BIM SPEED

Guidelines for BIM-based procurement, collaboration protocols and IPD for renovation projects

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

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Guidelines for BIM-based procurement, collaboration protocols and IPD for renovation projects

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Main author	Josephine Cooke; Richard Sichter
Co-authors	Larissa de Rosso (ACE); Piotr Dymarski (MOW); Jos Noordzij (DEMO); Jerson Alexis Pinzon Amorocho (TUB); Eugenio Quintieri (EBC); Fernando Sigchos Jiménez (EBC); Spyridon Pantelis (RHEVA); Roberta Stankeviciute (FIEC); Paul Stupin (PB40)
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Executive Summary

Common BIM guides usually focus on describing the BIM method in general and its implications for new building projects in different variations. In contrast the "Guidelines for BIM-based procurement, collaboration protocols and IPD for renovation projects" present the current body of knowledge regarding BIM, collaboration protocols, and Integrated Project Delivery (IPD) with a focus on renovation projects in a structured and applicable form. Public officials dealing with procurement issues, SMEs performing renovations, and policy makers, who define the legal conditions for the application of BIM form the key audience for these guidelines. They are designed to achieve three main objectives: 1) educate on all relevant related theoretical and practical basic concepts and legal aspects, 2) provide advice to foster BIM market uptake and 3) formulate reasonable practical steps for the application in real word renovation projects and present an overview on references for further reading.

The elaboration of the guideline was approached by firstly an extensive literature research on status quo of the market and research regarding the topics. Secondly, the identification and assessment of relevant principles and issues to be followed. In addition, practical expertise from bodies of practice was included by holding interviews, workshops, and questionnaires. The team consisted of organizations from research (TUB), practical experience (DMO, MWO), umbrella organisations (ACE, RHEVA, FIEC, EBC) and as task leader an initiative founded by various German construction stakeholders (PB40). How the guidelines apply within specific construction projects are exemplarily explained using two demonstration cases – one Polish and one Spanish renovation project.

The guideline is divided into three main parts following the introduction. Chapter 2 fulfils objective 1) and gives information on procurement procedures, public procurement legislation in the EU and selected EU member states. Also, principles on BIM-based collaboration protocols and use cases for renovation are touched along with methods of using these documents in procurement processes. IPD is being introduced and basic principles explained. Chapter 3 relates to objective 2) by giving advice and practical guidelines and also possible solutions. Objective 3) is clarified by chapter 4 which provides a case study of a BIM-SPEED renovation demo project as well as by the appendixes (1 to 5) with collections of e. g. templates of protocols.

List of acronyms and abbreviations

AEC	Architecture, Engineering and Construction
AIR	Asset Information Requirement
BEP	BIM Execution Plan
BIM	Building Information Modeling
BIM-SPEED	Harmonised Building Information Speedway for Energy-Efficient Renovation
BIR	Bouw Informatie Raad. Dutch Building Information Council
BOT	Build Operate Transfer
CEN	Comité Européen de Normalisation
CM	Construction Management
DB	Design Build
DBB	Design Bid Build
DBM	Design Build Maintain
DBFMO	Design Build Finance Maintain Operate
DBMO	Design Build Maintain Operate
DOA	Description of Action
EeB	Energy-efficient Building
EIR	Employer's Information Requirement
GDP	Gross Domestic Product
HES	Higher Education School
IDS	Information Delivery Specification
IND	Industry
IPD	Integrated Project Delivery
SME	Small and Medium sized Enterprise
OIR	Organization Information Requirement
PFI	Public Finance Initiative
PIR	Project Information Requirement
PPP	Public Private Partnership

List of contributors abbreviations, country and type

ACE	Conseil des Architects d'Europe, EU, Non-Profit
DEMO	DEMO Consultants B.V., NL, SME
EBC	European Builders Confederation, EU, Non-Profit
FIEC	Fédération de Industrie Européene de Construction, EU, Non-Profit
MOW	Mostostal Warszawa S.A., PL, IND
PB40	Planen-bauen 4.0 Gesellschaft zur Digitalisierung des Planens, Bauens und Betreibens mbH, DE, SME
RHEVA	Federation of European Heating, Ventilation and Air Conditioning Associations, EU, Non-Profit
TUB	Technische Universität Berlin, DE, HES

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1. Introduction

1.1 Description of deliverable content and purpose

The BIM-Speed Project is an EU-funded research project aiming to enable the use of BIM for renovation projects through the development of an interoperable BIM platform, suitable BIM tools for renovation means and accompanying standards, procedures and templates to unlock notable time and budget savings. A key part of the project is the inclusion of feedback in the work results by constant interaction with demo cases in which concepts are tested in real world environment and the discussion of preliminary results with interested audiences, such as professional bodies.

As part of the overall BIM-SPEED project aims, the partner organizations sought to develop guidelines for how to best deal with procurement related issues on a practical and daily basis. These guidelines are targeted towards EU member state public officials as well as practitioners who would like to introduce new digital means to renovation projects. The guidelines provide strategies, procedures, and advice on BIM in renovation touching on the mediation of key concepts (BIM procurement and collaboration, IPD), information on current legal frameworks, implementation strategies and examples in the form of recorded demo case experiences.

The purpose of this guide is shaped by distinct developments such as the need for renovation of large parts of the existing building stock, time and budget constraints and an AEC industry which is characterized by micro, small and medium enterprises (SMEs) and rising demands for energy efficient buildings. Digitization and BIM in particular promise to enable cheaper and faster renovation. Although renovation in current building stock and energy renovation plays a large role in the AEC industry, so far BIM research and development focused on new building projects. Moreover, SMEs have experienced difficulties to implement BIM technologies because of various factors such as high investment in new technologies and the need to train staff.

This guideline takes the stated issues into account and focuses on the implementation of BIM for renovation projects and recommends solutions, which allow SMEs to adapt to technology and organizational changes that come with the application of BIM.

The scope of the present guideline is limited to topics of BIM-based public procurement, collaboration protocols and IPD and does not expand for example to technical aspects and foundations of BIM or the benefits of using BIM in general.

1.2 Target group

This guide seeks to educate stakeholders which play a key role as an intermediate for introducing concepts of BIM and project delivery methods such as IPD into the context of renovation projects within the AEC industry in EU member states. Such stakeholders include on the demand side public sector officials dealing with procurement, as well as building owners and on the supply-side architects, engineers, consultants and constructors. Strategies and protocols presented consider the status quo of the SME dominated AEC industry and the traditional separation into a planning and execution phase. The interested audience can find an overview giving advice on what part of the guidelines might be of importance for whom depending on their interest in table 1.

Table 1: Instructions for readers

Reader	interested in		recommended chapter
Public sector/ Building owner	knowledge and basic principles	public procurement	2.1
		collaboration protocols of BIM based renovation	2.2
		IPD	2.3
	recommendations for facing issues		3 and 4, appendix
	BIM based renovation project examples		4
Designer, architects, engineers; Construction teams; SMES	knowledge and basic principles	public procurement	2.1
		collaboration protocols of BIM based renovation	2.2
		IPD	2.3
	recommendations for facing issues		3 and 4, appendix
	BIM based renovation project examples		4
EU commissioner			all

1.3 Approach

The approach of this report focused on subsequent tasks such as discover, capture, score, structure and describe specific knowledge on BIM in renovation, procurement strategies, renovation, and project delivery methods such as IPD. Additional to an extensive literature review three bodies of experts have been consulted: BIM-Speed projects consortium partners, professional bodies and institutions and demo cases – all experienced in related topics. The consortium consisted of a team of organizations with complementing backgrounds: planen-bauen 4.0 GmbH (PB40), founded and funded by major public clients and construction companies in Germany (as task leader), research-based Technical University Berlin (TUB), construction experience-based Demo Consultants B.V. (DEMO) and Mostostal Warszawa S.A. (MOW) as well as European umbrella organizations representing architects, HVAC engineers and construction firms

across Europe: Architects Council of Europe (ACE), Federation of European Heating, Ventilation and Air Conditioning Associations (REHVA), Fédération de Industrie Européene de la Construction (FIEC) and European Builders Confederation (EBC). The knowledge of the partners have been brought together by the conduct of interviews, organization of workshops and development of questionnaires to collaboratively involve all stakeholders. See figure 1 for a better understanding of the task's roadmap. The overall aim was to achieve a product, that gives guidance on BIM procurement for renovation projects covering strategies, protocols, and project delivery methods such as IPD for a semi-informed professional audience.

Figure 1: Roadmap Guidelines (Source: PB40)

1.4 Relations to other tasks

Within the BIM-Speed project the preparation of the guidelines at hand have prospered due to the link to other tasks, which contributed to its content through the following topics. For the reader interested in further BIM-SPEED research and results, the following tools or documents provide relations, follow-ups or complements to the here presented topics.

Task 2.1 Feasibility and Scope Definition of BIM for renovation projects (DOA, p.41)

"This deliverable presents a set of guidelines for BIM implementation in renovation projects taking into account the building typologies, scale of renovation, stakeholders, formal BIM requirements from the (local) authorities, etc. The guidelines will be presented integrated with an online questionnaire for feasibility/BIM maturity assessment at the initiation stage of renovation. "

Task 5.1 Cooperation with standardisation bodies (DOA, p. 47)

"This deliverable presents a report of the cooperation with standardisation bodies, consolidated recommendations for implementation of the latest BIM standards in EEB renovation projects, and proposed improvements. The updated drafts of this deliverable will be published yearly and socialised through the network of experts actively involved in standardisation bodies. "

Task 7.5 BIM Execution Plan, documentation, work coordination, health and safety (DOA, p. 54)

"This deliverable will describe a generic execution plan of BIM-based housing renovation projects. The deliverable consists of 2 main parts: the first part addressing procurement and Integrated Project Delivery (lead developer: PB40); and the second part focusing on operational coordination between the design and construction actors, including Health, Safety and Environment management during renovation for the construction workers and inhabitants (lead developer: MOW). "

Task 8.4 Best Practices and Benchmarking (DOA, p. 57)

"This deliverable consists of three parts: Part 1 – Practical implementation guidelines of BIM for EEB renovation projects for real estate clients, architects, HVAC firms, and construction firms; Part 2 – Best practices of renovation of residential buildings in Europe; and Part 3 – Roadmap for accelerated market uptake in all disciplines at national and EU level. The updated drafts of this deliverable will be published yearly for review by with the Community of Practice and Advisory Board. "

Table 2 gives an overview on contributions to this document via the described tasks.

Table 2: Overview contributions

Task	Contribution
T2.1 Feasibility and scope definition of BIM for renovation projects	- Understanding of typical barriers for getting usable information (data) in renovation projects - Relation between information at hand and feasible use cases - Basis for understanding of different building typologies and scale and types of renovation projects
T5.1 Cooperation with standardisation bodies	- Understanding of typical relevant standards for both BIM and renovation - Identification of renovation specific issues regarding standardization

T7.5 BIM Execution Plan, documentation, work coordination, health and safety	- Draft of standardized BEP for renovation - Owners' requirements for deep renovation projects and implications for BEP - Special issues for renovation projects in comparison to new building projects which have to be mirrored in BEPs - Different stakeholder perspectives (e. g. inhabitants, SMEs etc.) - Basic understanding for procurement and Integrated Project Delivery for renovation
T8.4 Best practices and benchmarking	- Understanding of BIM maturity levels and dissemination of skills e. g. across SMEs performing renovation

2. BIM-Based Procurement, Renovation and IPD – Basic Concepts and Legal Aspects

2.1 Public procurement

The digitization of the construction sector is currently in full progress and therefore many hurdles must be overcome. Compared to other industries like automotive, construction is least digitally developed and has experienced poor increase in efficiency and productivity over the last decades. Both sides – public and private stakeholders – are involved in implementing digitization, but it is widely acknowledged that public procurement enables a key entrance door for digital tools in the construction sector because of its wide range. Within the European Union, public procurement purchases for work, goods or services accounts for 14% of the GDP as of 2019[1]. Consequently, contracting authorities have a high influence on the economy regarding innovation, efficiency and quality of products. Also, changes and improvements in public procurement processes have a high impact on e. g. cost and bear great potential for savings. It is therefore crucial that public procurement seizes the opportunities created by the digitization shift by implementing for instance BIM. This method improves various performance indicators[2] for example award criteria, cooperative procurement, decision speed, involvement of SME contractors. In this context the implementation of alternative project delivery methods such as IPD creates even more value.

Especially when facing the renovation wave that Europe's building stock is dealing with the importance of increasing efficiency becomes clear. Since 90% of existing buildings were built before 1990 and the market share for renovation has overtaken that of new construction[3], renovating plays a major role in the economy. Furthermore, there is a special need for SMEs as the design and construction sector and in particular the renovation domain is mainly comprised of SMEs. Public clients are in a unique position to involve SMEs and facilitate their adoption of BIM by initiating BIM at an appropriate scale early in the project. This ensures that contracting authorities make use of their influence on project efficiency by demanding and describing BIM services via contracts.

Since lack of knowledge and experience, as well as legal implications seem to be the main hindrances, the following chapters attempt to shed light on these matters in addition to providing practical guidance.

[1] https://ec.europa.eu/internal_market/scoreboard/performance_per_policy_area/public_procurement/index_en.htm (last viewed: 30.09.2021)
[2] https://ec.europa.eu/internal_market/scoreboard/performance_per_policy_area/public_procurement/index_en.htm (last viewed: 30.09.2021)
[3] European Parliament (2016)

2.1.1 Procurement methods in construction

There are different project delivery methods that vary according to the degree of interaction, workflow structure, and other aspects. Figure 2 presents the categorization of the US Construction Industry Institute for four common project delivery methods including IPD. They can be described as follows[4]:

- Design-Bid-Build (DBB) is often referred to in the literature as the 'traditional' project delivery method. In this type of project, the contracted parties, the designer (the architect) and the general contractor become involved sequentially, one after the other. First the owner contracts a designer, who develops the project specifications; these project specifications are then used to contract the general contractor.
- In Construction Management at-Risk (CM at risk), the owner has one contract with the designer and a separate agreement with the construction manager (sometimes referred to as general contractor), but the construction manager becomes involved earlier, during the design phase, acting first as the design advisor and later as the construction manager. The construction manager offers at the end of design phase a guaranteed maximum price for the construction works.
- In Design-Build (DB), the owner has a single contract with one entity, a single company or consortium which provides both the design and construction services that are required. In this method, the designer and the general contractor become involved in the project at the same time.
- In IPD, the owner also has a single contract. However, this contract is not with just one company, but is a multiparty agreement which defines the mechanism(s) for distributing responsibility between the parties involved. As in Design-Build, the designer and the general contractor become involved at the same time in the project.

