contractors, designers, product manufacturers, etc.) to better cooperate on a project, saving time and costs, ensuring more visibility and sustainability in the renovation projects.

BIM-SPEED focuses on 2 main challenges. First, using BIM tools developed during project duration to reduce the time spent on the renovation by at least 30%. Secondly, to save up to 60% energy used during renovation process. This way it would help to improve the market uptake and accelerate the of currently staggering renovation of residential buildings stock across the EU.

WP8 focuses on the BIM-SPEED project proposed solutions in renovation, putting a target on evidence-based practice which might help to implement market uptake once the project reaches its end. More specifically, Task 8.4. aims at consolidating the gained

[1] World Economic Forum, « Shaping the Future of Construction. A Breakthrough in Mindset and Technology", page 3.
[2] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020DC0662
[3] https://ec.europa.eu/info/news/focus-energy-efficiency-buildings-2020-lut-17_en
[4] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020DC0662&from=EN
[5] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0662

insights and knowledge of the demonstration cases developed in Task 8.1. and produce practical guidelines and best practices of BIM for renovation across the EU Member States. More specifically, the objectives of this task are as follows:

- To prepare a survey to understand the level of BIM usage and adoption level across the EU,
- To conduct research of the existing EU and national legislation and examine the existing level of BIM usage in renovation,
- To disseminate the produced guidelines among the channels of the umbrella organizations (FIEC, EBC, ACE, REHVA),
- To prepare an overview and results of BIM-SPEED demonstration cases and how they could accelerate market uptake.

1.2. Links with other WPs and Tasks

Since of one the objectives of this task is to consolidate the best practises of the demonstrations cases, the tasks has close connections with most WPs (1-8). More concretely, it has close links with the following tasks:

- **T8.1 (Demonstrating best practices of BIM for renovation**)- this task is supposed to collect the achievement of the demonstrations cases and tools developed during project cycle. Therefore, overview will be taken as a basis to analyse how project achievements could contribute to market uptake.
- **T9.3. (Exploitation plan, business plan, market uptake strategy)**– this task focuses with more details than T8.4 on the strategy for market uptake than T8.4. While T8.4. is supposed to generally consolidate best achievements of the project demonstrations cases, T9.3. focuses more on leveraging the accomplishments in the project and its varied knowledge and expertise, from industrial partners to scientific researchers to umbrella organisations in relation to market uptake strategy.

2. Baseline EU Survey

2.1. Background Information

This project task started with a European-wide survey to evaluate the current state-of art to create a baseline in line with the model for the diffusion of innovations for internal and external alignment for BIM within constructing new buildings and in the renovation process. Diffusion of innovations is a theory explaining and describing at what speed and how new patterns and ideas spread among the population.

The survey was launched at the very beginning of November 2020 (M25). The main objective of the survey was to **understand the level of BIM usage in the EU, the obstacles and barriers construction actors are facing in renovation projects, the reasons for not using BIM in some companies and what should be improved in the legislation to make the market access to BIM easier and more accessible.**

The main target group of the survey were SMEs, although answers from any stakeholders having knowledge of BIM usage were admitted. Accounting for more than 95% of the enterprises in construction sector, SMEs are the main player in ensuring innovation uptake, creativity and creating new jobs. Having in mind that SMEs are also priority in the EU policies agenda, we can state that small and micro enterprises should be the main driver for the adoption of BIM in the EU.

The survey was composed of 39 questions in total. The majority of them were multiple choice questions, allowing the respondents to choose the best answer according to the specificities of their company. The questions varied from what different barriers the sector is facing (economical, cultural, technical, legislative), where companies get the most information about BIM and what are the biggest drivers for the adoption of BIM.

The survey was closed in January 2021 (M27) and received 269 replies.

2.2. Communication and Dissemination of the Survey

The questions of the survey were prepared by Erasmus University as the partner responsible for communication and dissemination together with the umbrella organisations (ACE, REHVA, EBC and FIEC). Other partners participating in the task were able to provide their comments and feedback to the questions to ensure that the survey would provide the most relevant and needed information.

In order to reach the highest possible number of respondents and to achieve a great response rate, the survey was translated and was made accessible in 19 different languages: *English, French, German, Czech, Estonian, Spanish, Croatian, Italian, Latvian, Dutch, Polish, Portuguese, Romanian, Slovenian, Slovakian, Finish, Greek, Bulgarian and Hungarian.* With these languages survey covered almost all the European countries, focusing not only on Western Europe (which is most of the time considered being more advanced in BIM adoption), but also Central and Eastern European countries.

The translation process from English to other languages was done automatically using online translation tools. In the next step, FIEC, EBC, ACE and REHVA asked for help from their members to revise the translation and to ensure the quality of the translated text.

Erasmus University prepared visual materials to be used for every available language used in the survey. All project partners shared them in their respective newsletters, organisations' websites and on social media (Twitter, LinkedIn) and invite all the concerned stakeholders to participate. In addition, the umbrella organisations circulated the survey to all their members inviting them to share it at their national level. While the survey was open, the partners were often sharing posts on social medial to reach more respondents to the survey. In total, 877 participants were reached through these methods, of which 269 answered all the questions. The survey completion rate is in line with the expectations for longer surveys and showcased the efforts from the consortium to reach a representative sample.

Examples of visual materials in different languages:

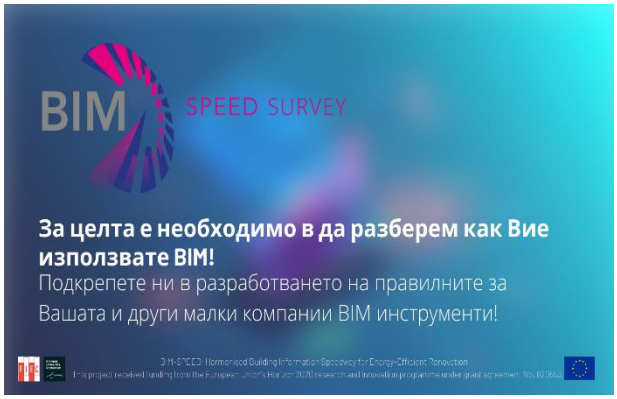


Figure 1 - Visual in Bulgarian language

Figure 2 - Visual in Italian language

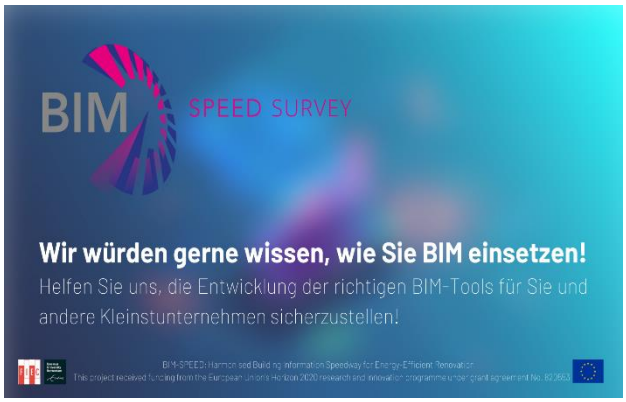


Figure 3 -Visual in German language

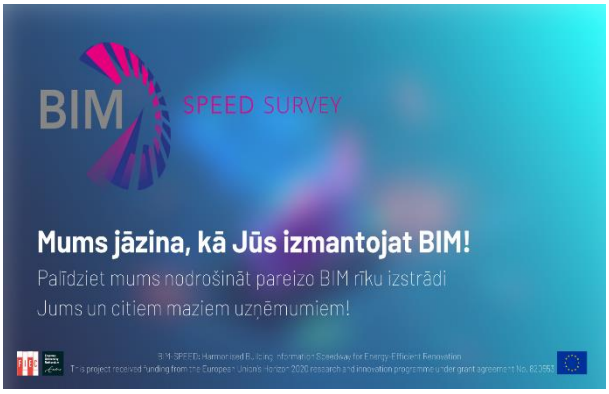


Figure 4 - Visual in Latvian language

The results of the survey were, first, discussed among partners involved in the task. Later, Erasmus University presented them in BIM-SPEED general assembly in May 2021 to inform all the consortium members about the results. The umbrella organizations shared the results in their social media, newsletters, and external websites. Moreover, FIEC wrote a summary of the main insights and presented it at a virtual event "Construction Technology Summit" on 11 May 2021 organized by a magazine "Construction Europe", in which FIEC has a monthly column. Several internal meetings (two) with interested FIEC members were also organized so that they could find out more about the survey, its results and ask questions.

2.3. Main results and insights

Sample description: the survey reached respondents in 24 European countries with most replies coming from Bulgaria, Spain, Italy, Hungary, France, and Germany. The answers in terms of company size and percentage of replies are as follows:

< 10 employees – 37.1% of answers

< 50 employees – 29.1% of answers

< 250 employees – 15.6% of answers

>250 of employees – 18.2% of answers.

The visual below (Figure 5) shows the percentage of replies collected in Europe:

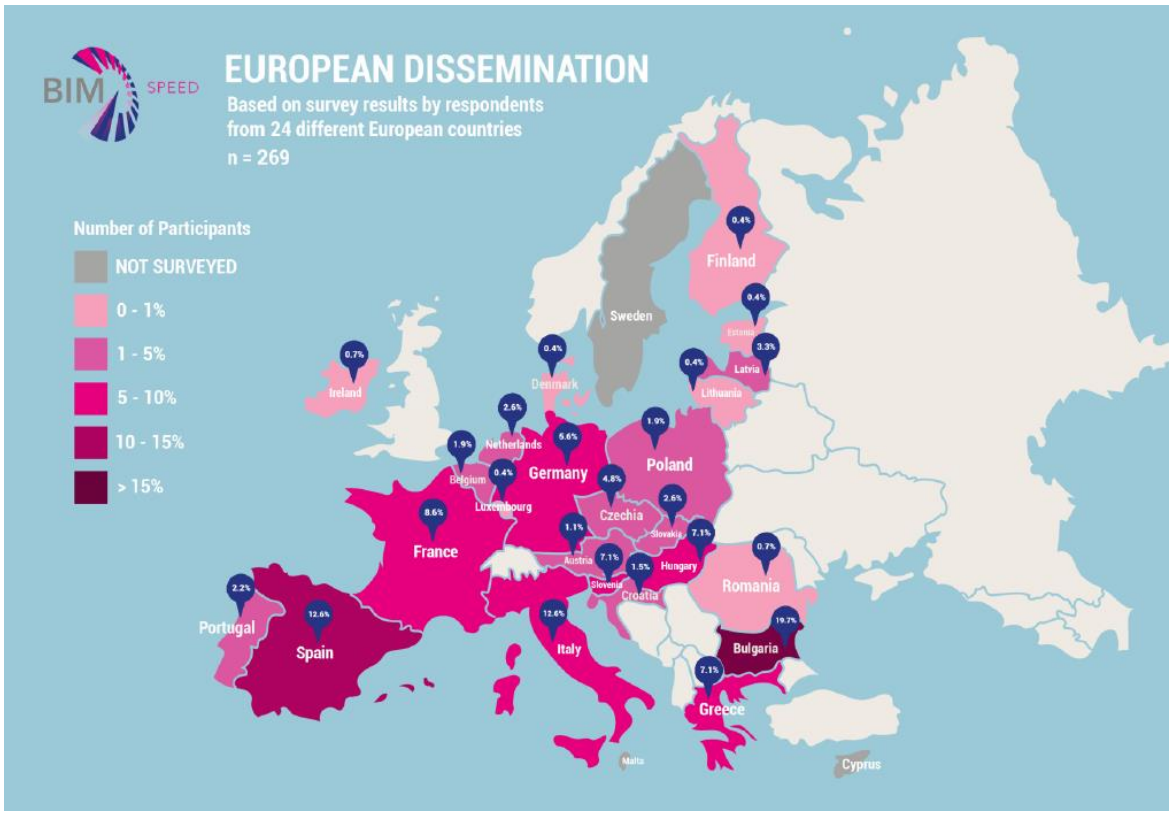


Figure 5 – Percentage of replies collected in the EU Member States

In terms of profile of respondents, mainly contractors, architects, and structural engineers were the main categories reached, as shown in the table below:

Sector	Frequency	Percent
Architecture	48	18.5
Structural Engineering	35	13.5
Main constructor	78	30.0
Real Estate	7	2.7
Manufacturing	7	2.7
Quantity Surveying	2	.8
MEP	14	5.4
Other Engineering activities	9	3.5
Subcontractor	7	2.7
Other Construction activities	28	10.8
Other	25	9.6

Figure 6 – Categories and percentage reached in the survey

Key findings:

- The usage and adoption of BIM are still relatively low among construction and operations industries compared to concept and technical design sectors. This could be explained by the fact that a lot of construction workers don't have any or a very low level of digital skills which results in a low adoption of digital tools in their daily work.

  The image below illustrates the percentage of respondents per industry that use BIM:

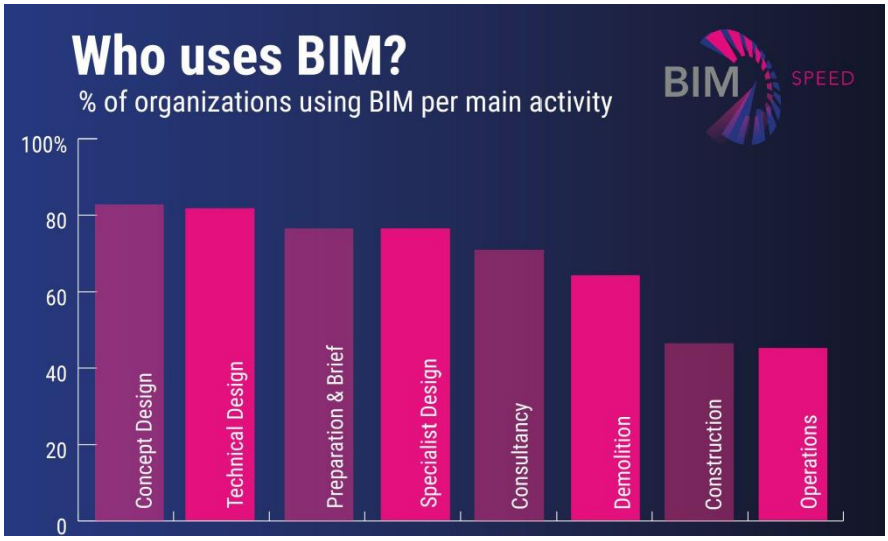


Figure 7 – Percentage of organisation using BIM per activity

- **SMEs identify more barriers to BIM adoption,** showing significantly ($p < .05$) different obstacles for BIM adoption than larger companies. The main obstacles identified by companies (both by SMEs and large companies) are lack of skills and awareness

that prevent using the technology. In general, SMEs struggle more and are not always able to keep up with large companies and their bigger budgets. In addition, the survey participants identified that a lack of regulation and guidelines and uncertainty about the legal and regulatory requirements were also key barriers for them to use BIM.

- The survey results show that even though the adoption of BIM is widely increasing, 37.3% of firms had no experience of BIM projects to date.
- A higher number of SMEs replied that the return on investment associated with BIM was yet another prohibiting factor. This indicates a significant difference in the way large firms and SMEs perceive the return on investment associated with BIM. This is as well supported by the fact that 33.9% of companies do not have any digitalisation strategy in place.
- The main motivation factors to use BIM identified by respondents are the following, in order of importance: the desire for innovation to remain competitive, streamline process and improved quality, improved communication to operations, improving built quality and time savings.
- Only 3.8% of the respondents said they are on track to use the full potential of BIM, showing a significant margin for improvement.

While analysing the results it is important to note that BIM is not adopted in renovation projects in Europe in its full potential and capacity. Different factors explain this - there is still a lack of EU and national regulations to speed up BIM adoption in the continent and the construction sector is not digitalised enough. Measures to increase BIM uptake could come from more public awareness on the advantages on BIM in renovation, more research on how BIM could contribute to sustainability and EU long term goals set out in the European Green Deal, increase social networking and conferences and most importantly, addressing the skills barrier by training more employees. Considering that in person contacts are mentioned as the most influential factor for adoption, in line with the expectations of the diffusion of innovation model, the COVID-19 pandemic may have also hindered efforts. Moreover, with rapidly evolving digital technologies and the need for new building to be energy-efficient, a lifelong training should be ensured to blue collar workers who constitute the main share of the workforce and usually have fewer digital skills and less availabilities for lifelong education.

2.4. Follow-up Survey

In order to see whether there is any progress in BIM adoption level in European companies, an updated version of the survey (designated wave 2) was circulated to measure the initial impacts of the BIM-SPEED strategic processes. This activity was as well foreseen in Task 8.4. of the project.

It was discussed among the Partners participating in the task to focus on a smaller scale of respondents. Therefore, the survey was sent by email to companies who had provided answers to the first survey and provided their emails for further communication. This allowed to see whether there were any changes in BIM adoption in the same respondents and what barriers and motivation they see in using BIM technologies.

To reach a higher number of respondents the second questionnaire was also translated into the same range of languages as the first one.

The questions of the survey were prepared by ERA with a possibility for other Partners to make changes to the questionnaire. To increase the response rates, the survey was made shorter, although some questions were repeated to track progress.

The wave 2 survey received 34 responses out of the 163 who provided their email address for a follow-up survey, a response rate of 21%. While this number is lower than in wave 1, this was expected considering survey attrition, but it nevertheless allows for a sufficient statistical power for significance testing.

Sample description: The sample for wave 2 was diverse, which reinforces the robustness of the results. 75% of the respondents were SMEs, 58% worked exclusively for the private sector. The main activities represented in the sample were concept design, technical design and construction.

Importantly, a total of 13 different countries were represented in the sample, validating the consortium's efforts of translating the survey into multiple languages.

Key findings:

- For this sample, the **adoption of BIM only had a minor increase of 3%** from 85% to 88%. As previously mentioned, the COVID-19 pandemic may have been a key factor for this small percentage.
- In terms of the barriers for adoption, there was a marginally significant ($p < .10$) **increase of lack of regulations and guidelines as a reason given by respondents to hinder BIM adoption**. It is not the case that such guidelines have ceased to exist, but probably that demand for them increased in the past 2 years.
- Conversely, while not statistically significant, in our sample **sustainability goals were the main external driver for BIM adoption to increase in the past 2 years**.
- In terms of the purpose for using BIM, respondents were consistent with their answers when compared to the first wave, which means that there were no new uses for BIM during this timeframe, at least for those who answered both waves of the survey.

2.5. Practical recommendations for BIM exploitation and market uptake

The construction sector is a key contributor to reach the energy efficiency goals set by the EU, though renovation rates are still low. Following the results of both surveys conducted in the project, it is possible to get insights on how market uptake in BIM renovation projects could be improved:

- SMEs may require more persuasion for BIM adoption, particularly regarding the perceptions of the returns based on the investments, time consumption and training.
- Existing and newly adopted guidelines at EU or national level should provide clear and simple rules in BIM and other digital tools application, as well as reduce administrative burden, and ensure easy adoption.
- Personal networks and conferences should be key parts of the exploitation strategy. Additionally, according to the survey results and the diffusion of the innovation model, opinion leaders may play a key role. Acting as intermediaries between targeted audience and law makers, they are able to communicate and transfer information in a way that influence the audience. Opinion leaders could as well act as role models for behaviour change and impact public opinion.

- The sectors that do not use BIM are not necessarily the ones that identify the most barriers. Exploitation plans should not just focus on eliminating barriers, but also on showing the advantages.
- Streamlining processes and a desire for innovation are the main motivations driving BIM usage, dissemination strategies should focus on these factors.
- Likewise, competitiveness and sustainability are the main external motivations. The competitive aspect would suggest that, after a certain threshold is passed, motivation will increase due to competition. This is also in line with the diffusion of the innovation model.