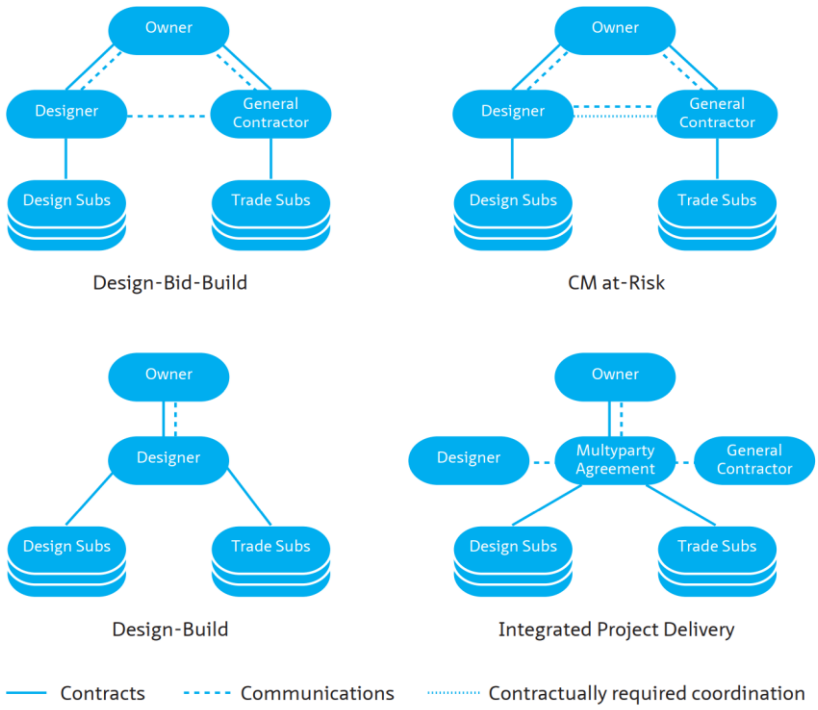

Figure 2: Project delivery methods: Contracts and communications. (Source: Salcedo (2015))

[4] Salcedo (2015)

In Europe the public sector may play a more relevant role in the context of building renovation projects, which make the financial aspect of the contract a key element of the project delivery method. In this context, other strategies such as Design-Build-Maintain (DBM), Design-Build-Maintain-Operate (DBMO), Design-Build-Finance-Maintain Operate (DBFMO), Build-Operate-Transfer (BOT), private finance initiative (PFI) or public-private partnership (PPP) can be considered. If we disregard the finance source, we could gather DBM, DBMO, DBFMO, BOT, PFI and PPP in the same category: Design-Build-Maintain project delivery method.

- In DBM the owner has a single contract with one entity, a single company or consortium which provides the design, construction and maintenance/operation services that are required.[4]

The level of integration of each of the methods can be understood through the degree of interaction between the stakeholders and the shared responsibility between them. Figure 3 presents these characteristics for the five project delivery methods described previously. The IPD method is the one with the highest level of shared responsibility since it includes well-defined and clear mechanisms and procedures to establish profits and losses.

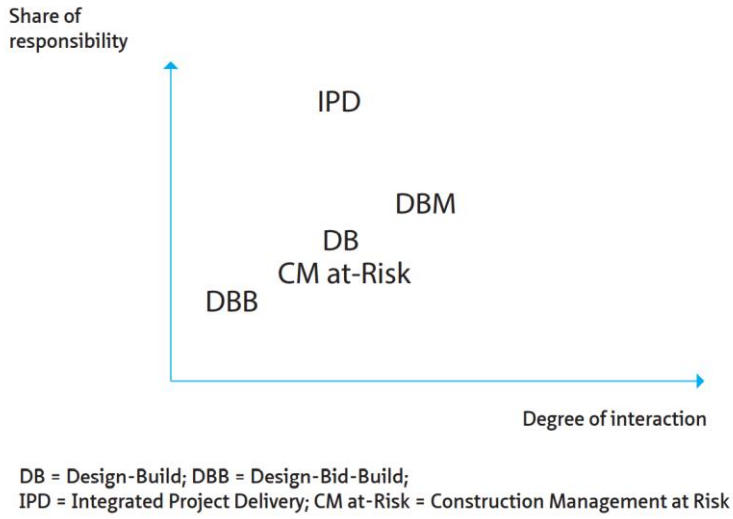

Figure 3: Level of integration of different project delivery methods (Source: Salcedo (2015))

2.1.2 Legal aspects of BIM-based public procurement

EU level

Laws and regulatory framework

As already stated in chapter 2.1, public procurement is an important driver in the design and construction industry sector and regulations on the topic have a high impact in the sector.

In 2014, the European Parliament approved the 2014/24/EU directive that regulates the public procurement in Europe to promote competitiveness in the internal market and ensure that public authorities purchase the highest quality at the best price respecting the principles of a transparent and equal treatment. This Directive also establishes the need to use software (for instance, media data, tools to model the building) in processes such as contracting construction work, services, and supplies. [5]

The directive establishes six types of procurement procedures, the open, the restricted, the competitive negotiated, the competitive dialogue, the innovation, and the design contest procedure.[6]

- The open procedure allows anyone to submit a full tender.
- The Restricted procedure allows anyone to participate but only selected providers can submit the tender.
- The Competitive negotiated procedure allows anyone to participate but only selected providers will be able to submit the initial tender and to negotiate.
- The Competitive dialogue allows anyone to participate but only selected providers will participate in the dialogue to propose a method to address a specific need.
- The innovation partnership allows the public authority to purchase something that is not yet available in the market.
- The Design contest allows public authorities to gather design ideas for a specific project. [7]

The Directive is applied for contracts above a certain threshold. For construction contracts the threshold is 5.350.000 euros and design contests 139.000 euros.[8] Any procurement above these limits should be published in the Tender Electronic Daily (TED) online portal. Contracts below these thresholds are under the national laws for public procurements.

This directive is an effort to simplify and make the public procedure more flexible to facilitate the access of SMEs into the European Market by promoting the free movement of goods and services. The directive aims to make the procedure more efficient by recommending and adopting digital means to support the public procurement.

[5] https://ec.europa.eu/growth/single-market/public-procurement_en
[6] https://europa.eu/youreurope/business/selling-in-eu/public-contracts/public-tendering-rules/index_en.htm
[7] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014L0024
[8] https://ec.europa.eu/growth/single-market/public-procurement/rules-implementation/thresholds_en

The eProcurement implementation is undergoing a process at European level. Since 2014, several actions were implemented towards the full digitalization of the procurement process, such as the creation of the eCertis to facilitate the certificates checks, and the eInvoicing, see figure 5. The integrated database facilitates business to participate in the procurement process.

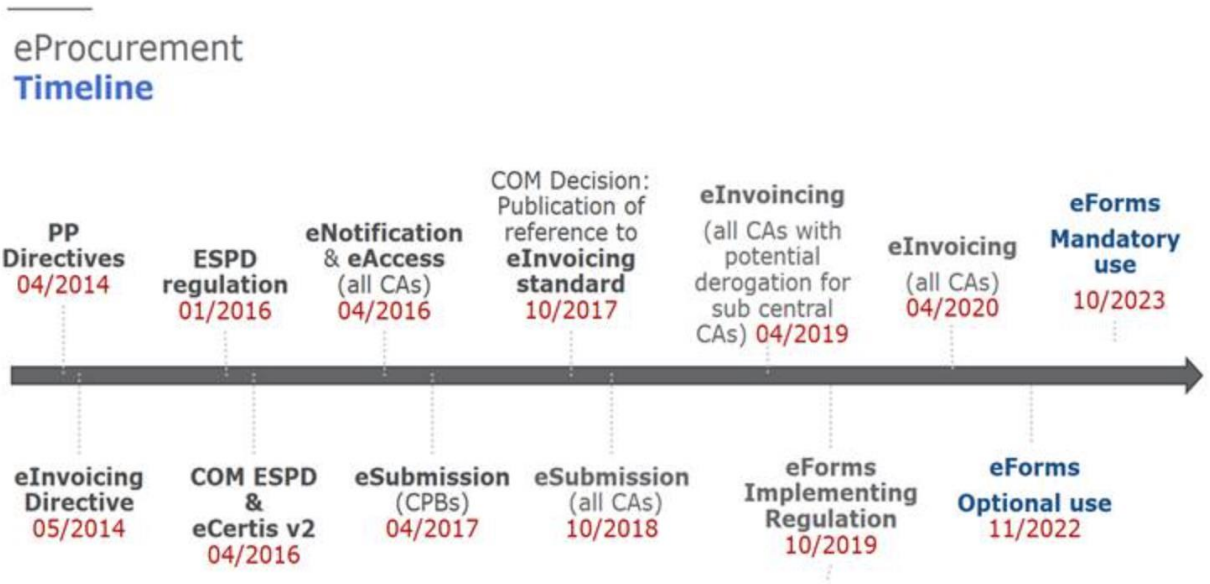

Figure 4: eProcurement timeline (Source: European Commission, Digital Procurement)

As part of the digitization effort, the use of BIM is also mentioned in the directive. The Article 22 paragraph 4 states that Building Information Modelling may be required for public works contracts and design contests, but authorities should generally make available the means to achieve that and should guarantee the interoperability of the tools to keep a fair and non-discriminatory process. However, there is a high effort to digitalize the procurement process and consideration on the use of BIM has been made, the directive still does not address specific details of design and construction procurement processes nor the legal challenges of BIM such as information copyright, ownership, liabilities, level of information.

These challenges are being addressed at national level, mostly by countries that have already implemented a BIM mandate, such as the UK, Netherland, Denmark, Estonia, Finland, Sweden, and Norway which is depicted in figure 5. It distinguishes between countries which have mandates, planned, will be planning or not yet planned.

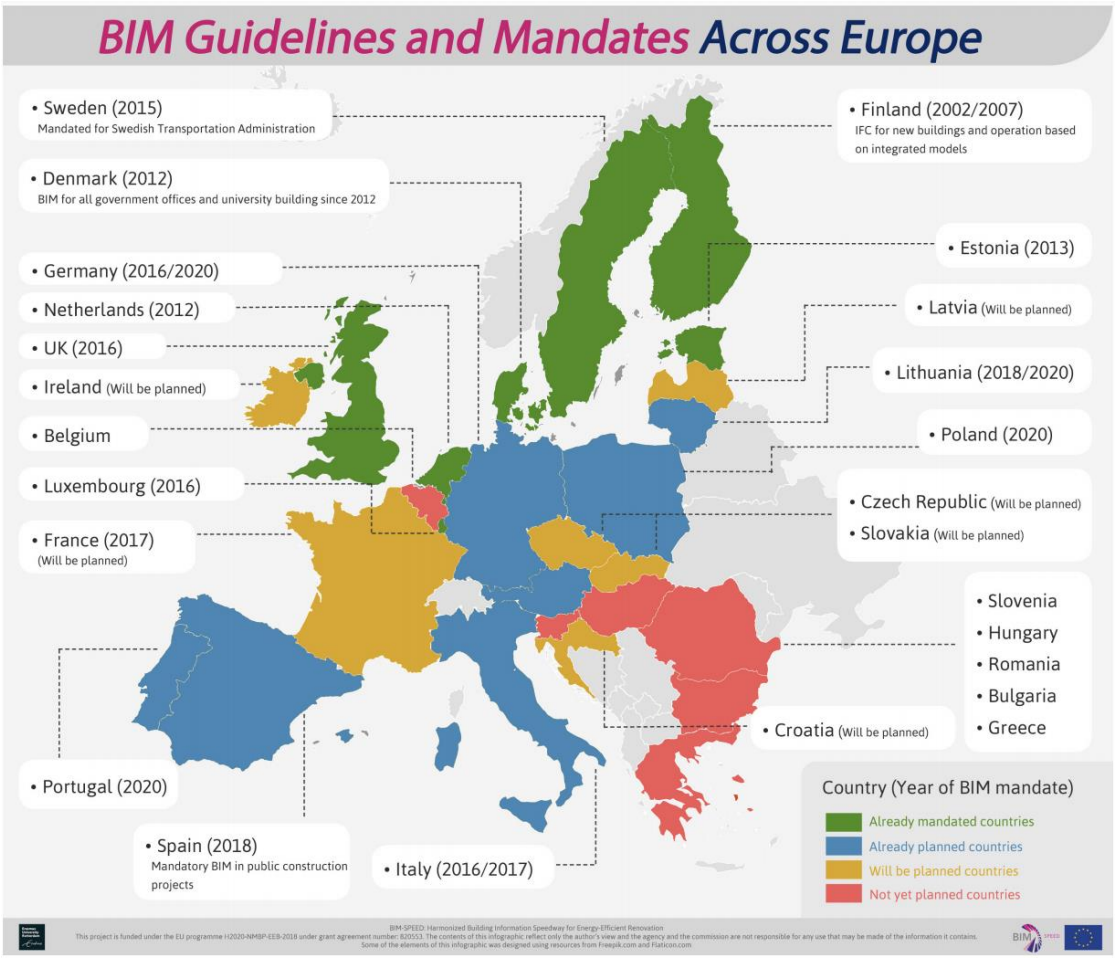

Figure 5: BIM guidelines and mandates across Europe (Source: BIM-SPEED (2019))

Industry standards and codes

EU wide industry standards and codes concerning BIM facilitate its use and ensure e. g. uniform understanding of specific terms. The most well-known standard is EN ISO 19650 series "Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) — Information management using building information modelling". It describes a normative framework of BIM considering the entire lifecycle of an asset. Concerning renovation there are also several standards, for example EN ISO 7518 or ISO 20887 but so far there is no standard specifically addressing BIM-based renovation.

The APPENDIX 4 – Overview of standards provides a helpful overview of existing and developing BIM standards categorized by topic.