3. BIM guidelines and best practises

3.1. EU legislation

The European Union strongly encourages digitalisation and lists it as one of the top priorities for the economy. Therefore, the EC has developed several initiatives and adapted legal acts and policies to stimulate digitalisation (including BIM), for instance:

- **EU BIM Task Group** – aims to foster the use of BIM by both public and private construction sectors. Supported and co-funded by the EC, this group suggests guidelines, principles, and advice to EU members regarding a common approach using BIM in public procurement.
- **EU Directive on public procurement 2014/24/EU** – Article 22 of the Directive states that as of January 2016 Member States are allowed to "require the use of specific electronic tools"[6], including BIM in procurement process for constructions works, services and supplies. Even though the Directive doesn't require the usage of BIM at national level, it strongly encourages countries to implement it in their legal base. Following the public procurement directive, EU countries started to adopt digital tools, BIM being the most popular one. In some MS BIM has been made mandatory (France, Spain, Finland), while in others it is still only a recommendation. Another important notice is that while the directive doesn't specifically mention BIM for renovation, it is an important legal tool to foster renovation in the EU and countries are allowed to require the usage of it in public procurement.
- **A Renovation Wave for Europe**, the Communication from the EC to the EP[7], being part of the European Green Deal and issued back in 2020, proposed to implement a holistic approach to building renovation. One of the main intentions of the initiative is to aim at doubling the continent's renovation rate in the next decade and contribute in making Europe climate neutral by 2050. European Commission stressed out that renovation is a win-win situation in order to achieve climate neutrality and recovery. This document mentions BIM as a solution that stakeholders and workers in building renovation are aware of and that is one of the ways to upskill the workers, attract new talents and create green jobs.
- **EU Directive on the energy performance of buildings** (EPBD) – with the earlier adopted Renovation Wave the EC sets a goal to at least double the number of renovation rate of the Union's building stock in the next decade, with a special target – to focus on deep building renovations. Having this in mind, one of the key legislative acts to reach this goal is the EBPD. At the end of 2021 the EC published its proposal for revision of the Directive. This revision should include ambitious goals for net-zero emission buildings, achieve climate change targets and play crucial role in Fit for 55 package. Stakeholders in construction sector raises the importance of BIM for renovation in the context of EBPD. It is one of the critical tools to reach climate change targets and significantly cut gas emissions across the EU. A new revision of EBPD opens a way to include BIM for renovation as a requirement in national legislation for all renovated public buildings and all infrastructure projects.

[6] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32014L0024&from=EN, Article 22
[7] https://ec.europa.eu/energy/sites/ener/files/eu_renovation_wave_strategy.pdf

- **2022 Strategic Foresight Report** – issued recently (June 2022), the report identifies ten key areas of action with the objective of maximising synergies and consistency between the EU's climate and digital ambitions considering current geopolitical situation. With regard to the construction sector, the report states, for example, that "by 2030, building information modelling could further increase the sector's energy and water efficiency, providing long-term analysis of design choices in construction and use of buildings".

3.2. National legislation

3.2.1. France

According to CAPEB (French confederation of craftsmen and small construction enterprises), renovation represents 56% of the construction market amounting to 48 billion EUR added value and more than half of renovation activities are done by SMEs[8]. Knowing that the renovation activities represent a huge part of the market, and that BIM could fasten ecological transition and reduce high costs of the projects, in the last years the French Government has been encouraging the use of BIM in the country. This could be also explained by the fact that the ecological transition Ministry wants to perform 500,000 renovations per year in the country.

One of the first steps taken by the Government was in April 2017 with the adoption of a BIM standardization roadmap, which raised the necessity for standardization. The presented tool was a part of national strategy called "Plan for the digital transition in the building industry" (PNTB) officially initiated at the beginning of 2015. The standardisation roadmap outlined the following benefits of how BIM can improve transition to digital:

- Reducing costs
- Optimizing deadline of the project
- Improved process and quality of data sharing
- Minimising errors and conflicts.

Another initiative adopted at the end of 2018 by the French Government is the Digital Transition Plan (Plan BIM 2022). With the help of eight action points set out in the plan, the idea is to fully implement the BIM methodology throughout France and to encourage stakeholders to start applying BIM on a daily basis. This plan also promotes the development of skills, among SMEs in particular, provides professionals in the sector with concrete methods and tools online, and gives a platform to share and disseminate information among various sectors.

Despite various ambitious initiatives, currently BIM is not mandatory to use in France. At this moment it only remains an encouragement by the Government, focusing on big-scale public project. For instance,

- Public Procurement Code article R2132-10 mentions that "*the buyer may, if necessary, require the use of tools and devices that are not commonly available, such as electronic building information modeling tools or similar tools*".[9]
- The General Conditions of Contracts article 4 says that "*In case of contradiction between the stipulations of the contractual documents of the market, they prevail in the following order of priority:*

[8] https://www.capeb.fr/
[9] https://www.legifrance.gouv.fr/codes/article_lc/LEGIARTI000037730717/2022-02-14/

[...]

if applicable, if the operation is the subject of a BIM approach, the BIM specifications of the contracting authority.

if applicable, if the operation is subject to a BIM approach, the BIM agreement, and its successive changes."

Even though France still doesn't have a BIM mandate and the law doesn't clearly mention the use of BIM in renovation, it is more and more applied by private sector companies, especially the big ones who in comparison to SMEs have abilities to invest in digital technologies. Companies applying BIM in renovation process, see that it can help understand technical structure of the buildings, helps to ensure long term and easier management, create simulation at lower cost with no environmental impact. Among examples of application of BIM could be found the following: renovation of the accommodation building for elderly people[10], the renovation of the workspaces on the wall and the volumes of the roof open to the public of the Grand Arche[11],

3.2.2. United Kingdom

Even though the UK is not a member of the EU, the country was chosen to be included in this deliverable report as one the leaders in BIM initiatives in the world, with almost 70% of construction industry stakeholders using BIM in projects. Even before the EU adopted the Directive on public procurement, the United Kingdom adopted a first BIM mandate back in 2011.

Formally back in 2019 the UK laid down general approach for BIM implementation in the country. It was developed jointly by the UK BIM Alliance, British Standards Institution (BSI) and the Centre for Digital Built Britain to implement international BIM standards within a UK context. The British government adopted a decision to mandate contractors to use Level 2 BIM for all public sector projects, which is at the moment the minimum target for all public sector in the country. This decision was followed by the fact that for a long-time the construction industry was inefficient, lacked productivity and needed improvement. The UK BIM strategy could be considered successful in terms of reduced waste, improved safety measures, accelerated digitalisation in the sector, improved collaboration among different stakeholders and saved time.

The UK BIM Framework includes the following:

- The published standards called upon to implement BIM in the UK.
- The UK BIM Guidance Framework.
- Useful links to other resources.[12]

UK BIM Framework guidance is a detailed guide, providing information on used standards, protocols, outcomes for individuals and companies in the UK on BIM adoption in projects. Published in 2018, it is being continuously updated to give the most relevant information and being accessible to everyone interested.

Regarding using BIM in renovation, it is lagging behind in comparison to using BIM in new buildings, mainly because only the public sector is mandated to apply BIM. However, it is important to stress that the Government has always pointed out that BIM has a high potential to be used for renovation projects and initial projects costs could be significantly minimised if BIM is adopted from the beginning.[13] Even though there are no official statistics of BIM usage in renovation projects, as obstacles could be

[10] https://www.cub-architecture.fr/le-bim-et-la-reno/
[11] https://abcdblog.typepad.com/abcd/2018/03/a-voir-sur-bim-world-le-bim-pour-la-renovation-gestion-et-maintenance-dun-batiment-prestigieux-l-arche-de-la-defense.html
[12] https://www.designingbuildings.co.uk/wiki/UK_BIM_Framework
[13] Building Information Modelling—Industrial Strategy: Government and Industry in Partnership; HM Government: London, UK

considered the facts that the majority of buildings is privately owned, the complexity of the projects, the lack of trained workers, legal issues and data exchange between different software systems.

Example of BIM use in renovation project:

Garth House, located within the University of Birmingham and built back in 1901 was designed by architect William Henry Bildlake. The building being extremely old, it needed urgent renovation to be used as a new hotel and conference centre. The issues to be addressed during the renovation were water leaks, thermal expansion, rotting, structural cracking. Additionally, due to the fact that it was built at the beginning of 20th century, detailed records of maintenance and original plans didn't exist.

As required by the Government, BIM level 2 was used in the process. Different tools were applied, for instance, 3D BIM to isolate and name various levels of the building, Scan-to-BIM to identify original areas and structures. It helped to isolate problematic areas, understand original proportions and lighting.

Renovating using BIM tools provided advantages: understanding the original building environment, the size and proportions of the rooms, evaluating the areas of the building that had historic heritage value.

In the case of Garth House, applying BIM tools helped not only saving costs and time, but as well understand the historic importance and environment of the building. BIM tools highlighted the value and specific aspects to be taken into consideration while renovating historic buildings. Therefore, there could be a potential to use BIM for heritage databases and to offer society a greater understanding of renovation and conservation requirements for heritage. [14]

3.2.3. Lithuania

At the end of 2021 the Government of Lithuania adopted a resolution prepared by the Ministry of Environment that sets out the cases in which contracting authorities will have to apply and specify requirements and criteria to use BIM in public procurement. According to the changes in the national law, contracting authorities and entities will be required to specify in the procurement documents the requirements and criteria for the mandatory application of BIM methods in accordance with the procedure established by the Minister of the Environment. These provisions shall apply to the purchase of new construction and reconstruction design services for the special category buildings and the new construction and reconstruction works themselves. They will also apply to the purchase of installation, conversion design services, installation, reconstruction works in urban areas quarter modernization design services, modernization works.

The changes in the law foresee that buildings, movables and residential quarters will have to meet all the conditions specified in the resolution. High-value facilities that will be required to use BIM methods include buildings with an estimated construction cost of € 5 million and above. In addition, engineering structures, movables, of which estimated construction cost or investment amount is 10 million EUR and above. In urban areas, renovated quarters with an estimated construction cost or investment amount of 5 million EUR and above.

The government stipulates that the estimated construction costs and investment amounts from which the BIM methods would be mandatory will be gradually reduced every two years.

[14] https://wlv.openrepository.com/bitstream/handle/2436/622902/Accepted%20-%20Critical%20issues%20in%20the%20implementation%20of%20refurbishment%20BIM%20in%20the%20heritage%20context.pdf?sequence=2&isAllowed=y

The adopted changes in the legal basis are applicable only to public procurement due to the fact that the in comparison to private sector, the public one stagnates in digital tools application. It is expected that the changes will foster and push digitalisation in construction and will improve the quality of the projects.

Example of BIM use in renovation project:

Back in 2015 a Lithuanian private company "Miesto laboratorija" started a renovation project of a high school in a residential area in the capital of the country – Vilnius. Like the majority of the buildings, the school was built back in 1993, therefore it was physically worn out, had a broken and inefficient heating and ventilation systems which used a lot of energy. The building did not meet anymore the requirements of safety and cost effectiveness.

In addition, two store building had outdated electrical installation and even though exterior concrete structures were not damaged, windows and roof did not meet safety requirements.

It was the first integrated renovation project conducted by "Miesto laboratorija" using BIM. The company planned a complete renovation of the heating and ventilation systems, to install a canteen and a dance hall, to reconstruct hot and cold-water supply systems, to modernize lighting and to perform sewage system reconstruction.

While performing renovation, the company used the following software:

- Autodesk
- BIMsight, and
- DDS-CAD

According to the company, using BIM in this renovation process helped to avoid the intersection of different engineering systems which often occurs in more complex projects.

More information on this BIM project could be accessed here. [15]

3.2.4.Spain

In Spain, the use of BIM was already contemplated in the Public Sector Contracts Law, Law 9/2007, with further attention being paid to it for example when the Advisory Council of the ITeC (The Catalonia Institute of Construction Technologies) Board of Trustees created in 2015 the "Building the Future Commission" to discuss the future of the construction sector and analyse the use of BIM, Lean and IPD (Integrated Project Delivery) technologies, among other topics. The Commission, gathering more than 50 public and private entities, published in June 2021 the Guidance for the implementation of BIM[16] in public procurement with the aim of supporting both large companies and SMEs in the gradual adoption of BIM.

Moreover, the Spanish government took concrete action in 2018 with the adoption of the Royal Decree 1515/2018 of 28 December which led to the creation in April 2019 of **the "BIM Commission" – Inter-ministerial Commission for the incorporation of the BIM Methodology in public procurement (CBIM),** with the Ministry of Transport, Mobility and Urban Agenda (MITMA) holding its Presidency and Secretariat. Its purpose is to promote and guarantee the coordination of the General State Administration, its

[15] http://www.darnistatyba.lt/renovacijos-bim-projekto-bandymai/
[16] https://docs.itec.cat/e/Guia-de-Licitacion-BIM-ESP-junio2021.pdf

public bodies and related or dependent public law entities in the implementation of the BIM methodology in public procurement. The CBIM encompasses the sustainable management of resources and the circular economy, as well as digital innovation in its Urban Agenda. The use of the BIM methodology was also included in the discussion document of the Strategy for Safe, Sustainable and Connected Mobility 2030, currently being drafted.

Furthermore, BIM is today present in various national strategies:

- Specific attention was devoted to it in the National Reform Program and the Green Public Procurement Plan of 2019 (key topics were the infrastructure development, sustainability, and digital trans-formation).
- In June 2020, the Spanish Circular Economy Strategy (España Circular 2030[17]) was also approved where construction was one of the six priority sectors identified.
- In July 2020 the Spanish government launched the Digital Spain 2025 agenda[18], aiming to drive the country's digital transformation process, in order to take stock of the progress made and adapt it to the 2026 horizon, improving its alignment with the Recovery, Transformation and Resilience Plan, and promote high-impact strategic projects.

Recently, on 24 June 2022 the Spanish government launched a call for grants for training in BIM Methodology in 2022 with the purpose of contributing to the implementation of projects for on-site and off-site training actions, in order to facilitate the acquisition of practical knowledge on the use of BIM methodology in public procurement and aimed at the largest possible number of professionals.

3.2.5.Italy

In Italy, BIM is emerging as a constantly expanding tool, stimulated by important regulatory and disciplinary measures. The use of BIM was already regulated in Italy in 2016, with the New Procurement Code (Legislative Decree 50/2016[19]), followed the next year by the Baratono Decree[20] (or BIM Decree, n. 560/1.12.2017 amended by the Ministerial Decree n. 312/02.08.2021) which entails the progressive compulsory use of BIM, from 2019 to 2025 , for public works of decreasing complexity, until it includes them all, year after year (BIM will become compulsory in public works above EUR 1 million from 1 January 2025). This measure is flanked by intense standardisation activity that plays an equally important role in defining the guidelines to be followed in the adoption of this methodology. In particular, the UNI 11337 standard applies the international standards established by ISO 19650, adapting them to the Italian context.

UNI 11337 standard is a document divided into ten parts, six of which have already been published, which deals with digital management of building information processes. The first part (UNI 11337-1) deals with models, designs and information objects for products and processes, covering the general aspects of digital information process management in the construction sector. UNI 11337-4 is about the qualitative and quantitative aspects of digitised process management. UNI 11337-5 and UNI 11337-6 are linked and concern the management of information flows in digitised construction processes. The standard defines the requirements for the production, management and transmission of information content through the introduction of specific documents. UNI 11337-7 has been published in 2018 and addresses the definition of the requirements for the professional

[17] https://circulareconomy.europa.eu/platform/sites/default/files/espana_circular_2030_executive_summary_en.pdf
[18] https://espanadigital.gob.es/sites/espanadigital/files/2022-07/Espa%C3%B1aDigital_2026.pdf
[19] https://www.codicecontrattipubblici.com/
[20] https://www.mit.gov.it/sites/default/files/media/normativa/2018-01/Decreto%20Ministro%20MIT%20n.%20560%20del%201.12.2017.pdf

activity of the figures involved in information management and modelling. The standard identifies four figures associated with the BIM field, which are: the CDE Manager, the BIM Manager, the BIM Coordinator and the BIM Specialist. For each role, areas of competence and management and operational limits related to their professional activity are clearly defined. UNI 11337-7 does not appear to be the conclusion of the BIM standard and it is expected that further parts will supplement the series covered.

3.2.6. Belgium

In Belgium there is no BIM Mandate from the government. The implementation of BIM in the country have been pushed and supported by the design and construction industry and regional efforts. In this process, the Flemish Agency for Roads and Traffic (AWV) and the Belgium Building research Institute (WTCB/CSTC/BBRI) are leading two important initiatives.

Since 2019, the AWV (the road authority in Flanders) is working to support their partners in the BIM implementation in all AWV projects in infrastructure. For this purpose, the agency published a BIM protocol and a BIM implementation plan and developed an ObjectType Library to be used by their partners from the design, construction handover and use . The main objective of AWV is to build up an Asset information Modelling of their infrastructure to better manage it.

The WTCB/CSTC/BBRI is a private Institution founded by and for the sector in 1959 to support applied research in the construction filed. Currently, the institute has 90,000 statutory members from the Belgian construction companies (general contractors, carpenters, glaziers, plumbers, roofers, floorers, plasterers, painters, etc..), mostly SMEs.

Since 2016, the institute stablish a technical committee in BIM and ICT that gathered professionals involved in all the design and construction cycles as well as representatives from academia and IT solution providers.

The committee is structured in 5 working groups (WG) classification, exchange protocols, E-Catalogue BIM, legal aspects, and training.

The most important outcomes of the working groups are:

- Belgian BIM protocol,
- Belgian BIM implementation plan,
- General framework of exchange protocols,
- BIM Modelling Guidelines,
- The BIM competency matrix
- The classification systems and BIM,
- Comparison of classification systems in the context of BIM
- TechBIM, BIM object library
- The calculator and BIM

There is not specific guidance on BIM implementation for building renovation works. However, all documents establish standards that can be applied to any type of design and construction project including renovation projects. The BIM protocol step up the four

different phases of the project encompassing the existing, design, constructed and the as built or as constructed phase. These phases are in line with renovation projects.

The BIM Object library, TechBIM, is also a massive contribution to the standardization of the processes in the country facilitating renovation projects.

A set of training material produced by WTCB/CSTC/BBRI in the links below are also facilitating the implementation of BIM companies.

- Which BIM competencies for the traditional roles of the construction industry?
- The project leader and BIM
- The site manager and BIM
- BIM webinars

3.2.7. Portugal

The Portuguese government has not yet established a BIM mandate for public building works in the country. However, some efforts have been made by the industry toward a national standard and guidance for BIM implementation in the country.

In 2015, a technical committee of standardization in BIM, the CT 197, was created as a mirror committee of the CEN/TCC422, EU BIM taskforce and ISO 59 responsible for the BIM standard at European and International level. The committee is under the Portuguese Institute for quality (IPQ) and it is currently coordinated by the BUILT CoLAB. The CT 197 is responsible for the development of the National classification system, the standards for information modelling and process of life cycle for constructions developments.

The SECClasS (Sustainability Enhanced Construction Classification System) project funded by EEA and supported by CT197 is working on a National Classification System. The project has analysed current classification systems for construction projects available and selected the Uniclass 2015 system from UK for translation and development of rules for the use in BIM. The project is developing web applications to facilitate the use of the system in construction projects. At the end of 2022, the project will publish the results of the pilot's cases and system.

There is also an initiative to standardize the implementation of BIM for building permit coordinate by the Portuguese Architects Order. This work is conducted in conjunction with the Agency for the Administrative Modernization (AMA), the General Direction of the Local Councils (DGAL), the Engineers and technical engineers Order, and the landscape architect's association of Portugal. The University of Minho have developed the platform open-source platform called BIM LiMA already tested and implemented in the Council of Lisbon and Vila Nova de Gaia. This platform will be the basis for the standardization of the building permit in Portugal using BIM as the main source of information and deliverable in the process.

Finally, the Portuguese BIM excellence Awards run by the BUILT CoLAB, the EAC Cluster, and the technological platform for the Portuguese construction (PTPC) aims to foster the good practices in the use of BIM in the country.