National levels

For the sake of this guideline a selection of European countries and the status quo on procurement and BIM developments have been analysed. These countries are

- Germany
- Netherlands
- Spain
- Italy
- Lithuania
- Poland
- Hungary

The national details can be found in appendix 5. There, a set of key questions is presented regarding BIM-based procurement and BIM developments in general and answered for the different countries. At this point, a brief summary of the presented countries is given. In most of the countries BIM is not mandatory for public projects. An exception to this is Lithuania, which demands BIM in certain types of public projects. The range of support (e.g. publicly available templates) on procuring BIM services varies widely. Each country has implemented the above-mentioned EU directive of 2014. In most countries, national contractual BIM documents are not widely adopted and sometimes not existent. The Netherlands stands out as the most BIM-developed country and national templates on for example the BEP are commonly in use.

2.2 Collaboration protocols of BIM-based renovation

Using BIM methodologies requires a new manner of documenting the processes and services. When applied correctly, collaboration between interdisciplinary teams and an efficient project execution must be secured. Within any BIM project Employer's Information Requirements (EIR), a BIM Execution Plan (BEP) and a BIM protocol (or addendum) are essential as they contain specifications for the application of the BIM method. They supplement the contractual provisions for the execution of planning services with BIM and are henceforth addressed as *BIM collaboration protocols*.

Figure 6 provides an overview of the different documents together with other general project documents (contract, work description, project manual), project-specific BIM collaboration protocols (EIR, BEP, BIM protocol) and project-neutral BIM documents (templates for: e.g. EIR, BEP, use cases, etc.). These documents and especially the project-specific ones can have various positions in the hierarchy of contractual documents depending on project and stakeholder.

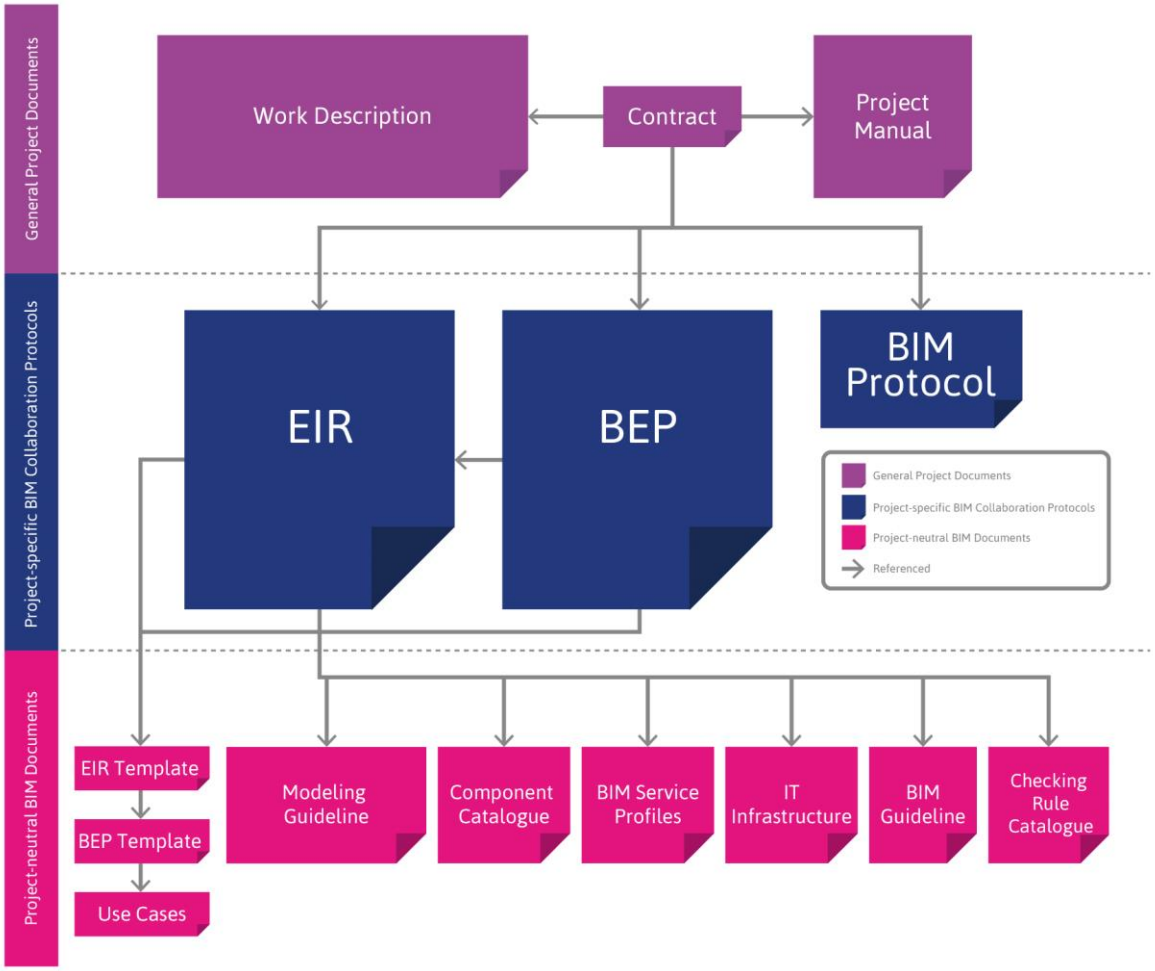

Figure 6: Overview project documents (Source: PB40)

Chapter 2.2.1 introduces EIR, BEP and BIM protocol by explaining what they contain and shows different possible forms of their use in award processes.

A list of links to templates of EIR, BEP and BIM protocols of different countries can be found in Appendix 2.

Chapter 2.2.2 explains about the importance of defining use cases and highlights several ones for BIM-based renovation.

2.2.1 Definition of information requirements

Within any BIM project there is a need for defining information requirements to set goals, liabilities, risk allocation, early warning, etc. There are different types of information requirements which fulfil different purposes. ISO 19650-1 has defined the following:

- Organizational Information Requirements (OIR): defines the organization's objectives and needs
- Project Information Requirements (PIR): defines all required assets, their management and maintenance
- Asset Information Requirements (AIR): defines the asset information to be delivered for each project milestones
- Exchange Information Requirements (EIR): defines the information that must be delivered during information exchanges

Figure 7 depicts the relationships between these requirements. It also shows the information deliverables OIR, PIR and AIR which are not being discussed further in this guideline.

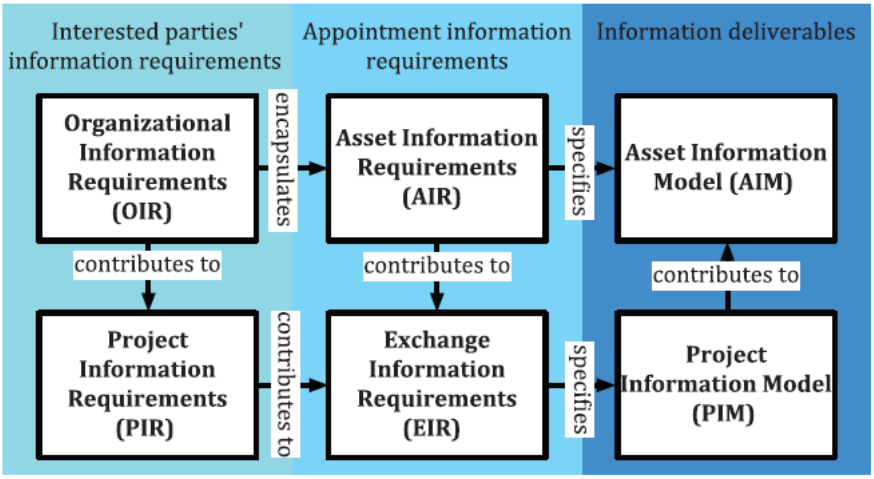

Figure 7: Relationship OIR, AIR, EIR, PIR, AIM and PIM (Source: ISO 19650-1)

The OIR, PIR and AIR contribute to the EIR which is an essential document for successful procurement. Although ISO has introduced EIR as Exchange Information Requirements, it is also referred to as Employer's Information Requirements in practice. Both terms have identical meanings. Besides EIR, the BIM

Execution Plan (BEP) plays a very important role in protocolling BIM tasks throughout and beyond procurement.
In general, the EIR defines what must be delivered whereas the BEP defines how this is delivered. A BIM protocol can be used to set BEP and EIR into a legal order and protocol liabilities.

Employer's Information Requirements (EIR)

The prerequisite for commissioning BIM-services is a sufficient definition of information requirements, considering the creation, processing, and managing of information, in alignment with the employer's organizational goals and project specific constraints as stated in the requirements documents above. Therefore, the employer first must define their organizational and project specific goals. The EIR then is used in the tendering process for bidders to respond to the tender.
The definition what the EIR should contain varies slightly and can also be adapted according to the project. As an example, the following topics can be covered by the EIR according to the German VDI 2552 Part 10, which deals with the formation of EIR and also BEP:

- introduction
- general framework
- glossary
- project specifics
- objectives and use cases
- organization, roles and suitability requirements
- processes
- technology and information
- data

In terms of renovation, it is important to set out what detail is needed for the renovation and what derives from there, e.g., what is the purpose of the use of BIM (simulation, operation etc.). Therefore, the employer should specify what data do they need about the part of the building that will be kept. It is also sensible to distinct roughly the interfaces between the planning parties, at least if the employer does not commission a general planner. Otherwise, the scope of the services to be provided is difficult for the planners to calculate.

BIM Execution Plan (BEP)

It is of particular importance to have clearly defined BIM goals and BIM use cases derived from the scope of the renovation project and the EIR to facilitate a common understanding[9] and therefore comparable tenders and a target-oriented project execution. At this step, the BEP defines the cooperation between the planning and construction parties as well as with the employer and the BIM manager. The BEP is often a formulation of the contractual requirements in the EIR and BIM protocol and shall be prepared by

[9] VDI 2552 – Part 10 (2021)

the contractor. The BEP is no static document, which means that changes throughout the project are made if necessary because the exact scope of the services to be provided is not yet determined when the contract is agreed but is only specified and determined in more detail by the BEP. However, these are only concretisations of the functionally described services in the EIR, which usually do not represent changes in performance and therefore do not entitle to additional renumeration claims[10].

A BEP may consist of:

- general project information
- definition of BIM roles and responsibilities
- standardized use case definitions & process diagrams/maps
- technology
    - used software and data exchange formats of different disciplines
    - data exchange protocols & CDE (milestones for data-drops)
    - modelling standards (as-is modelling and design modelling)
    - data acquisition (as-is & as-built model)
- digital deliverables and deliverable dates
- model structure and model contents
    - Information Delivery Manual (IDM)
    - LOD
- nomenclatures & classification systems
- BIM collaboration strategy
    - coordination meeting framework
- BIM object libraries
- quality assessment (model checking)
- approval processes (input & output data, communication)
- data maintenance strategy (CAFM-System)

EIR & BEP in the Award Process

The separation of EIR and BEP contents according to the structure described above allows these documents to be used in different forms in award processes. The greatest distinction between these forms lies in the decision on whether the BEP is subject of the contract. Employers must decide according to their own affinity for risk and their own available resources to what extent they would like to become involved in data exchange processes themselves and make detailed specifications in this respect.

Figure 8 shows possible EIR and BEP constellations in the award process. In the following, they are explained and their pros and cons according to BIM4INFRA (2019) are presented.

[10] Esch, D. C. (2019)

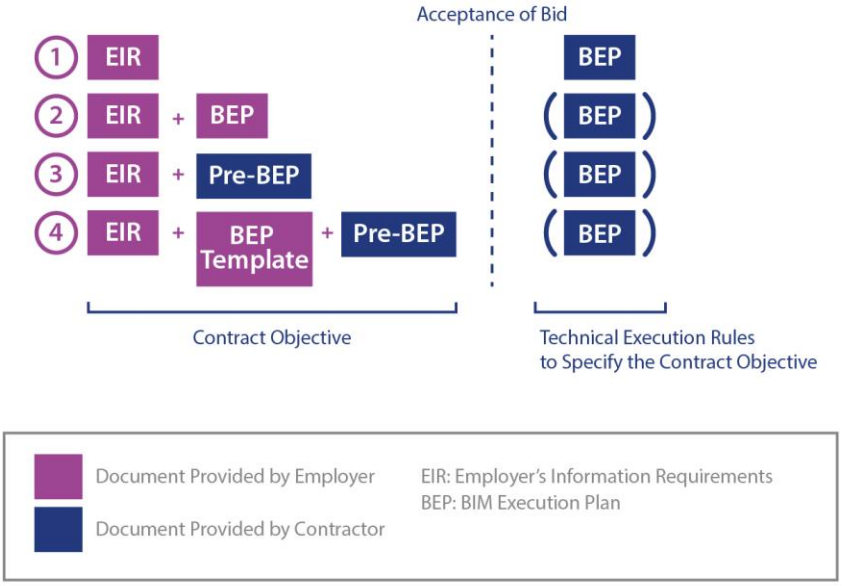

Figure 8: Different constellations for EIR and BEP (Source: BIM4INFRA (2019))

- **Variant 1:** In addition to the usual contractual bases, the contracting authority only specifies the EIR in the tender and no BEP. After commissioning, the contractors are obliged to develop a BEP in coordination with the other project participants in order to document specifications on planned cooperation for the implementation of the EIR.
    - Pro: Employers are able to define their EIR, but do not consistently find themselves in a position to define a BEP.
    - Con: It is often impractical for the client if the parties involved in the planning process do not have to agree on how to produce digital work results until after they have been commissioned.

- **Variant 2:** In addition to the EIR, the employer prepares a BEP that specifies all details of the subsequent BIM processing.
    - Pro: If desired, the employer can be in full control of how the clients achieve the digital work results.
    - Con: This is a difficult task for employers and may not be feasible due to today's level of experience. Also, it may not be sensible for reasons of efficiency and liability because the project may become too bureaucratic and contributing partners can not involve their experience and special skills of BIM.

- **Variant 3:** The employer specifies the EIR and requires the bidders to submit a preliminary version of a BEP (a pre-BEP) in the award procedure, in which the bidders describe their implementation

concepts for the fulfilment of the EIR. The pre-BEP is further detailed by the contractors into a BEP after commissioning.

- Pro: A pre-BEP can be used as quality criteria in the award process.
- Con: More workload is being added to bidders which might make the tender less attractive.