3.2.8. Germany

The construction sector in Germany being one of the most important sectors in the country, for many years has been lagging in terms of digital tools. According to the study of Leibniz Center for European Economic Research, companies think that it costs too much to go fully digital but believe that digitalisation is a way to have more opportunities and competitiveness.[21]

In December 2015 the German Ministry of Transport and Digital Infrastructure presented a roadmap called "BIMStufenplan" that would include a strategy for a gradual BIM adoption in the country until mandatory use of BIM in 2020. In the road map there are three key advantages of BIM exploited:

- *Increased design accuracy and cost certainty* - BIM facilitates more accurate planning, specifications of services, cost estimates and construction scheduling. Many risks, such as planning, technical, planning approval, interface risks, etc., can be reduced with BIM while transparency as well as acceptance, for instance in the case of public participation, can be improved. Risks are manageable to such an extent that the insurance of project cost risks for large-scale projects is to be examined in several initial pilot projects.
- *Optimization of life cycle costs* – this could prevent the loss of knowledge that usually occurs during the transition from construction to operation stage. Digital model contains information on every single structural component – e.g., material, manufacturer, costs, location in the structure, service life, maintenance cycles – and thus enables, among other things, the combined optimization of investment in maintenance and replacement.
- *Implementation of the Reform Commission's key recommendations* - this applies primarily to the recommendation to intensify cooperation and collaborate in teams, both in design and construction. Implementation of the Commission's proposal to make sound risk management mandatory for major public projects is simplified significantly using BIM.

To implement the goals of the Roadmap, the Government of Germany created a BIM4INFRA2020 working group, which was supposed to supervise BIM pilot projects, publish guidelines for a successful BIM implementation and define BIM 2020 scenario. This working group was active from the beginning of 2017 to mid-2019).

A while ago, the German Government created the German Centre for the Digitisation of the Construction Industry (BIM Germany). Its main objective is to continue work of BIM4INFRA2020 by "pushing forward standardization and harmonization, developing a comprehensive training concept, providing consultancy and support for BIM projects and creating a vision for the future digitalization of the German construction sector."[22]

From the end of 2020, Performance Level 1 is to be used, on a regular basis, in Federal Government transport infrastructure projects that are to be newly planned. The purpose of the first phase, which is currently underway, is to prepare for the application of BIM by creating the necessary conditions and providing targeted support to clients and members of the supply chain alike. At the same time, it is being examined for which types of projects BIM makes sense and in which way it should be applied. In addition, it is important that the market participants themselves gain concrete experience with BIM. For this purpose, the Federal Ministry

[21] https://dmexco.com/stories/digitalization-construction-industry/
[22] Germany's Governmental BIM Initiative– The BIM4INFRA2020 Project Implementing the BIM Roadmap (André Borrmann, Christian Forster, Thomas Liebich, Markus König, and Jan Tulke), p.13

of Transport and Digital Infrastructure is already providing funding totaling € 3.8 million for four BIM pilot projects including accompanying research in the road and rail sectors.

Until now, Germany doesn't have mandate to use BIM in construction projects, but it is expected to have it in the coming years.

3.2.9. Finland

Like all Scandinavian counties, Finland has been implementing BIM for more than two decades.

Senaati (Senate Properties) is Finland's property services agency under the Ministry of Finance and is in charge of the BIM program. Since 2001 it has been adopting BIM in all their projects. In the same year they have as well published the Senate Properties' BIM Requirements for Architectural Design.[23]

Back in 2007 the Finnish construction industry federation has made a decision to make it mandatory that each design software package had IFC certification (open BIM) and operation based on integrated models. In addition, the Finnish Government decided to introduce BIM in public procurement – it's been necessary to use BIM since then for projects of over 1 million euros. Therefore, the level of BIM in Finland has been steadily growing in the last decades, with "Common BIM requirements" published by buildingSMART Finland in 2012.[24]

The private industry has been active in digitalisation and in the adoption of BIM in construction sector. Finnish universities have also been offering master degrees in BIM technologies. In 2012 with the help of some big construction companies Senate Properties transformed above mentioned BIM Requirements for Architectural Design into the Finnish National BIM Guidelines (COBIM), that became Common BIM Requirements. The objective of the COBIM was to produce national requirements instead of guidelines, that could be used as an appendix in various contracts and would be applied to the whole project lifecycle. The requirements are practical, created by stakeholders with relevant experience.

The adoption of BIM in renovation projects is being applied as well across the country. There are different projects across Finland using BM technologies, for instance, Salpaus school. Currently, COBIM are often applied both in public and private sectors. [25]

Finally, in the notification to the Article 4 of the Energy Efficiency Directive (2012/27/EU) to the European Commission on 30 April 2014, the Finnish Ministry of the Environment expressed that BIM should be used in renovation of old buildings because it could help to achieve energy performance goals.[26]

3.3. Conclusions

After performing desk research of European and national legal requirement regarding BIM adoption in renovation, the following conclusions can be highlighted:

- Only a few national governments in the EU have already put in place BIM requirements. Moreover, EU policy makers support digital tools with various initiatives and legislative acts. We can note that more and more countries implement requirements in their legislation to use BIM at least in all public procurement projects. Both EU and various governments

[23] https://bimvet3.eu/courses/bim-tenders-for-projects-and-public-works-and-bim-implementation-processes/lessons/international-bim-standards-benefits-and-limitations/
[24] https://biblus.accasoftware.com/en/bim-around-the-world-scandinavia-boasts-a-consolidated-practice-in-the-construction-industry/
[25] https://ec.europa.eu/growth/document/download/01afafff-16f1-4eb8-9d89-23f14194fdd9_en
[26] https://ec.europa.eu/energy/sites/ener/files/documents/fi_building_renov_2017_annex_4_of_neeap_en.pdf

acknowledge the advantages that BIM could bring, i.e., cost efficiency, sustainability, better data exchange among value chain and smooth project management.

- Even though the construction sector is undergoing a transformation towards digitalisation, BIM adoption in renovation is still very low and applied to a small number of projects across the EU, even though renovation represents a huge part of market share in many countries. Therefore, the EU legislation could be more ambitious, and regulators should set up more concrete targets in order to adopt digital technologies like BIM (for instance, all public procurement projects regarding renovations could require BIM at least in some project stage). By doing so the number of annual renovations per year could be increased significantly. For now, renovation rates remain quite low across the continent and do not always improve energy efficiency sufficiently – this might be changed with adoption of BIM.
- According to the results of the survey (see Chapter 2), there is a high need from companies (especially SMEs) to train their workforce to be more competitive in applying digital technologies. Currently, one of the main obstacles preventing firms applying BIM is a lack of skills of the employees. To have a successful market uptake of BIM, it is essential to come about with upskilling training programmes for all employees (including workers on construction sites, who usually have lower level of digital skills) in the construction value chain. The President of the European Commission recently announced 2023 as "European Year of Skills" which will be the perfect opportunity to focus on improving the digital skills of European workforce and further investments in continuous learning and upskilling.
- Desk research and analysis of legal basis and requirements in various EU member states show that at the moment approaches to BIM adoption and implementation differs from one country to another (for instance, Belgium where there is no Government mandate and Finland requiring to use BIM to some extent). A wider EU-level approach could as well help to achieve EU renovation targets and avoid lack of coordination.
- Initiatives to increase the level of BIM adoption should come from both public and private sectors. As stated by the European Construction Sector Observatory, public and private sectors have different roles, but coordination and synergies between them can ensure a proper BIM implementation in renovation projects.[27] If policies put in place by Governments support and call for BIM adoption, engagement; initiatives and support by private companies are equally necessary to upscale the use of digital tools in renovation.

[27] http://biblus.accasoftware.com/en/wp-content/uploads/sites/2/2019/07/ECSO-BIM-in-construction.pdf

4. Main achievements of BIM-SPEED project

During the BIM-SPEED project lifecycle, numerous tools (more than 30) and services have been developed and milestones reached that could show examples of collaboration, support market uptake by providing innovative knowledge and improving ways of working. Additionally, offered tools consider different stages and aspects of the renovation projects. For instance, BIM-SPEED tools could improve quality of the process and communication, ameliorate buildings' quality, ensure time saving and save costs.

Sub-chapter 4.1. below shows non exhaustive list of some of the project achievements, that could be recognised as the key milestones, i.e., being the most promising ones, having the long-term impact after the project ends, aiming at improving public knowledge and objectives of the Renovation Wave in the EU.

4.1. Overview of the main project achievements

A list of examples of the main project achievements:

- 13 real demonstration cases of BIM across the EU (in Spain, Poland, the Netherlands, Italy)
- Development of as-built BIM model for all demonstration cases
- Selection of the BIM-SPEED tools applicable to each of the demonstration case
- One of the main results of the project is BIM-SPEED platform developed by CSTB. This platform has a Common Document Environment (CDE) and collaboration possibility that can be extended with renovation related-services integrated in a one-stop-access platform. Being an important key exploitable result and a tool for project business model, it is explained in detail in the deliverable 9.4.
- Established a Community of Practice (currently having more than 100 professionals)
- Launch of EU BIM Competition for student and professionals
- A series of training activities (18 videos in total) targeting all stakeholders in the renovation market
- Survey about use of BIM for renovation projects.

During the project implementation it was agreed with Building Smart International[28]that its use case database will be used to document and communicate about BIM-SPEED use cases. This process is based on ISO 29481-1: 2016 (Building information models – Information delivery manual) and it ensures a common language and a uniform understanding of BIM applications (use cases) within the entire construction and real estate industry.

[28] https://ucm.buildingsmart.org

Using a template of Building Smart International, it is shown and described the use of BIM tools to achieve specific goals and solve problems during renovation stage.

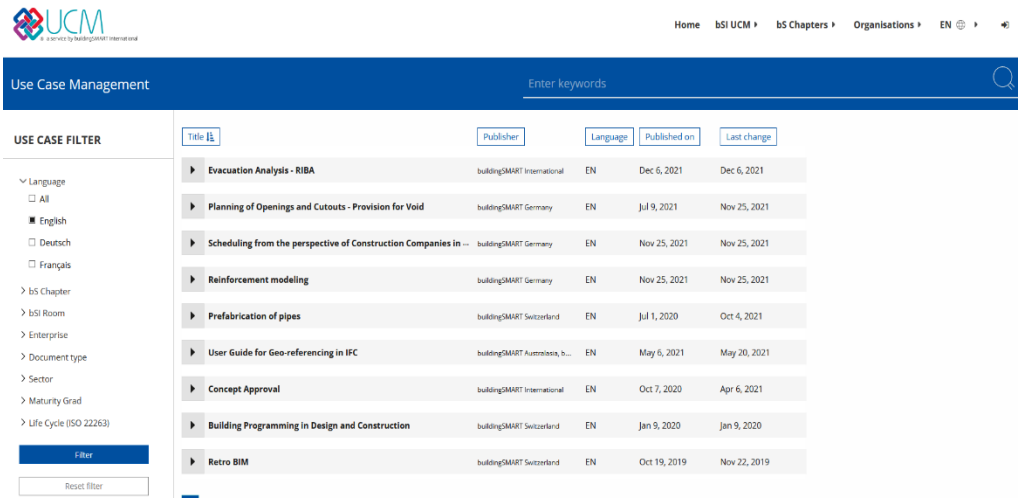


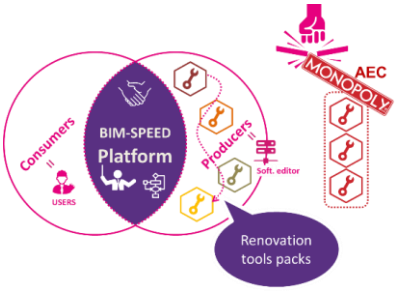
Figure 8 – Example of BIM-SPEED use case on Building Smart International

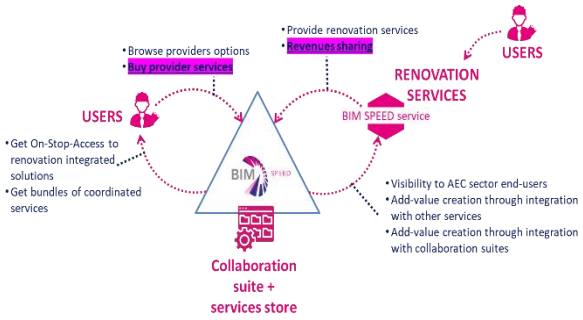
Task 8.4 aims to crystalise the achievements of BIM-SPEED project and present best lessons learnt how developed tools can contribute to renovation. For this purpose, the next sub-chapter (4.2) will present in more details chosen promising tools, impact of use cases and how their proposed approach differs from traditional one.

The following use cases will be presented and their impact summarised:

- BIM-SPEED platform
- Crowd Data Collection_Inhabitants'app
- 3D Modeling of Existing Asset Based on Point Clouds (Scan2BIM)
- BIM to BEM process – CYPETHERM Procedure
- VR Safety Training

4.2. Best practises and lessons learnt

BIM-SPEED Platform	
Description of the potential	In construction and renovation sector, the stakeholders are expecting easy to use tools to collaborate and manage projects. The BIM-SPEED platform composes an easy-to-use Common Document Environment (CDE) and collaboration platform which can be extended with renovation related-services integrated in a one-stop-access platform. Furthermore, it is easy to opt-in and opt-out from the different renovation services proposed by the platform using a software as services model and a monthly invoicing based on actual consummation for services.  Figure 9 - Visualisation of BIM-SPEED platform
Impact of the use-case	BIM-SPEED proposes is a working collaboration platform that integrates renovation services from different vendors of the BIM-SPEED consortium. The impacts of BIM-SPEED platform are: • *for Customer* ➢ Have a one stop access platform for renovation: An integrated platform with simple collaboration suite and sets of predefined renovation services packs. ➢ Access to renovation service packs is proposed so that renovation use cases are easier to achieve using different vendors tools ➢ Have integrated financing plans with access to several services from different vendors providing easy monthly opt-in /opt-out ➢ Enjoy a non-locking technical solution • *For software vendors* ➢ Get Visibility to AEC sector end-users via the one stop access platform ➢ Leverage BIM-SPEED platform users ➢ Create value through integration with other vendor services ➢ Achieve greater value through integration with internal collaboration suite: user management, file management features are provided, the vendor can concentrate on specific business matters

	 Figure 10 - Collaboration on BIM-SPEED Platform
Difference between traditional and BIM-SPEED proposed approach	In practice construction stakeholders collaborating on renovation projects have yet to take advantage of integrated IT services. And if the opportunity arises, the preferred option is to buy single vendor tools suites that are expensive and lead to a vendor lock in for customers.

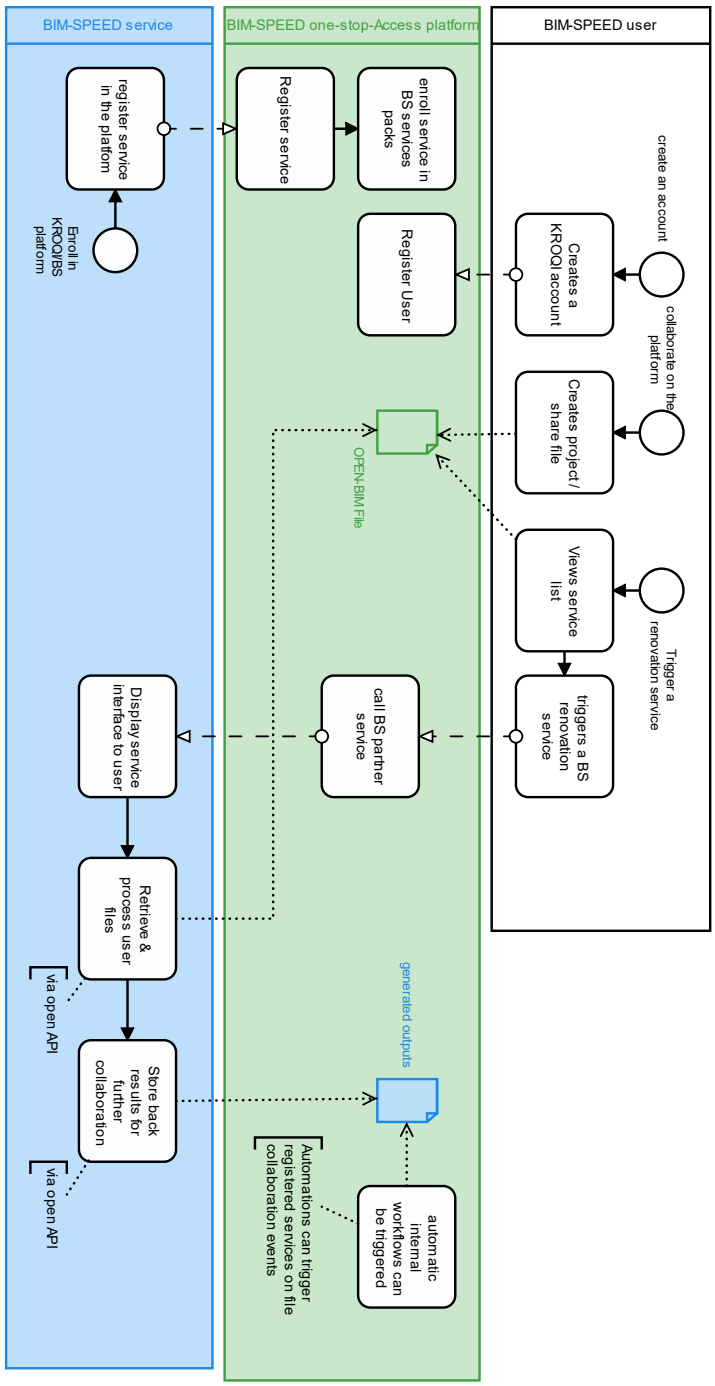
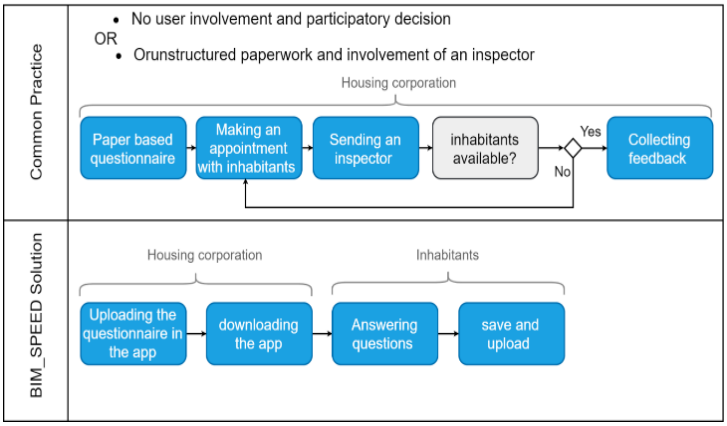
Workflow showing interoperability to achieve the use-case (if applicable)	

Figure 11 - Workflow of interoperability of BIM-SPEED Platform

Crowd Data Collection_Inhabitants'app	
Description of the potential	To propose and develop optimized renovation solutions, a good understanding of the as-is situation of a building as well as the needs and requirements of the prospective inhabitants is required. Inhabitants' inputs are crucial to complement a set of analyses and simulation results, particularly concerning comfort. In this respect, a user-friendly application is developed to collect such input from inhabitants. This has been achieved by firstly identifying the cases that require inhabitants' inputs for further analyses, simulations, validations, or calibrations. After the identification of relevant cases, a set of questions has been gathered and implemented in a user-friendly app taking privacy and data protection protocols into consideration. The main use case of developing this app is to optimize and digitize the process of data collection and data analysis from the inhabitants.
Impact of the use-case	The main potential impacts are: • Reduce the cost by outsourcing part of the inspection activities to the inhabitants. • Involve the end-users in the process of decision-making by collecting their needs and preferences. • Streamline and standardize the process by uploading the results in a structured way in BIM-SPEED cloud platform.
Difference between traditional and BIM-SPEED proposed approach	The main differences can be summarized in terms of time and cost savings as well as the inclusion of inhabitants in the decision-making procedures. In the traditional approach, either inhabitants are not involved or the procedure to collect their feedback is done via an inspector and paper survey. The latter is a very time-consuming approach as it relies heavily on the availability of inhabitants. Moreover, the collected data is not digitized and so the data is not structured which makes any further analysis very challenging.  Figure 12 - Approach proposed by Inhabitants'app