- **Variant 4:** The employer specifies the EIR and requires the bidders to submit a pre-BEP during the award procedure, but simultaneously provides a BEP template which is to be completed by the bidders. The pre-BEP is further detailed by the contractors into a BEP after commissioning.
  - Pro: Compared to variant 3, a more uniform implementation of the employer's concepts is ensured and the employer's expectations regarding the depth of content of the pre-BAP are communicated more clearly
  - Con: More workload is being added to bidders which might make the tender less attractive.

BIM protocol

A BIM protocol or BIM addendum is used as a supplement to the agreed terms within EIR and BEP. There is a great variety of BIM protocols on the market and of its understanding in the European countries which is why each has its own characteristics for example regarding terminology and content.

In general, it contains all legal topics that may arise in connection with BIM. They regulate, for example, the liabilities of the EIR, the question of how the BEP is created and adapted and the duty of cooperation in the practical handling of the project. In addition, they contain general legal provisions on data quality, data security and data protection. Such regulations are also mandatory in conventional contracts, but in BIM they are much more extensive. Naturally, rights of use and ancillary copyrights must also be regulated, especially if the model created by the planners and contractors is to be used in the operational phase. In addition, it is also advisable to define at least basic terms for later use in the BIM protocol, which must then be specified and deepened in EIR and BEP. It is not advisable to let the BIM protocol go too far; the essential technical and economic regulations should not be made by the lawyers in the BIM protocols, but by the practitioners in the EIR and BEP.[11]

2.2.2 Definition of use cases

Speaking of renovation, the BIM contract structures do not necessarily have to change compared to new building. EIR, BEP and BIM protocol are used in the same manner. What has to change is the content of EIR and BEP and thus the use cases and their data. The following chapter briefly explains use cases and gives examples for uses cases relevant for renovation projects.

[11] Esch, D. C. (2019)

"A Use Case is a list of actions that describes how a user achieves a goal by using software and system engineering. In particular, a Use Case defines the interactions between an actor and the system used to attain particulars targets. A Use Case is characterized by three elements:

- Actor: the type of users that interact with the system. The actor can be a human or external system;
- System: the mean used by the actor/s through which the goals are reached;
- Goals: the final scope such that the actor/s fulfils a list of actions."[12]

It is of particular importance to define standardised use cases based on the information requirements described in chapter 2.2.1. These use cases should be selected according to the demands of the specific needs of each project. This will ensure a uniform understanding of tasks amongst all project members. Before creating use cases for a project it should be checked whether the desired use case already exists in a standardised form. There are existing well-defined use cases in literature as well as provided by different national organisations throughout the EU. Therefore, it is advisable to first look for national initiatives.

For example, in the Netherlands, recently, a new market initiative called *BIM Execution Plan 2.0*, which specifically addressed standardisation of BIM use cases, got rewarded the first prize in the Dutch DigiDare award. The BUP 2.0 stands for central and interactive sharing of knowledge of BIM applications via hyperlinks where information is bundled via a website, so that every BIM worker can apply it de-centrally. An online platform with BIM use cases has been realised in 2021 Q1. Also, general BIM use cases have been documented into a Dutch knowledge poster managed by the Building Information Counsil (BIR). The BUP 2.0 aims to combine the use case sources of the BIR and buildingSMART into one online platform and also further collect BIM use cases with the help of partners throughout the Dutch industry.

Another example are the German developments on standardised use cases at the initiative *BIM Deutschland*. Experts from different fields are developing standardised use cases for Germany in the name of the federal ministry. They are expected to be publicly available in 2022.

On an international level buildingSMART is providing a webpage which delivers standardised use cases from different players in the industry and from various countries.
As the awareness for BIM in renovation is missing, there is also a lack of use cases directly approaching renovation processes, both on national and EU level. This is why BIM-SPEED project is delivering use cases for this purpose. They can be viewed in detail and downloaded on the above-mentioned buildingSMART webpage.

This guideline attempts to provide an overview of which uses cases are relevant for BIM-based renovation, see table 3. Nevertheless, it does not provide detailed information about e.g., processes and tools

[12] BIM-SPEED Deliverable 4.1 Baseline and Uses Cases for BIM-based renovation projects and KPIs for EEB renovation

for the specific use case. Please refer to BIM-SPEED documentation on use cases ("*D4.1: Baseline and Use Cases for BIM-based renovation projects and KPIs for EEB renovation*")

Table 3: Exemplary renovation-specific use cases

Use Case	Description
Building Surveying	This 3D data acquisition can be accomplished by making use of various technologies depending on scope, budget, etc. Examples of these technologies: • manual (electronic) surveying • laser scan • tacheometry • photogrammetry • tomography • point cloud • 2D drawings • pictures • PDF files
energy analysis/ simulation	The building's energy performance is being analysed or simulated, using BIM data to support the assessment based on measured data or simulated data.
operation analysis/ simulation	The building's operation performance is being analysed or simulated, using BIM data to support the assessment based on measured data or simulated data.
thermal comfort analysis/ simulation	The building's thermal comfort performance is being analysed or simulated, using BIM data to support the assessment based on measured data or simulated data.
acoustic comfort analysis/ simulation	The building's acoustic comfort performance is being analysed or simulated, using BIM data to support the assessment based on measured data or simulated data.
inhabitants' data collection on use	This data acquisition is accomplished by involving inhabitants by e.g. questioning them via apps for smartphones.

The following listed use cases are examples of use cases also applicable to renovation projects but which are as well used in all kind of construction projects:

- design coordination
    - 3D
    - 4D
    - 5D
- clash detection
- quantity take off
- site coordination

- construction safety and health
- AR/ VR

2.3 Integrated Project Delivery

A route of procurement that seems explicitly promising for BIM usage in renovation projects is the application of Integrated Project Delivery (IPD) or related concepts. The application of IPD concepts focus on the fashion of how and when parties work together; meaning the definition of their relationships and responsibilities.

Hence the implementation of IPD is generally abundant from the use of certain technology and does not rely on rolled out BIM. Projects which are organized in an IPD manner are imaginable without any use of BIM or BIM use case. Nevertheless, both IPD and BIM share the principle of knowledge integration with the aim to foster efficiency and speed. The relationship of IPD and BIM can be seen in the way, that the IPD project delivery approach can be enhanced by the use of BIM technology which delivers the tools to enable concurrent sharing of project information. The overall purpose of this chapter is to assess the relevance and practical implications of IPD for renovation projects. It describes briefly what IPD is and gives a listed overview on underlying basic concepts and strategies. The chapter demarcates IPD to BIM and indicates the possible positive outcomes that the application could yield in renovation projects in respect to common challenges. The chapter ends by a draft description on what is needed in terms of contracts and project management.

2.3.1 Introduction

Integrated Project Delivery (IPD) is a project delivery approach that aims at integrating "people, systems, business structures and practices into a process that collaboratively harness the talents and insights of all participants to reduce waste, and maximize efficiency through all phases of design, fabrication, and construction" [13]. In short, IPD promises to help deliver better buildings in shorter time. Its development goes back to concepts that have been derived from W. Edward Demings work with Toyota in the 1950s. He realized sustainable productivity improvements and management optimization under the use of systems thinking. IPD focusses on overcoming adversarial relationships which characterize the traditionally fragmented construction industry. Different IPD concepts have been developed, taking local requirements of both the demand and supply side of the AEC industry into account. A cornerstone of all IPD concepts is the idea to bring in the collective expertise of involved parties into a project as early as possible. A concept which could be extremely fruitful in renovation projects, because often construction companies undertaking renovation have large experiences with certain building typologies and their specifics and therefore can give valuable input right from the beginning of the design phase. Furthermore, two elements are frequently found in IPD contracts: a multi-party agreement in some form and a shared risk and reward component. IPD therefore provides a framework to integrate shared goals and values for the project participants and helps to reduce adversarial relationships that cost productivity and efficiency in traditionally organized construction projects. Apart from seeing IPD as a project delivery method, it can be defined as a strategy for procurement or a form of contract as well.

[13] J. A. Wright (2012): p. 4)

2.3.2 Basic Concepts

In the technical reports from AIA contract documents on integrated project delivery, different experts identified key elements that should be present in the context of IPD implementation, those are categorized in IPD markers and IPD strategies as follows[14]:

IPD Markers

- Relational Contracts
- Protection from litigation
- Aligned project goals (Jointly Developed Project Target Criteria)
- Informed and balanced decision-making (Collaborative Decision Making)
- Open Communication
- Risks Identified and Accepted Early

IPD Strategies

- Key participants bound together as equals (Multi-party Agreement)
- Budget & create team for design intensive work
- Early contribution of expertise (Early Involvement of key participants)
- Pre-existing relationships between parties
- Champion/ Facilitator (Leadership by All)
- Shared financial risk and reward based on project outcome
- Liability waivers between key participants
- Fiscal transparency between key participants
- BIM - virtual rehearsal of construction and ongoing constructability reviews
- Lean Construction processes
- Co-location

Each project has its own particularities and the delivery suitable for it depends on some of those particularities. Some experts pointed out the motivations for selecting and implementing IPD in a certain project:

- Market advantage: IPD may give valuable experience. Improving the delivery may also be a market advantage if measurable results can be attained. For serial owners, savings on one project done in IPD can be leveraged across many subsequent projects.

[14] AIA Minnesota (2011)

- Cost predictability: All projects would like to meet budget, however, for some the predictability of cost is a notably driving factor and IPD can reduce unpredicted over costs.
- Schedule predictability: Similar to cost, all projects share the goal of meeting their planned schedule, but for some projects this is a major issue.
- Risk Management: Reducing or managing risk can be tied with cost or schedule, but also may include transactional risk inherent to project type, site or other conditions. If risk management is a critical factor, the increased communication in IPD may be of particular advantage.
- Design Complexity: A high degree of complexity will usually demand integration of expertise and require a level of coordination that is achievable in an IPD environment. IPD sets up structures that make integration and cooperation more likely to occur than not.

2.3.3 Relationship IPD and BIM and renovation projects

As described above the application of IPD concepts focus on the fashion of how and when parties work together; meaning the definition of their relationships and responsibilities. In this segment this relationship is elaborated further; also, findings from BIM-Speed project arguing for a use of IPD for BIM for renovation projects are presented.

IPD and BIM

The relationship between BIM and IPD can be described as mutual reinforcing. Both IPD and BIM are process innovations respectively imply process changes and are driven by advances in technology and redrawing of social relationships.

BIM is more connected with technology and its opportunities of exploitation and IPD with the reorganisation of the conduct of a project and its participants. They share the ideal of a free flow of information within a project and the close cooperation between the participants and different professions. Rowlinson states that "BIM is likely to slip from our lexicon, and we will just talk about IPD with BIM technology as merely an enabler of IPD" when their role out is successful.[15]

IPD for renovation projects

Within the elaboration of the guidelines at hand several experts that have been consulted pointed out, that they or their organizations see IPD (and related concepts) in combination with BIM as an attractive procurement route, especially for renovation projects. Recurring rguments supporting a role out of IPD for BIM for renovation included:

1) Construction expertise integrated early can reduce expensive redesign and changes at a later stage
    a. Early involvement of all important stakeholders into a renovation project, can help better the predictability of cost. E. g. a constructor involved early can give his experience on

[15] Rowlinson (2016, p. 48)

certain building typologies and common cost drivers; this can help shape the design for specific building types.

b. Project goals can be checked against different professions experience.
c. Early check of design by constructors may reduce often occurring design performance gap in renovation.
d. The more complex a building or apartment block is, the more important is the integration of professions; the sooner the better.
e. Projects schedules become more realistic when key participants draw them together.

2) Jointly described and decided project goals can enhance understanding and collaboration. As renovation can tackle a wide range of problems, it is relevant to include all important stakeholders to assess what kind of renovation they deem important and with link to existent resources (macroeconomic parameters, budget, time, skill etc.).
    a. A clear understanding of parameters and KPIs for renovation between all important participants help to concentrate resources.
    b. The co-creation of those goals ensures that participants can evaluate whether they are realistic from their profession's perspective, given the project budget etc.
    c. Project participants in an IPD lead project will gather more overall project information which may lead to market advantages in the future.
3) IPD-agreement gives the information flow and cooperation a legal framework which helps to overcome uncertainties that occur with BIM only because of the status quo in the industry of separation of design and construction phase. This is of particular interest for SMEs performing renovation who see legal risks with the application of BIM and need distinct agreements to overcome this hurdle.
    a. Open discussions and agreements between participants that are needed to achieve 1) and 2) can only be successful when a legal bracket is formulated that compensate risks and rewards.
    b. The same goes for sharing of information such as data models etc.
    c. Efficient risk management depends on a sound and clear legal situation.

2.3.4 Legal aspects

Consulted industry representatives and professionals pointed out, that the legal situation regarding the application of IPD concepts is mostly unclear within the industry. This is because IPD tents to develop an integration of two traditionally separated procurement elements: the procurement of services (design) and the procurement of goods (construction). The common legal documents are bound and build on this traditional separation.

Some stakeholders are willing to take first steps to integrate both, e. g. implementation of an intermediate phase between design and construction phase in which the constructor can share his

knowledge about construction which can lead to redesign. But the legal situation has to be analysed and assessed from project to project and is dependent to country, organisation and local experience of procurement and design, construction staff. Nevertheless, a BIM for renovation project that completely integrated IPD concepts has not been found; at least not one in which experts were keen to share their knowledge for interview purposes. But pilot projects, from which others can learn is what is needed for an application of IPD concepts.

As an example, for the German situation Eschenbruch points out for how common local legal situations contain aspects that can be used for an application for IPD-pilot-projects. [16] Elements that the author describes that are important for application of IPD refer to shared leadership and decision-making committees; top priority for IPD is using all stakeholder's specific knowledge as early as possible and the integration of design and construction phase. This has to be build into the legal arrangements. Eschenbruch analysed that IPD-contracts generally can make use of in Germany widely known and used project management concepts such as project lead, consultancy and decision-making committees. Although pilot project experience in Germany with IPD are hard to find, he describes that those concepts can be applied using traditional project management concepts, with the change only of integrating not only the owner but all-important stakeholders (main designer and main constructor) e. g. in the decision-making committee. For the formulation of a contractual arrangement within a project three different solutions are presented: Standard contracts with additional IPD general business terms, multi-party-contracts and realization via a project specific company. For all solutions the arrangement entails only an agreement between the involved top stakeholders such as owner, main designer and main constructor. Subcontractors have specific contractual agreements as it is in traditional organized projects. At least for private owners in Germany who want to initiate IPD- pilot projects it seems realistic to take on the proposed solutions. The situation for public procurement is more complicated, because it is usually bound to the separation of procurement of services and goods and has to be studied additionally. For other countries it might be also a route to take, to look up which traditional elements of contracts can be applied to go first steps to try out aspects of IPD.

[16] Eschenbruch (2019)

3. Practical Guidelines: Issues and possible Solutions

This subchapter proposes practical solutions for issues which stakeholders encounter in practice when renovating buildings and approaching new methods such as BIM and IPD thus supporting in developing best practice and quality management. Although the list of worth mentioning issues is long, the scope of this document lies within the topics of public procurement (including collaboration protocols), BIM-based renovation and IPD. Moreover, they depict a momentary capture of the status quo as they are derived from questionnaires and interviews held with practitioners.

These three topics have different dimensions, as shown in figure 9. For example, procurers in practice are facing a varying legislative framework regarding BIM regulations and liability issues due to contracts and/or BIM collaboration protocols. Regarding BIM-based renovation, dimensions like technology and data play an important role whereas in the field of IPD shared risk and reward is a key word to current problematics.

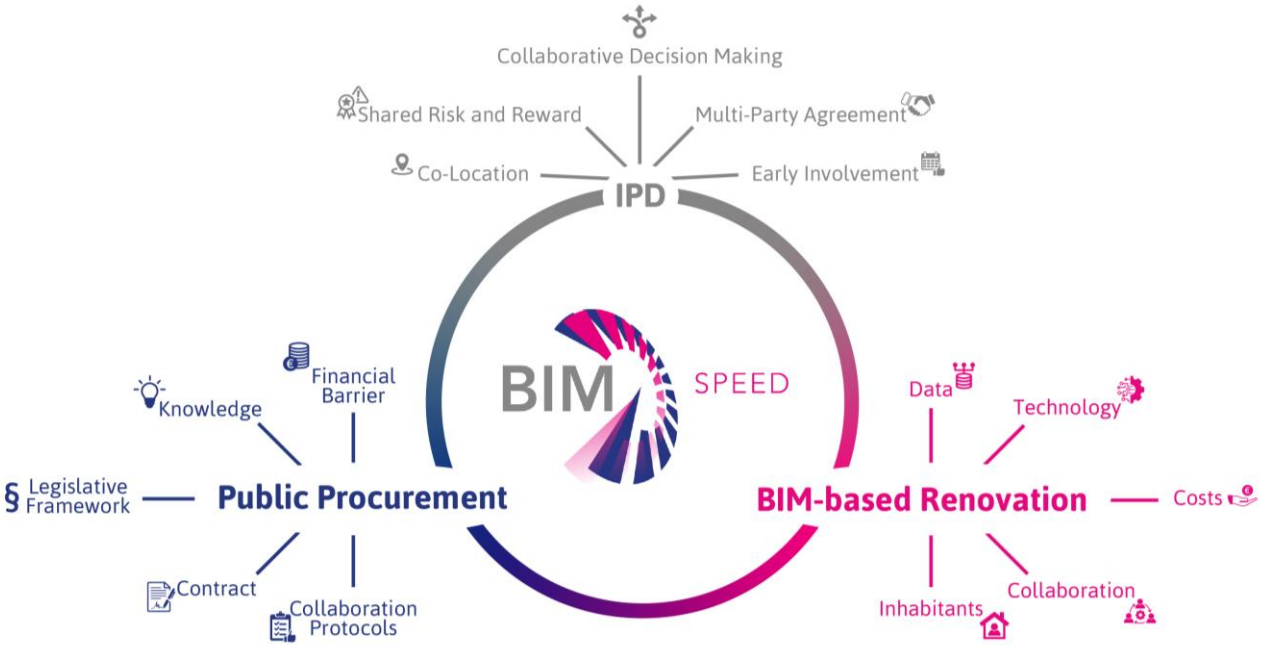

Figure 9: Dimensions of issues (source: PB40)

3.1 Public Procurement

3.1.1 Legislative Framework

As already stated in chapter 3 there is a need for legislative and regulatory framework on EU level because BIM is not legally binding as contract. Also, there are differences in roles and responsibilities within countries as well as contracts and processes. This leads to a lack of incentives for the use of BIM in renovation projects. The difficulty of making BIM-based procurement lies in including all market players, especially SMEs and avoiding void tenders.

POSSIBLE SOLUTIONS

Public Procurers can create incentives by demanding BIM. Hereby, the call for tenders should not be too demanding concerning BIM. Sometimes it is still necessary to combine traditional working methodologies and BIM based methodologies until tenderers reach a certain BIM level. In particular, SMEs should be included by an openBIM approach (product neutrality) and by keeping requirements regarding references and experiences rather low.

3.1.2 Contracts

Often, procurement documents do not provide clear BIM requirements which leads to amendments to the contract during work as well as after commissioning. Also, some existing contracts are not fully suited for the use of new methods especially for working with BIM collaboratively. In addition, experience from BIM-SPEED demo cases show that BIM services are not being implemented in contracts which results in liability issues.

BIM collaboration protocols are often underestimated which is why chapter 4.1.3 looks at them in more detail, although they are part of the contract.

POSSIBLE SOLUTIONS

The earliest decisions have most impact on later costs. Therefore, the importance of using BIM contracts and protocols in the procurement phase must be emphasized and the requirements and objectives in these documents must be unambiguous and detailed. BIM also implies a new type of collaboration to which all parties must commit.

Regarding the juridical impact of BIM, it is to say, that BIM itself does not change much about the legal rules which apply. Two juridical aspects that especially are of importance to BIM are those of liability and intellectual property.

- Liability: because BIM changes the process and the way of working, this can lead to a change of legal position among the diverse building partners. Information often gets available to other parties in an earlier stage, and can lead to mismatches in level of detail, leading to problems while exchanging this data. Clear agreements are

needed for this. Also, being able to trace back who has made changes or additions when needs attention.

- Intellectual property: Two aspects deserve extra attention. In the first place, joint property rights can originate by jointly building a BIM model. The second concern is that digitization makes it easier to multiply intellectual products and data. It is therefore even more important to make agreements who receives licenses to any resulting intellectual properties and data.

The contract shall define clear BIM requirements for the competition, owner, etc. It should elaborate and not only stand as a declaration of intent, e.g. provide contractual agreements on specific BIM subjects like

- BIM roles and responsibilities/ obligations;
- BIM technical terms: nomenclature/ terminology/ naming convention (e.g., as-is/planned/built model);
- BIM use cases;
- representation conventions (e.g., color codes for different planning disciplines) → clarity and uniform understanding
- treatment of intellectual property: models vs. plans for further use during the building lifecycle
- software (also on smartphone); especially CDE

A decision should be made on how the BIM services are integrated in the contract. Two main approaches can be followed: either BIM Integral or BIM Annex, meaning that the services are integrated in the main contract or not. In addition, it is advisable to stick to the scope of renovation work when demanding BIM services e.g., if you do insulation works there will be no need for an interior model. Also, new contract types such as IPD should be considered thoroughly as traditional procurement methods do not deliver the best solution in some cases.

3.1.3 Collaboration Protocols

One of the most common mistakes within BIM projects is underestimating the effort for creating the EIR and the BEP. In addition to this, the decision to use BIM is often made very late. This results in multiple chains of further issues. Firstly, there will be time problems for creating the EIR because of the unexpected workload and information for creating the BEP is missing. When bidders respond to an unclear EIR, they often do not ask for the missing information and submit an equally unclear BEP, rendering it effectively worthless. Secondly, the BIM services or use cases are not thoroughly described in the EIR. As this is essential for contractors, they cannot know what they are expected to deliver and may end up in having to deliver BIM services in which they do not have enough experience.

Another common mistake is underestimating the effort for the actual services even if they are thoroughly described in EIR and BEP. Contractors are not aware of the effort and will fall behind schedule.
In the end, all these issues lead to an inconsistency of information and data which provides little value of BIM models for further operation and maintenance.

Furthermore, the BEP is often not understood as a living document that needs to be adapted to the influences and factors arising from the project process.
Another mistake is that the BEP is not treated as contract and not referred to in the main contract.

POSSIBLE SOLUTIONS

When entering a procurement process all stakeholder shall be aware of their responsibilities (e.g. the employer shall create EIR and not the contractor), as described in chapter 2.2. The pros and cons of various EIR and BEP constellations in the contractual hierarchy must be evaluated and an appropriate solution to one's own BIM maturity and resources chosen. Incorporation clauses within a BIM protocol/ addendum regulate liabilities of EIR and BEP. Further, content of EIR and BEP must be thorough without regulating too much.

The following provides a list of best practice advices:

- have a template/ make use of (preferably national) templates of
  - EIR
  - BEP
  - uses cases
- identify early on use cases for defining required information and interfaces
- centralize & share information
- simplify approval workflows
- archive projects for later use in other projects

Finally, it must be noted that it is more complicated to involve SMEs in contracts and BIM collaboration protocols due to more interfaces. Coordination must be distributed cross-data, which means that data has to be shared among a variety of project participants with different data infrastructures and limited resources regarding for example the purchase of software. During these projects it is crucial that data stays consistent so that data loss and data devaluation is minimised. Thus, collaboration and interfaces must be carefully planned and protocolled.

3.1.4 Financial Barrier

The financial aspect is a clear barrier for construction SMEs to use BIM tools as well as for building owners because it requires investment regarding hardware, software, training, and time to get started. Employers must pay in addition for the extra services.

POSSIBLE SOLUTIONS

The advantages of using BIM once the method has started running smoothly are summing up against the high investment costs. Awareness for these benefits must be heightened. BIM can be interlinked with financial management tools to attract more SMEs to adopt BIM. Apart from this, one can make use of free software on the market as well as public support for BIM tools and portals (e.g. Kroqi in France). For employers willing to work with BIM it is advisable to get started with procuring small BIM services.

3.1.5 Knowledge and Expertise

One of the main hindrances in implementing successful BIM projects is the lack of knowledge regarding the method. As there are no or very few projects to evaluate there are no lessons learned for practitioners, public authorities, and owners. Also, there is a lack of awareness and training among construction SMEs.

POSSIBLE SOLUTIONS

Public procurers should be aware of the shortfall of skill and knowledge when working with BIM, especially with subcontractors because they have more difficulties integrating BIM with their daily practices. Local SMEs in renovation are not yet fully BIM ready. A solution is to demand small BIM services and isolated tasks (models, etc.) according to the companies BIM maturity. Apart from this, building owners often have no knowledge about the technologies but they need at least a general understanding to promote BIM in the project. They can be familiarized e.g. by smartphone applications.

For reasons of misconception, it is advisable to use generally recognized definitions of technical terms and e.g. integrate a glossary in the tender documents. Generally recognized term definitions can be found in BIM glossaries such as the BIM Dictionary, which is gathered and reviewed by volunteers from practice and academia based on existing standards and accessible free of charge. It is also advisable to first look at national initiatives for glossaries.

FURTHER RECOMMENDATIONS

Stakeholders should make themselves familiar with international and national BIM standards that are important for the chosen use cases (see appendix 4 for an overview). They should make use of results from national standardization initiatives (regarding use cases, protocols (EIR, BEP)) before researching for international examples etc.

3.2 BIM-based Renovation

3.2.1 Data

One of the greatest hurdles in renovation projects is that as-is/built data mostly show a higher uncertainty compared to new construction (depending on the type and condition of the building). Often there is a lack of building documentation that represents the actual state of a building which results in an incomplete data base. For example, information on building material or on interventions and changes to the initial building plan can be missing. It should be noted that even building surveying might not complete the information in all cases, especially concerning HVAC systems. But also after renovation works the BIM model should be kept up-to-date for making it available the entire building's life cycle and for future maintenance interventions.

Apart from this, generating data raises the question of privacy, ethics, and security.

POSSIBLE SOLUTIONS

Creating data depends on the budget available as well as the scope of the project. The effort for using BIM should be carefully evaluated and neither under- nor overestimated.

Liabilities such as intellectual property of models must be stated in the BIM protocols. National data security measures or laws must comply with the project.

3.2.2 Costs

If the data base is incomplete, building surveying will have to be carried out to be able to create a BIM model. The cost and effort of creating an as-is BIM model can be very high due to applied technologies like thermal scan which are time and labour intensive. This can result in more time and money that is spent on the BIM model than on carrying out practical work.

POSSIBLE SOLUTIONS

It is essential to be aware of what is necessary and affordable in each renovation project depending on the scope and level of performed activities. It has to be carefully evaluated which BIM uses cases are feasible, i.e. which will give higher gain than cost. Being focus-orientated will create added-value to the project.

3.2.3 Collaboration

Building projects in general show a lack of collaboration. Often information is not being shared and communication is missing or misleading. All project participants must be aware that it is crucial to align for a successful project.

POSSIBLE SOLUTIONS

To enhance collaboration, the number of coordination and cooperation meetings have to be increased compared to before. At best, this will also result in major time, cost, and quality benefits. However, the workload for designers may increase at the same time. Apart from

regular meetings, data delivery plans are essential for efficient collaboration. All these agreements should be noticed in the collaboration protocols (see issue from chapter 4.1.3). It is advisable to make use of a CDE to provide a single source of truth. Questions of licenses and responsibilities for the CDE must be answered within the collaboration protocols.

Also, efforts in encouraging a shift in culture towards more sharing of data and information should be intensified. This can include for example involving building teams as early as possible and approaching the project through IPD.

In general, 3D BIM models can help to better understand complex structural relations between building elements, which is particularly beneficial when communicating with e.g. building owners who are not familiar with blueprints. However, due to 3D visualization, there is a risk of deceptive representation of a structural situation. This can lead to misunderstandings and mistakes.