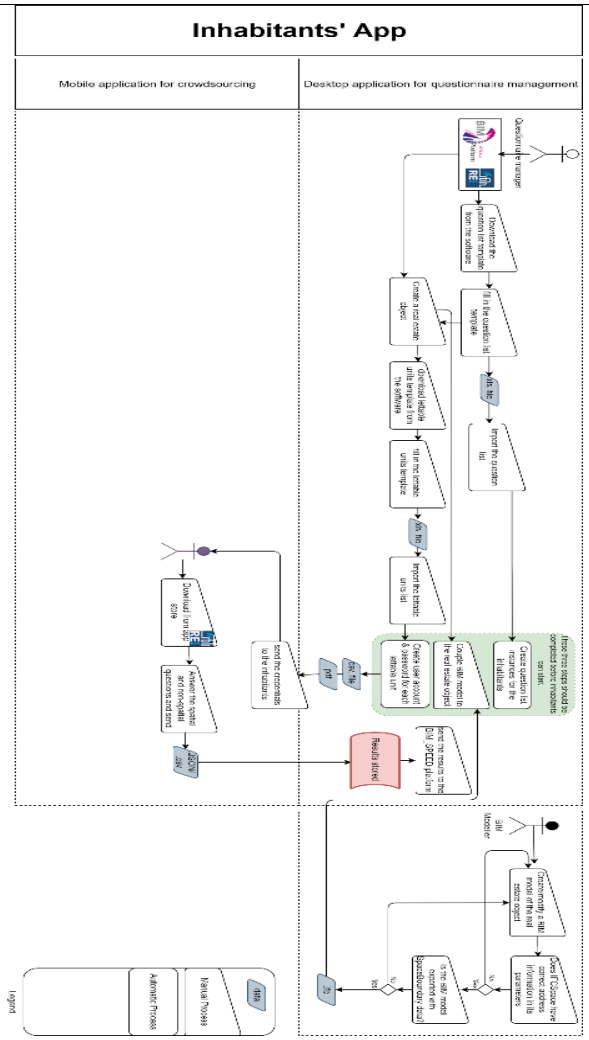
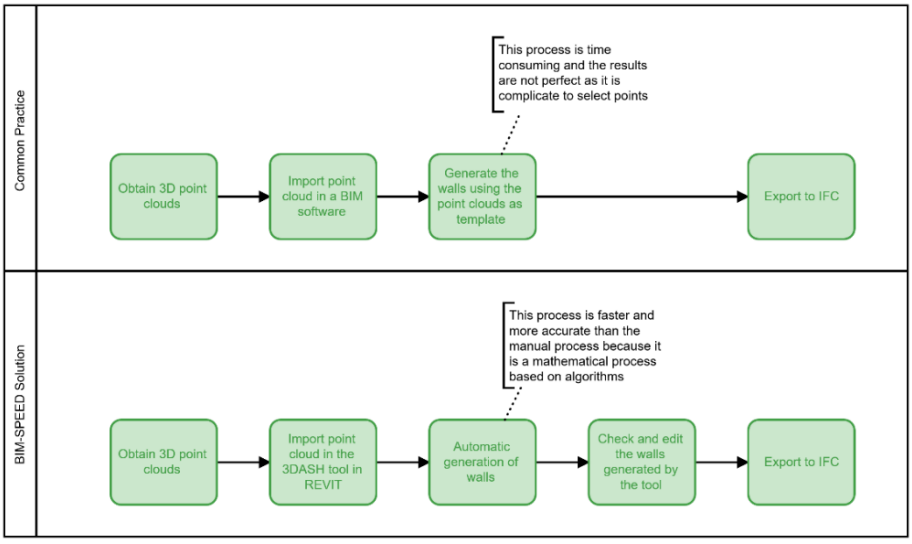
Workflow showing interoperability to achieve the use-case (if applicable)	

Figure 13 - Workflow of interoperability of Inhabitants'app

3D Modeling of Existing Asset Based on Point Clouds (Scan2BIM)	
Description of the potential	3DASH tool: Plug-in for REVIT which makes easier the generation of the building model in BIM using 3D point clouds as input.
Impact of the use-case	• -Time reduction in the generation of walls in BIM in a low Level of Development (LOD), LOD200, from point clouds. • -Accuracy in the generation of walls from point clouds due to the fact it is a mathematical process based on algorithms.
Difference between traditional and BIM-SPEED proposed approach	In the traditional way, the generation of the walls is a manual process using the point clouds as a template within a BIM software. This process is time consuming, and the results are not perfect due to the manual selection of the point clouds. In the BIM-SPEED approach, with the use of the 3DASH tool, this generation of walls using point clouds as input is an automatic process. After this automatic process, a manual process is required to check and edit the walls generated by the tool.  Figure 14 - Approach proposed by Scan2BIM tool
Workflow showing interoperability to achieve the use-case (if applicable)	This use case can be used directly from the BIM-SPEED platform by selecting the point clouds in the format required by the tool and launching the service to download the plug-in. The option to download directly from a web service without using the BIM-SPEED platform is also available.

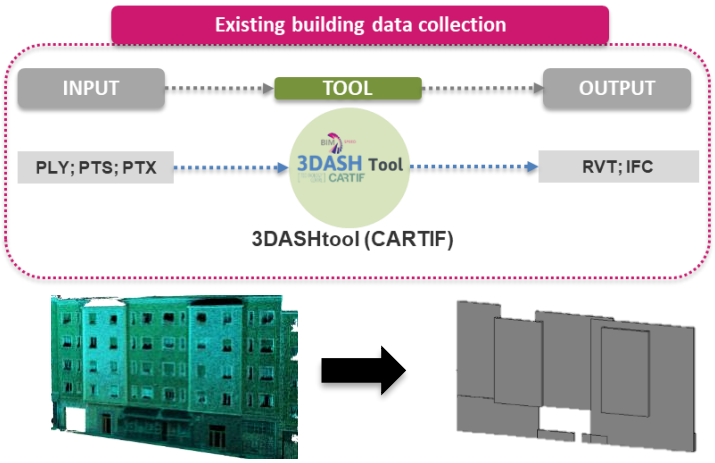
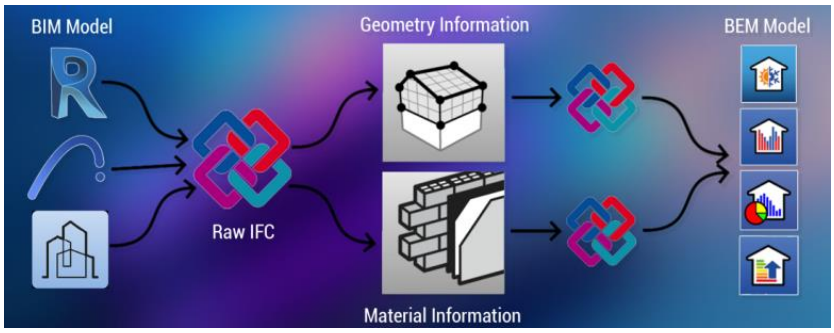
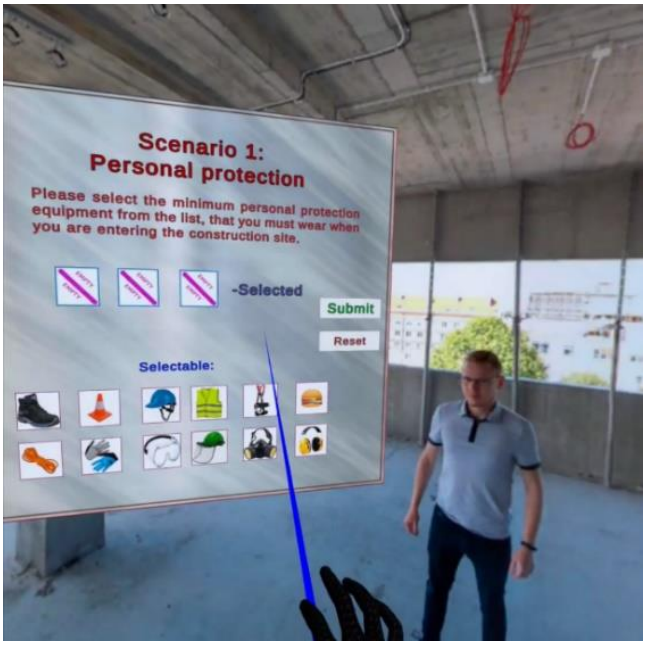


Figure 15 - Workflow of interoperability of Scan2BIM tool

BIM to BEM process – CYPETHERM Procedure	
Description of the potential	This work is a milestone in the development of BEM (a process that calculates how much energy building will consume once it is built) projects, since for the first time it will be possible to take advantage of the information from a BIM model to generate a functional BEM model not only automatically, but also in a synchronised manner. This means that any architectural/engineering project developed in BIM (of which there are more and more) will have all the facilities to add energy balance to the project's BIM uses. This will greatly facilitate the consideration of environmental energy parameters in any type of BIM project (both new projects and renovation projects) not only in the final phase of the project, but in an iterative way throughout its development, being able to use this information to choose more efficient and less polluting construction systems, energy systems or building design elements in terms of energy consumption.
Impact of the use-case	This solution democratizes access to energy criteria in project development. Since the tools developed incorporate internal calculation engines with a simple and intuitive interface, even an architect or engineer who is not an expert in the field of energy will be able to determine how much your building consumes in a few clicks. In short, the time required to produce a BEM model has been drastically reduced, fully automating the definition of the model from pre-existing information.
Difference between traditional and BIM-SPEED proposed approach	Before the availability of these tools, anyone who wanted to know the energy dimension of a BIM building was forced to model it almost entirely using specific precision tools, or else to settle for estimates and imprecise calculations whose results are neither significant nor relevant to the expected level of precision of an energy balance. In other words, any relevant analysis required the investment of many extra hours and the necessary collaboration of an expert energy team that was able to correctly model the building. This working system did not tolerate any kind of iteration and was usually done at the end of the design process with a mere justification for the regional regulations or requirements (e.g., for the issuance of an energy certificate for the building). There was also no guarantee that the energy model corresponded to the final state of the BIM model, as any changes to the BIM model would have to be reflected "manually" in the energy model.