3.2.4 Technology

Also, BIM methodologies are still dealing with technical issues as there is no perfect solution out there yet. For example, when renovation design changes it cannot be evaluated easily by existing BIM-based simulations. This results in a performance-prediction gap[17]. Another example is the little or non-existent information about many possible energy improving renovation products, in particular about HVAC systems[18]. BIM data may not be available on this subject which hinders the BIM modelling process. However, in many cases the BIM modelling process in renovation projects is carried out identically to new construction, which is why these issues may only occur in special cases.

POSSIBLE SOLUTIONS

It needs to be taken into consideration that constructive solutions for renovation are depending on the availability of know-how of local companies and building materials on site. I. e., choices on solutions during design phase may not be feasible in practice due to regional circumstances.

3.2.5 Inhabitants

In renovation projects inhabitants are often involved and disturbed by the works (e.g. pollution, scaffolding, accessibility). They are scarcely informed about the works and due to lack of understanding can hinder the works. BIM or other digital tools can help improve communication with residents and facilitate data collection. The goal should be to limit the disturbance for the residents. However, practice shows that often the modelling is not taken to a level that would be useful for resident communication and residents are not at all involved.

[17] BIM-SPEED Description of Action
[18] BIM-SPEED Description of Action

POSSIBLE SOLUTIONS

BIM-based renovation enables project stakeholders to communicate with inhabitants for example via apps. Also, this method can be used for gathering information and data about the building as well as feedback on the renovation works.

FURTHER RECOMMENDATIONS

The feasibility of BIM-based renovation depends on the project type and the type of building. For example, a small scale (thus less than 1000 sqm) is likely to have a loss of benefit. It is advisable to use different technologies depending on the scale e.g. to create BIM models from 2D drawings instead of laser scans in case of a small task.

3.3 IPD

3.3.1 Application

IPD seems to be an attractive procurement route to tackle specific problems that occur on renovation projects as described in chapter 2. But how can concepts of IPD can find its way into application in an industry that is characterized by segmentation and a traditional separation between design and construction phase. For sure individual organizations willing to make a difference have to take opportunities to try out this concept; may the following lines help support this attempt.

POSSIBLE SOLUTIONS

For various reasons, presented in chapter 2 it makes sense to apply IPD concepts in BIM-based renovation projects. But one has to start. For stakeholders willing to go this route it can be a starting point to first look for other stakeholders wanting to go new paths and partner with them. Second stands the education on this specific concept to build up an organizational knowledge base; this guideline can be used to disseminate first ideas and concepts. If organizations have taken on enough knowledge to start, it may make sense to start the application on little projects to try out this new method and maybe choose one aspect to integrate after another, e. g. bringing in all important stakeholders as early as possible. And as described, BIM is not mandatory use IPD but

both methods stimulate each other. The following ideas and strategies can help structure the application of IPD.

In general, the implementation of IPD requires stakeholders to define and establish different elements that will set the mechanisms and framework to guide the development of the project.

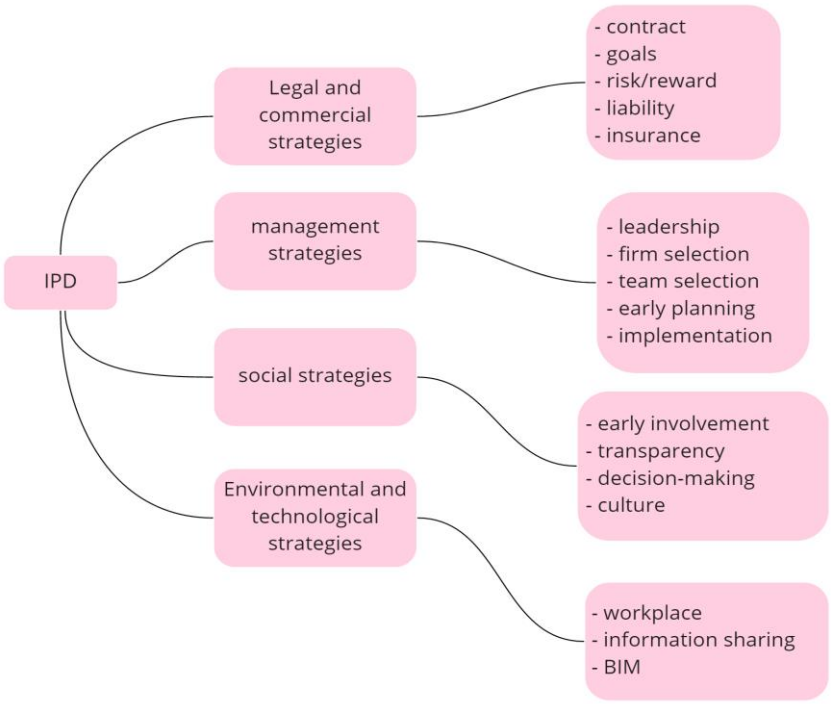

Figure 10. IPD strategies and elements (Source: TUB & PB40)

According to technical reports from AIA Contract documents on integrated project delivery[19], these elements can be classified in four main sets of strategies: legal and commercial strategies, management strategies, social strategies, and environmental and technological strategies as presented in Figure 10.

- Legal and commercial strategies: for the legal and commercial aspects of the project it is important to define the type of contract that will rule the project and the goals of it. The risk/reward mechanism is a key element, it plays an essential role in guaranteeing a fair and clear interactions between the different stakeholders when controlling and checking the progress and results of the project. Liability and insurance agreements are also relevant at this stage.
- Management strategies: in the context of IPD, the management strategies should consider early planning approaches to guarantee that the main decisions and elements of the project are defined in the early stages of it, paving the path to increase predictability and anticipation on the workflow and activities of the project. The selection of firms and teams designated to perform the tasks of the project should be defined clearly to ensure that the participants are suitable for the project and the integration will be achieved.

[19] AIA Minnesota (2011)

- Social strategies: stakeholders working in an IPD environment should consider mechanisms to stimulate, facilitate, and support the early involvement of the diverse stakeholders taking part in the project. Moreover, the integration, cooperation and interaction culture should be encouraged across all the participants. Transparency policies and agreements should be stablished to ensure that the stakeholders have access to truthful information when making decisions and evaluating the progress and results of the project. A well-defined decision-making framework is required to guarantee that the decisions are made on time, by the right stakeholders, having all the required information and involving all the affected participants in the process.
- Environmental and technological strategies: finally, technological resources are essential to allow the flow of information and cooperation between stakeholders. Information sharing schemes are required, technologies such as BIM modelling may play a key role in promoting and enabling the integration of the different teams, gathering, sharing, tracking, storing and leveraging all the sufficient and required information to carry the project out.

3.4 Outlook

Public procurement with BIM and the application of project delivery methods such as IPD in renovation projects may all contribute to a better quality of deep renovation in the existing building stock. Also, to ensure delivery in shorter time and in compliance with declining budgets. To support the adoption of prescribed strategies and to foster the digitization of the AEC industry; not only the directly affected stakeholders such as owners, designers and constructors have to move accordingly, but also within the EU and their member states the regulatory framework should allow easy application. Policy makers and public officials are obliged to guide the development on a meta level setting rules that help the directly involved stakeholders to take new routes. It is therefore helpful to point out issues and strategic solutions that have worked out for other EU member states and which can function as role models for others to follow.

The previous chapters have shown that the state-of-the-art implementation of BIM as well as its regulation varies amongst EU countries and that BIM-based renovation is still widely overlooked. The main case for BIM is mostly made for new projects. It therefore becomes clear that there is a need for an EU wide legislative and regulatory framework with special attention to renovation. A phased plan which sets out time frames and clear regulations can facilitate this process of adopting new rules.

Bodies of profession and decision makers in public procurement must set an organizational BIM implementation strategy that takes renovation seriously. This should include consulting BIM experts, education for employees, refitting hardware and software. Especially for renovation purposes, BIM application fields which may not be as well-known, like involvement of inhabitants, have to be considered. For this reason, chapter 2.2 provides exemplary renovation-specific BIM use cases. Also, a change of

cultures with the focus on collaborative work should be considered. This will facilitate the use of procurement methods like IPD which is described in chapter 2.3.

When shaping BIM tools, methods and support by public bodies the involvement of SMEs shall be insured with the aim that they fit real needs on construction sites.
Finally, it is to say that in general improvement and declining prices for technology as well as increasing knowledge and training in the community of practice will make BIM for renovation more profitable.

4. Case Study

This chapter provides case studies derived from the BIM-SPEED demo cases. In particular, a demo case in Spain and a demo case in Poland was chosen to illustrate the above discussed theoretical basics on e.g., collaboration protocols and use cases and to show current practices of BIM-based renovation. Key takeaways are given for each case study.

4.1 Demo Case Vitoria-Gasteiz, Spain

One of the BIM-SPEED demonstration sites is a group of residential buildings located in urban area of Vitoria in Spain (Basque Country). The buildings are part of Lighthouse demonstrators in SmartEnCity Horizon 2020's project and BIM-SPEED project. SmartEnCity aims to develop a systemic approach for transforming European cities into sustainable, smart, and resource-efficient urban environments in Europe. The renovation activities within SmartEnCity project consisted of insulation of the building envelope with focus on façades and roof and connection of the dwellings to a new District Heating system based on biomass energy. During BIM-SPEED project new tools and solutions supporting as-built data acquisition, designing, energy simulation and construction works have been implemented.

The following passages present this demo case as a case study for BIM-based renovation projects.

4.1.1 At a Glance

Table 4 shows the project's profile.

Table 4: Project profile Vitoria-Gasteiz

Project Description		
Project	Aldabe 26 ALD26	Manuel Diaz Arcaya 5 MDA5
Location	Vitoria-Gasteiz, Spain	Vitoria-Gasteiz, Spain
Building Type	Multistorey residential building	Multistorey residential building
Building size	8 dwellings Ground floor + 4 floors	12 dwellings Ground floor + 4 floors
Contract Type	SMEs	SMEs
Building Owner	Individual private owners	Individual private owners
Architect	David Velasco	David Velasco
Contractor	Indenort Proviser	Indenort Proviser
Project cost (VAT not included)	189.574,07 €	271.904,75 €

Project Characteristics	
Private / Public	private with funds by EU and government/ municipality
owner occupied	partially

4.1.2 Project Description

"The two buildings were built in 1958. They are located in the city of Vitoria-Gasteiz, in the North of Spain. The first demonstration site is a four-storey residential building with eight flats, a garage and a bar in the ground floor. The building form is U in Shape. The external walls are made from double layer of brick with an air-camera in between, cavity-wall. The second demonstration site is a 5-storey residential building with 12 flats, with a storage room and a bar in the ground floor. The building form is H in Shape. Most of the main external walls are made from double layer of brick an air-camera in between, cavity-wall. Others just are composed of a simple layer of brick without any air-camera. Both buildings are not insulated and have poor energy performance with condensation and humidity problems."[20]

Table 5 shows the retrofitting and BIM work descriptions which were carried out.

Table 5: Work descriptions Vitoria-Gasteiz

Retrofitting Work Description		
Project	ALD26	MDA5
Envelope improvement	Façades: 14 cm ETICS (External Thermal Insulation Composite System) in all the façades	Façades: 14 cm ETICS (External Thermal Insulation Composite System) in all the façades, except front façade where ventilated façade was used as technical solution
	Roof: new roof with insulation	Roof: new roof with insulation
	Windows: no changes, they were already in a good state of conservation	Windows: double windows (an additional new window was installed over the pre-existing window)
District heating connection	Connection works: piping to each dwelling	Connection works: piping to each dwelling
	Boiler substitution: individual gas boiler is substituted by an individual heat exchanger + building heat exchanger subcentral	Boiler substitution: individual gas boiler is substituted by an individual heat exchanger + building heat exchanger subcentral

[20] BIM-SPEED (2019)

BIM Work Description		
Models	• pre-retrofitting status as-built model using laser scan and 2D drawings • project model with the aimed changes • Post-retrofitting status as built model	• pre-retrofitting status as-built model using laser scan and 2D drawings • project model with the aimed changes • Post-retrofitting status as built model

4.1.3 Detailed BIM Work Description

The first step was a performance of a digital process for gathering the data about the building to create as-built model. 3D laser scanning was made and a point cloud that describes the geometry of each building was performed. Based on the point cloud a Building information model was created. The model was done with the use of one of the tools developed within the project by Spanish partner CARTIF. 3Dash allows to support the creation of As-Built models using point clouds as data for the generation of BIM models. Next step was thermal 3D mapping to help detect heat losses and air leakage in building envelopes before renovation.

Figure 11: 3D laser scanning (Source: BIM-SPEED)

Figure 13: Point cloud model (Source: BIM-SPEED)

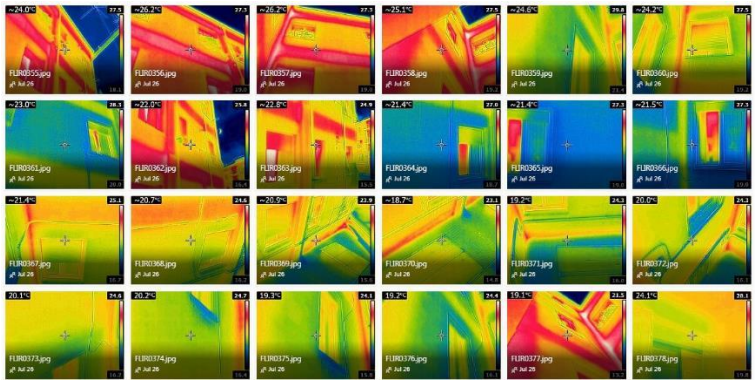

Figure 12: Thermal 3D mapping (Source: BIM-SPEED)

In parallel with retrofitting works, the comfort conditions and energy consumption monitoring infrastructure were deployed in the dwellings. This monitoring infrastructure consisted of a kit of sensors to measure indoor temperature, humidity, and CO2 (in certain potentially problematic dwellings to detect excessive damp problems as soon as possible), and electric consumption as well.

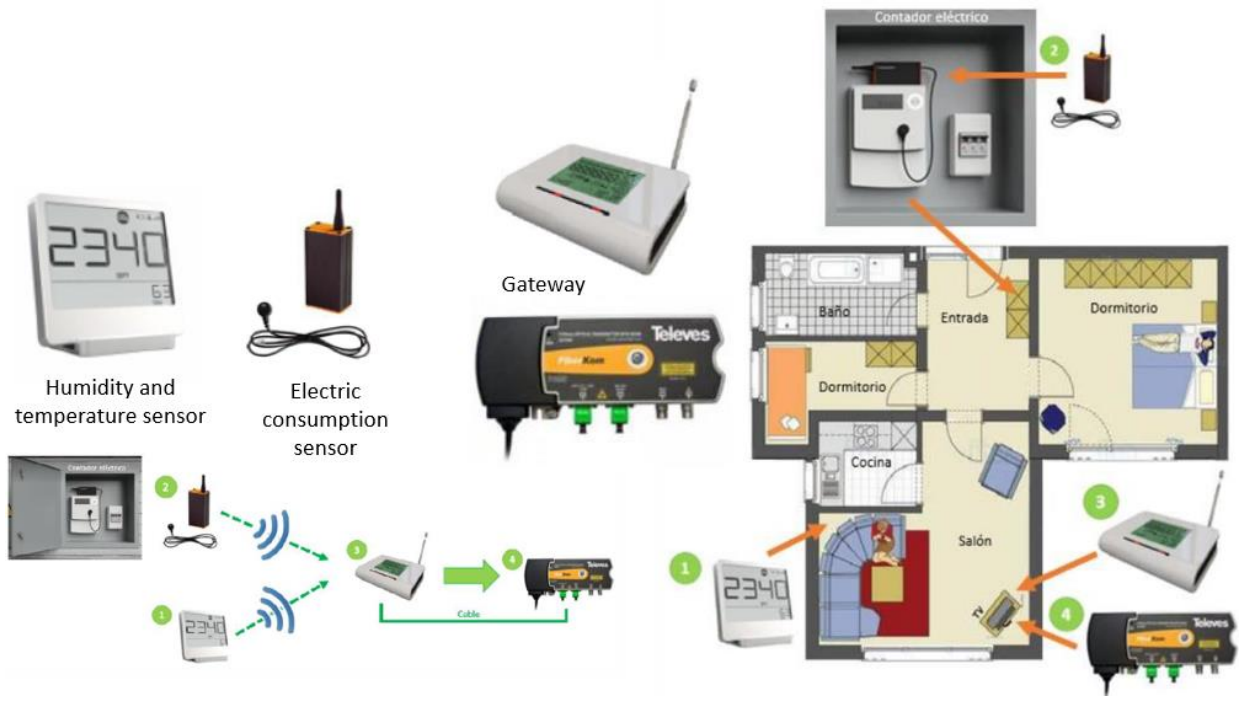

Figure 14: Monitoring infrastructure (Source: BIM-SPEED)

Building information models were used to perform energy calculations and to select the most appropriate renovation scenario. Data from the monitoring of the building was used for calibration processes.

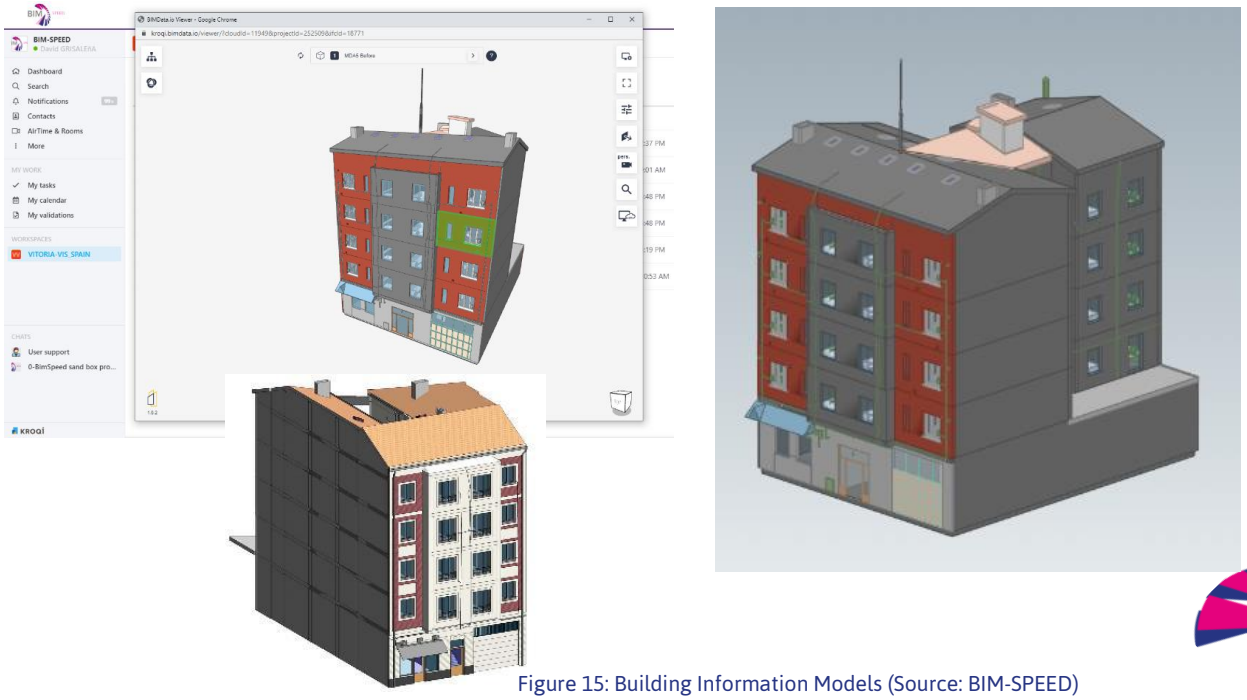

Figure 15: Building Information Models (Source: BIM-SPEED)

4.1.4 Legal Strategies

Table 6 shows certain aspects of legal strategies of the case study.

Table 6: Legal strategies Vitoria-Gasteiz

Legal Strategies	
Contract type	Bid-Design-Bid-Build
Tendering Process	• For the design phase 55 architectural firms took part in a framework agreement. From these, 14 companies were awarded to carry out design works. • For the construction phase, 13 construction companies applicated to tendering processes. Out of these, 5 companies were awarded.
Award Criteria	• cost • experience in retrofitting • technical competence
Liability	
Main Contract	ordinary liabilities (quality etc.)
BEP	BIM liabilities

The procurement strategy followed in this demo case has not been different because of BIM implementation. This is due to the fact that when BIM arrived to the demo project the retrofitting design works were already started. Once the contract was awarded to the firm in charge of retrofitting works, the facultative direction was asked to collaborate in BIM-SPEED. The renovation firm was already using BIM up to some extent but not in a full-BIM methodology.

When the project started SMEs in the region were not “fluent” in BIM so it could not be asked for BIM as a requisite in the procurement process. There would not have had any bidding company. So, bidding companies offered BIM as a voluntary improvement in their offers and, as an improvement, this had low value or weight in the final decision.

In total 26 buildings were retrofitted, but building’s retrofitting projects were merged in batches to reach a higher budget and made it more attractive for construction companies. This means that the same company, for instance, was awarded to retrofit Aldabe 10, 12 and 16 (3 buildings). At the same time, as tenders were launched in succession along several months, the same company could be awarded in different batches. That’s why, despite of having addressed 26 retrofitting projects only 5 construction companies have taken part on the process.

4.1.5 BIM Strategies

Table 7 shows certain aspects of BIM strategies of the case study.

Table 7: BIM strategies Vitoria-Gasteiz

BIM Strategies	
Procurement Requirements	• BIM model will be modelled before execution project beginning • BIM coordinator will oversee all the critical decisions related to BIM implementation • Project and models must comply with the provided BIM template's requirements. • Comply with required LOD levels • Guarantee interoperability among BIM and any other information or database system. • Supervise and manage models updating, information, reviewing processes, interference (clash) detection, etc.
Documents	• BIM templates • EIR • BEP
Roles	• BIM manager • BIM coordinator • BIM modeler
Used tools	• BACN to BIM • CYPETHERM Eplus • 3D Scan-to-BIM • BIM-based Life Cycle Cost and Asset Management • BIM Passport • BIM-BEM process • Multicriteria decision making tool • VR/AR visualisations • BIM Execution Plan
BIM Standards	• GuBIMclass (for building elements classification) • specifications have been used to develop the model template that companies must fulfil
Collaboration	Regularly scheduled meetings.

It was clear that the awarded construction company was not fluent enough in BIM. They knew the methodology and had started doing some simple things within BIM environment but did not have

enough experience and technical competence in this subject. This is why BIM Speed partners LKS, Cartif and CYPE carried out the BIM services.

4.1.6 Inhabitants and Owner Involvement

To involve inhabitants, an information office was set in the heart of the district where any interested citizen could be informed about SmartEnCity project. Then, specific meetings were held by Visesa with the owners of each community (building) which signed up in the project. In those meetings owners decided, in accordance with Visesa and Architects, over project details: technical solution (ETICS or ventilated façade), aesthetic details (colour of the façade, type of windows, etc). Once the project was fully agreed with owners, a Construction Work's Commission (group of proactive owners) was set up in each community (building) to maintain frequent meetings as main communication channel for day-to-day decisions or announcements.

4.1.7 Takeaways

1. Local SMEs are not ready yet for full BIM deployment. Public bodies must pave the way for them to get trained and experienced in this field. Public tenders must ask for BIM but it cannot be too demanding yet, otherwise tenders could be declared void because of lack of tenderers. It is still necessary to combine traditional working methodologies and BIM based methodologies until tenderers reach a certain BIM level. Full BIM performance can be achieved by big construction companies that build new buildings but local retrofitting SMEs are not ready yet. It is advisable to find out the maturity of bidding companies and take the one who is willing to learn. Also, pre-project workshop to find out together with possible applicants how and which BIM use cases should be exploited and examples should be given (e.g. quantity take off, model creation, energy performance simulations).

2. The tendering process for the retrofitting works failed to target the intended audience, SMEs. Few and mostly invalid applications were received. Visesa was inexperienced in leading a retrofitting project as they are the Social Housing Developer of the Basque Government and their core activity is developing new buildings. In these activities, project budget is much higher and as well are the requirements and only big construction companies have the technical competence and experience to carry out this kind of work. When launched the first tender process for the first retrofitting project was launched it seemed that the tender was asking for excessive requirements that SMEs could not fulfil.

3. BIM is currently in the integration process at Visesa. There is a need to define yet which are the real necessities as developers. Designing in BIM is not necessary as others do this task but it is necessary to review in an efficient way many parts of the process. Procurements for future buildings development already include some BIM requirements, although Visesa is not ready yet for

migrating the whole day-to-day workflow to BIM methodology and/or tools. BIM templates defined by Visesa are provided to any bidding company to ensure that files or projects are similar and consistent with other projects and files produced by Visesa or other bidding companies. It is a collection of settings, features, and office standards that any IFC file must comply with. For instance, this template contains all the requirements that social housing must fulfil by law. Once a new project is being reviewed, it is possible to see in a very simple way if the projected building complies with the social housing compulsory requisites. In a sense, it is fixing the way a provider must draw. It sets the nomenclature, number, and type of drawings (that later will be exported), tables structure, families of items (for instance, the family of windows that fulfil our requirements (materials, aesthetic, performance, etc.) and among which the provider may choose for his project), etc. If the BIM modeler follows the provided template, coordination will be much easier. Visesa, only should have a supervisor role.

4. It is important to start getting experience with BIM because the technology will determine the future. Projects like this demo case can be taken as an opportunity to learn. It is not necessary to instantly make the most out of a model but rather to see it as a first accomplishment creating models. The second step will then be to make use of the models when more experience is available. This step-by-step approach can guide introducing BIM.

5. Local and renovation specific characteristics must be taken into account. They have many facets; the following were encountered within this case study:
    - coordinating agreements with a variety of owners
    - convincing inhabitants of improvements
    - local heating system (individual gas boilers instead of a connection to the district heating)
    - BIM knowledge of the local companies was very basic

4.2 Demo Case Warsaw II, POLAND

On January 24, 2020, the Capital City Development Authority announced a tender for the development of design and tender documentation for the reconstruction of the existing underground passage. The design had to include a change of the functionality of the space to a social and hygienic point. The investment is entitled "Adaptation of the underground passage under Waryńskiego street as a first contact point for homeless people".

The scope of work consists in demolishing everything that is in the underground passage and building partition walls and installations from the beginning

4.2.1 At a glance

Table 8 shows the project's profile.

Table 8: Project profile Warsaw II

Project Description	
Project	Warsaw II
Location	Warsaw, Poland
Building Type	Multi-family dwellings
Building size	Three-storey-buildings
Contract Type	SMEs
Building Owner	City of Warsaw
Architect	n.a.
Contractor	n.a.
Project cost (VAT not included)	n.a.
Project Characteristics	
Private / Public	public
owner occupied	no

4.2.2 Project Description

Table 9 shows the retrofitting and BIM work descriptions which were carried out.

Table 9: Work descriptions Warsaw II

Retrofitting Work Description	
Project	Warsaw II
Improvements	Building Envelope
	HVAC System
BIM Work Description	
BIM, Models	BIM has been integrated at the design phase. The following BIM models will be made: • Architectural with land development, • Construction, • Water and sewage installations, • Electrical installation, • Air conditioning installation, • Heating installation

4.2.3 Detailed BIM Work Description

The BIM works included as a first step scanning the underground passage for the purpose of making an inventory. Using this data, the BIM models were prepared. Also, a coordination process using the BIM models was introduced.

The use of the BIM methodology resulted in reducing the amount of waste and shortening the implementation time. Apart from this, based on the BIM models the implementation schedule could be simplified.

A difficulty that arose was the location of the point cloud: here, particular attention had to be paid to locate the point cloud in the correct coordinate system.

4.2.4 Legal Strategies

Table 10 shows certain aspects of legal strategies of the case study.

Table 10: Legal strategies Warsaw II

Legal Strategies	
Contract type	Bid-Design-Bid-Build
Tendering Process	It was difficult to find the design office that could meet the client's requirements and work in BIM. For this reason the procurement process had to be repeated.
Award Criteria	• Cost and time

	• experience in retrofitting • technical competence
Liability	
Main Contract	ordinary liabilities (quality etc.)
BEP	The contractor developed procedures taking into account: a) collision detection; b) compliance of component parameters; c) the naming convention; d) rules adopted at the Calibration Stage adjusted to the proposed BIM Implementation Plan.

4.2.5 BIM Strategies

Table 11 shows certain aspects of BIM strategies of the case study.