Workflow showing interoperability to achieve the use-case (if applicable)	The "CYPETHERM procedure" provides a practical BIM-to-BEM workflow, to create BEM models starting from BIM models and using a suite of tools to bridge the gap between the BIM models and the BEM models. The workflow is defined below: 1. Create a new project on the BIMserver.center and upload the .ifc file/files of your project coming from any kind of BIM software 2. Automatically generate the analytical model of the building using Open BIM Analytical Model tool 3. Define the stratigraphy with all the relevant material thermal properties using Open BIM Construction System 4. Complete the BEM (operating schedules, HVAC system, thermal zones features, etc.) using CYPETHERM Eplus Any changes in the design of the project will be synchronized.  Figure 16 - Workflow of interoperability of CYPETHERM Procedure

VR Safety Training	
Description of the potential	VR safety training has the potential to be an integral part of every OSH manager's toolkit to increase workplace safety and decreasing accident rates.
Impact of the use-case	Training in a VR environment allows users to better retain the information they are being presented.
Difference between traditional and BIM-SPEED proposed approach	As opposed to a more traditional approach towards safety training, operating in a VR environment enables users to retain more information as they are able to interact with it itself.
Workflow showing interoperability to achieve the use-case (if applicable)	As part of BIM-SPEED, two safety training scenarios were envisioned, the first being personal protection equipment training, while the second is a scenario where there is an unsecured opening on the construction site. These two scenarios were then developed into VR tools operating on Oculus devices. A controller-free, hand gesture tracking solution was developed with the help of Solid Works. **Scenario 1:** The first scenario places the worker directly on the construction site via a 360 image. The worker must pass a short quiz, where they must choose the correct PPE that is required on the construction site. Within the frame, there is a worker visible, showing the before and after photos of them putting on the PPE.  Figure 17 - Image of VR Training

Scenario 2:

The second scenario places the worker in a dangerous situation, where there is an opening on the construction site that is unsecured, posing a risk to themselves, as well as to other workers. The scenario takes place within a virtual model of the building's construction site, which was extracted from the BIM model of the building. The worker is required to move around and interact with their environment, all while learning what should be done in such a scenario. For this scenario a custom virtual controller was developed allowing for hands-free gesturing.

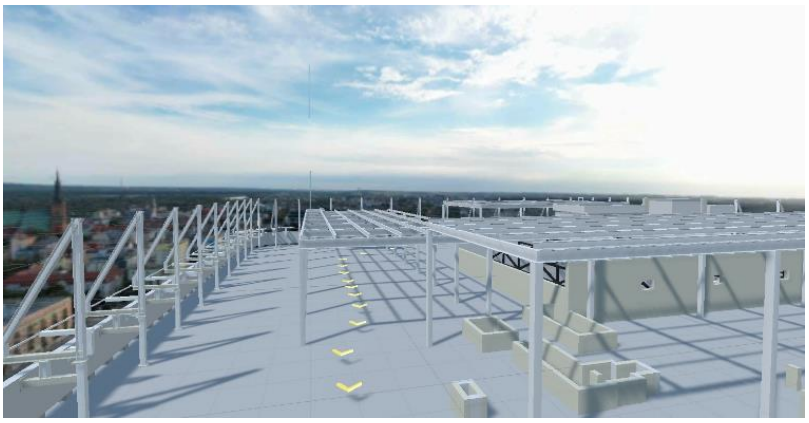


Figure 18 - Image of VR Training

5. Roadmap for accelerated market uptake

Market uptake could be defined as a process making technological developments available for public. In terms of the BIM-SPEED it could be explained as innovative actions and offered solutions that project, and its achievements bring to the stakeholders in the renovation process. This chapter presents the main steps of a roadmap to market uptake that could be considered crucial to ensure competitiveness, accessibility, innovation in the renovation process, attract investments, and guarantee project sustainability.

Market uptake strategy is also closely related to exploitation plan which is developed and presented in D9.3. (Exploitation plan, business plan, market uptake strategy). Its main results are briefly described below in subchapter 5.2.

5.1. Objectives and roadmap to the market uptake

Market uptake, together with exploitation and dissemination strategies of BIM-SPEED, are important for sustainability and efforts to maximise the impact of the project, involving all supply chain actors. Therefore, the objectives of the BIM-SPEED market uptake could be described as follows:

1. **Increase market share of usage of BIM in renovation process across the EU.** Throughout the project lifecycle, BIM-SPEED developed and tested a significant number of tools in renovation in demo cases. They showed that BIM could be a simple, efficient, useful, and easy to be applied.
2. **Deconstruct misconceptions of the digital technologies, including BIM.** The survey results show that a significant number of stakeholders still see BIM as expensive, too complex an available only for construction phase technology.
3. **Ensure the proper functioning and exploitation of the BIM-SPEED platform**, that offers an online working collaboration platform online that integrates renovation services from different Partners of the BIM-SPEED consortium.

The roadmap to accelerated market uptake of BIM could be divided in the following steps:

- **Improve the data and information sharing about existing building stock in the EU**. It is essential to have access to accurate data of the existing buildings to ensure their renovation processes. Comparing new constructions and renovations, the latter is still lagging behind due to various factors. BIM could be a perfect accelerator for information sharing and collaboration starting from an early design phase.
- **Upskilling of employees taking into account a high number of employees needed in the next decades to reach renovation goals set by the EU.** Digital skills are key for innovation, economic growth, and competitiveness.
- **Better legal requirements to apply BIM in renovation across the EU.** Legal requirements should be consistent with regards to regulatory framework in all Member States. From desk research we see that some countries require BIM in public procurement, but it should be required by EU and national law in more cases. It would accelerate application of BIM, would make the image of construction more attractive to young people; foster communication, and collaboration among different stakeholders and increase productivity.
- **Ensure continuous financial support to research and innovation of digitalization at the EU and national level.**

5.2. Main results of T9.4. – Exploitation plan, business plan, market uptake strategy

Task 8.4 has clear links to the deliverable **D9.3 "Exploitation plan, business plan, market uptake strategy**" developed in the context of task T9.4 led by EBC and ERA, the main results of which can be summarised as follows:

- Development of a detailed **BIM-SPEED Exploitation Plan**, under the lead of FASADA. This entailed the identification and analysis of all **BIM-SPEED Key Exploitable Results** (supplemented by the completion of dedicated **KERs Business Models Canvasses** (BMC) and **KERs Risk Matrices**, under the lead of ERA). Exploitation links were also identified with the **training material and activities** carried out in *T9.2 Training and Continuous Professional Development* and with the **technical publications** produced by the consortium. As a final step for the exploitation processes, an **Exploitation Strategy Seminar (ESS)** was organised, benefiting from the services and expert advice provided by the **Horizon Results Booster** - Module C. The ESS focused in particular on 3 selected BIM-SPEED KERs (*BIM-SPEED platform; 3DAHS - 3D Scan-to-BIM; Comfort Eye*) for which dedicated **HRB templates** (*characterisation table; risk assessment and priority map; exploitation roadmap; use options*) were previously compiled.
- Development of an innovative and plausible **BIM-SPEED Business Plan,** under the lead of ERA. To this end, in addition to preparatory activities such as the analysis of market opportunities and review of competitive landscapes, a series of **six internal exploitation workshops** were undertaken to gather consortium feedback on specific business considerations and elements. As a result, **a BIM-SPEED Business model** was created, including an overview of the BIM-SPEED platform, an analysis of value propositions, identification of cost and profit centres and an initial definition of pricing and licensing elements associated with the BIM-SPEED services.
- Finally, a **Market Uptake Strategy** was drawn up, thanks also to the constant **interchange with the T8.4 activities**, benefiting for example from the results of the T8.4 surveys on BIM adoption, the research on BIM guidelines and the analysis of BIM-SPEED project use cases and tools. The strategy included the drafting by ERA of **Sales and Customer Service Plans** for the market uptake of the BIM-SPEED platform and envisaged a possible **follow-up of the BIM-SPEED services within the KROQI platform** (which should be managed by a private company - a spin-off of CSTB).

6. Conclusions

This deliverable is divided in several parts that are interconnected among each other. First of all, a survey was launched which helped to evaluate the current state, use, awareness and application of BIM technologies in the EU. A year later a follow-up survey was conducted to see whether any significant changes could be observed and what obstacles stakeholders are facing while applying BIM in their work and how BIM-SPEED could contribute to any improvements.

The survey was followed by desk research of the EU and national guidelines. The aim of this exercise was to analyse the legal framework and challenges of BIM in renovation project. Analysis included different EU initiatives and legal acts, as well as examination of various EU countries (Belgium, Finland, France, Spain, Lithuania, Italy) to cover as much of the continent as possible, including West, Eastern and Scandinavian countries. The UK, widely considered as a pioneer and the most advanced country in applying BIM, was included in the analysis as well despite not being an EU Member State anymore. The conclusions of the exercise show some positive insights, initiatives taken by the EU to foster digitalization in the sector, more and more countries acknowledging advantages of BIM and requiring use of BIM to some extent. At the same, there is still space for improvement, like ensuring better financing (especially for SMEs), training more workers, implementing the use of BIM in more renovation projects.

Finally, this deliverable consolidated and presented the achievements of the demonstration cases showing what was learnt, what impact BIM-SPEED tools can have in order to accelerate market uptake and BIM application in renovation sector. Examples presented in Chapter 4 explained what BIM-SPEED tools could achieve – accuracy of the renovation projects, time saving, facilitation of the creation of the As-Built BIM models of the buildings, bridging the gap between the BIM models and the BEM models, increasing workplace safety, and decreasing accident rates, boost productivity and ensure better collaboration among stakeholders.

To ensure sustainability and the dissemination of knowledge, finalized deliverable will be shared with the members of the Advisory Board of the project. The Advisory Board consisted of experts from the industry and academia as well as from standardisation bodies in the EU. The members of AB are in the best position to exploit and raise the discussions about the task results. The umbrella organisations will also promote the results through their channels on social media and their network of members.

This task was undertaken by the of four umbrella organisations in the consortium (EBC, ACE, REHVA and FIEC) as well as other partners who contributed to the results and implementation of the deliverable.