Table 11: BIM strategies Warsaw II

BIM Strategies	
Procurement Requirements	In the procurement process there were the following BIM requirements: • Inventory of the existing state based on a point cloud as a result of 3D scanning. • Execution project made in BIM. • Bills of quantities and Investor cost estimates prepared on the basis of BIM models of the detailed design. • Quantity takeoff and cost estimates prepared on the basis of executive design. • The implementation schedule should present the works on the basis of the existing BIM models.
Documents	EIR and BEP were applied: EIR was prepared at the procurement stage. BEP was prepared by the design office at the calibration stage. The main goals of BEP were as follows: • a. determining the framework for design works; • b. standardization of file names; • c. analysis of the condition of the existing facility; • d. verification of the assumptions of the construction design; • e. use of the CDE platform as a data exchange platform between the employer and the contractor;

	• f. support for the project management process in terms of the deadline and cost of implementation; • g. developing a modeling schedule based on the agreement and the employer's requirements.
Roles	BIM coordinator
Used tools	The following BIM-SPEED tools have been or will be tested in the project: • BIM-SPEED platform • 3DASH (3D Scan to BIM) • BIM Execution Plan • CYPETHERM Plus • Multicriteria decision making tool • VR/AR • Acoustic tool
BIM Standards	The following file formats were applied: • * .ifc - models in IFC 2x3 format; • * .bcf - communication in the BIM environment; • * .pdf - uneditable files; • * .dwg - editable files, openable by ACAD, version from 2017; • * .e57 - point cloud file; • native format - files transferred along with other documentation at the end of contractual stages. CDE compliant with the standard PN-EN ISO/IEC 27001:2017-06.
Collaboration	Coordination and MEP models published by the design office every three weeks.

4.2.6 Inhabitants and Owner Involvement

Because the underground passage is closed, no inhabitants can be involved.

4.2.7 Takeaways

1. The time to choose a design office should be longer. This applies to smaller projects where smaller design offices present their offers.
2. Trainings are needed for small and medium-sized design offices to increase their competences in the field of openBIM.
3. Setting goals for the use of the BIM methodology is very important to achieve good project quality. These goals can be for example:
    a. Implementation of investments within the assumed budget.
    b. Completion of construction works on time.
    c. Optimization of facility construction implementation costs.

d. Obtaining a facility with a high level of energy efficiency and environmental friendliness.

e. Obtaining an object with the lowest possible cost of maintenance.

f. Support for cooperation and improvement of communication between entities implementing the investment - a pilot project for the Ordering Party

5. Summary

This guideline introduced the reader to common procurement procedures and public procurement legislation across the European Union, in particular talking about BIM-based approaches. Following the content line of procurement, BIM collaboration protocols as part of each procurement process were presented. EIR, BEP and BIM protocol are crucial to successful projects. The possibilities on combining EIR and BEP in the procurement phase were discussed as they have various pros and cons. Falling and standing with EIR and BEP are the BIM use cases which are particularly lacking for BIM-based renovation projects. This is why possible use cases for renovation were touched.

The simultaneous application of BIM technology and IPD project delivery method on renovation projects have the potential to mutually reinforce each other; specifically, the cooperation, sharing of information and risk management. Stakeholders should take the opportunity to apply both promising approaches to reduce time and budget expenditure in renovation projects and yield important experiences which may lead to future market advantages.

In order to allow building owners, public procurers and stakeholders on the supply side to adopt to the changes created by the use of methods such as IPD and BIM, strategic and practical guidelines and possible solutions to existing issues were developed and thoroughly described.
The case study of the BIM-SPEED demo case presented a real-life BIM-based renovation project and helps gaining a deeper understanding of the possibilities when working with BIM in renovation as well as best and worse practices.

In summary, this document gives guidance on BIM procurement for renovation projects covering strategies, protocols and project delivery methods such as IPD. Introducing these methods cannot be accomplished on short notice. Based on complexity, experience, data availability, budget, etc. the extent of use has to be evaluated and carefully scaled.

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Biudžetinė įstaiga https://statyba40.lt/wp-content/uploads/2020/08/LRV_2020_05_20_pasitarimo_protokolo_Nr_25_2_kl_israso_kopija.pdf (last viewed: 30.09.2021)

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RVB BIM Specificatie: https://www.rijksvastgoedbedrijf.nl/expertise-en-diensten/building-information-modelling/rvb-bim-norm (last viewed: 30.09.2021)

RVB CAD Specificatie: https://www.rijksvastgoedbedrijf.nl/expertise-en-diensten/building-information-modelling/rvb-cad-specificatie (last viewed: 30.09.2021)

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Other

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APPENDIX 1 – Overview of standardised Use Cases

Table 12: Overview of standardised Use Cases

Country	Focus	Publisher/ Organization	Link
International	General (including BIM-SPEED UC)	buildingSMART International	click here
Germany	Infrastructure	BIM4INFRA/ BMVI	click here
Lithuania	General	Skaitmeninė statyba	click here
			click here
			click here
			click here

APPENDIX 2 – Overview of templates

Table 13: Overview of templates

Country	Type of Template	Focus	Publisher/ Organization	Link
Germany	EIR	Infrastructure	BIM4INFRA/ BMVI	click here
	BEP	Infrastructure	BIM4INFRA/ BMVI	click here
	BIM protocol/ BIM-Besondere Vertragsbestimmungen	Infrastructure	BIM4INFRA/ BMVI	click here
				click here
Lithuania	Various (EIR, BIM protocol)	General	Skaitmeninė statyba	click here
Netherlands	Various (EIR, BIM protocol)	General	BIM Loket	click here
United Kingdom	BIM protocol	General	Construction Industry Council	click here
				click here
				click here

APPENDIX 3 – Overview of guidelines and glossaries

Table 14: Overview of guidelines and glossaries

Country	Type of Document	Focus	Publisher/ Organization	Link
Germany	Set of Guidelines	Infrastructure	BIM4INFRA/ BMVI	click here
	Glossary	Infrastructure	BIM4INFRA/ BMVI	click here
	Glossary	General	buildingSMART Germany	click here
	Guideline	General	buildingSMART Germany	click here
Lithuania	Set of Guidelines	General	Skaitmeninė statyba	click here
				click here
				click here
				click here
				click here
				click here
				click here

APPENDIX 4 – Overview of standards

Table 15: Overview of standards

Country	Name	Topic	Focus	Publisher/ Organization
International/ European/ EU country	DIN EN ISO 12006 - Building construction - Organization of information about construction works	Data structure for BIM-catalogues	General	DIN
	DIN EN ISO 16739 - Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries	Data exchange	General	DIN
	DIN EN ISO 16757 - Data structures for electronic product catalogues for building services	Data structure for BIM-catalogues	General	DIN
	DIN EN ISO 17412 - Building Information Modelling - Level of Information Need - Concepts and principles	Data exchange	General	DIN
	DIN EN ISO 19650 - Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) – Information management using building information modelling	Strategy/ Information Management	General	DIN
	DIN EN ISO 21597 - Information container for linked document delivery — Exchange specification	Data exchange	General	DIN
	DIN EN ISO 29481 - Building information models - Information delivery manual	Information management with BIM	General	DIN
	VDI 2552 - Building Information Modeling	Generally recognised codes of practice	General	VDI

Appendix 5 – National Levels

The following paragraphs present the details of the analysis on national levels regarding BIM regulations as summarised in chapter 2.1.2. The discussed countries are:

- Germany
- Netherlands
- Spain
- Italy
- Lithuania
- Poland
- Hungary

Table 16: Key questions; questionnaire for acquisition of information

Topic	Question
BIM-based procurement	Do national legal frameworks exist? Which laws exist? Is BIM mandatory?
	Do national guidelines exist? Are they provided on a federal base or by the industry/ umbrella organisations? Provide some information about each guideline, e.g. for which sector is this guideline? Infrastructure, structural engineering, renovation?
	What else to be aware of?
BIM in general	Do national legal frameworks exist? Which laws exist?
	Do national guidelines/ templates provided on a federal base exist?
	Do national guidelines/ industry codes/ templates provided by the industry/ umbrella organisations exist?
	Are there national initiatives for BIM-Glossary (common definition of BIM technical terms)?
	What else to be aware of?
Renovation	Do national legal frameworks exist?
	Do national guidelines/ industry codes exist?

	E. g. ISO 7518 - Technical drawings; construction drawings; simplified representation of demolition and rebuilding

Germany

In Germany the above-mentioned EU directive of 2014 was implemented by the "Vergaberechtsmodernisierungsgesetz (VergRModG)". This law lays down the course of the award procedure, from the specification of services to the examination of grounds for exclusion, the suitability test, the award of the contract and the conditions for the performance of the contract.[21]

In general, the VOB/A ("Vergabe- und Vertragsordnung für Bauleistungen – Teil A: Allgemeine Bestimmungen für die Vergabe von Bauleistungen") provides regulations concerning the award of construction contracts. It does not have the status of a law but is still mandatory for public sector contracts below the EU threshold. Three areas are being distinguished: national procurement procedures, EU tenders and procedures in sector contracting authorities. Similar to the awarding contracts above the EU thresholds, the processes for awarding contracts below the EU thresholds are also being extensively digitized. Award procedures can be handled completely electronically via the website www.evergabe-online.de .[22]

Regarding BIM and public procurement, it must be noted that since the end of 2020, a soft BIM mandate came into force for all publicly tendered infrastructure projects. The German Federal Ministry of Transport and Digital Infrastructure (BMVI) aims to award contracts to companies that work with BIM, at least in the planning phase. This applies to both infrastructure construction and infrastructure-related building construction. I.e., BIM is still not mandatory in infrastructure but it is desired. For building construction BIM is not mandatory in general. But federal projects with a construction cost volume of 5 million euros or more represent a special case: According to a decree from 2017, the use of BIM must be examined.

The national BIM center "BIM Deutschland – Zentrum für die Digitalisierung des Bauwesens" is the federal government's central public point of contact for information and activities related to BIM. It provides advice and information regarding BIM to all players in the construction value chain.

To implement the BIM mandate for infrastructure, the BIM4INFRA2020 project has released a series of guidelines. They are useful in the context of public procurement as for example parts 2 and 3 explain about EIR respectively BEP. Another helpful series of national guidelines consists of VDI 2552 which represent the national position of Germany's Association of Engineers (VDI) in the international BIM standardization activities. With the publication of DIN SPEC 91391 a national proposal for functional requirements of a common data environment (CDE) is presented.

[21] https://www.bmwi.de/Redaktion/DE/Artikel/Service/vergaberechtsmodernisierungsgesetz.html
[22] https://www.bmwi.de/Redaktion/DE/Dossier/oeffentliche-auftraege-und-vergabe.html

Netherlands

Most common BIM contractual documents

In the Netherlands the most common BIM addendums that are nowadays being added to building contracts are: the Information Delivery Specification (IDS), the BIM Protocol, and the BIM Execution Plan (BEP). The IDS describes *what* must be delivered, the BIM Protocol describes *how* it will be delivered, and the BIM Execution Plan contains working agreements between BIM parties.[23] The IDS and the BIM Protocol are often contractual documents, while the BEP is not. However, exceptions might occur.[24]

National BIM Norms

BIM Protocols and BIM Execution plans are largely standardized in the Netherlands, since in May 2017 the Dutch Building Information Counsil (Bouw Informatie Raad - BIR) in collaboration with the Dutch public BIM platform BIMLoket, published the Dutch *National Model BIM Protocol* [24] and the *National Model BIM Execution Plan* [25]. Both can be seen as templates for defining project-specific BIM agreements, or as checklists for BIM related aspects that need to be addressed in contracts between client and contractor. The documents are largely based on the international ISO 19650-1 & 2, and ISO 29841-1 & 2. BIR followed the British example of separating contractual definitions and working agreements.[24]

BIM not yet mandatory

BIM is not yet a legally mandated requirement in the Netherlands, but it is generally considered to be desirable and demandable.[26] In the past the Dutch Governmental Real Estate Agency 'Rijksgebouwendienst' (RGD) did mandate BIM deliveries from market parties. However, when the RGD merged into the 'Rijksvastgoedbedrijf' (RVB) in 2014, the mandatory state of BIM did not remain in force.

Governmental BIM norms for buildings

The Dutch Governmental Real Estate Agency (Rijksvastgoedbedrijf, RVB) maintains their own BIM guidelines since 2014: the RVB BIM Norm[27], and the RVB BIM Specification[28]. The RVB BIM norm prescribes BIM in various contract forms, such as in DBFMO contracts. In contract types where the RVB does not (yet) prescribe a BIM specification, the RVB prescribes the RVB CAD Specification.[29]

Governmental BIM norms for infrastructure

[23] https://www.omgevingsweb.nl/nieuws/bim-hoe-werkt-het-contractueel/
[24] https://www.bimloket.nl//documents/Nationaal_Model_BIM_Protocol_Release_0_9.pdf
[25] https://www.bimloket.nl//documents/Nationaal_Model_BIM_Uitvoeringsplan_Release_1_0.pdf
[26] https://bpd.ogdb.nl/external/bimkeepercom/news/nl/169/wordt-bim-ook-in-nederland-verplicht-
[27] https://docplayer.nl/5945907-Rijksvastgoedbedrijf-rvb-bim-norm.html
[28] https://www.rijksvastgoedbedrijf.nl/expertise-en-diensten/building-information-modelling/rvb-bim-norm
[29] https://www.rijksvastgoedbedrijf.nl/expertise-en-diensten/building-information-modelling/rvb-cad-specificatie

The Dutch Governmental Infrastructure Agency (Rijkswaterstaat, RWS) also maintains their own BIM program called AIRBIM, which aims to standardize the way in which project data is described, collected, stored, managed, and exchanged.[30] Recently, AIRBIM was limited by order of the minister of Infrastructure, because its Object Type Library (OTL) was considered too complex. The OTL is now being simplified.[31]

BIM Basis ILS (BIM Basic IDS)

Since many years the Dutch BIMLoket maintains a national open BIM standard called the BIM Basis ILS (BIM Basic IDS)[32]. The BIM Basis ILS describes the minimal step for delivering exchangeable, structured, unambiguous, correct, complete and reusable data. It is a very low-level and easy-to-reach benchmarking document that has helped many companies in the Netherlands to make their first steps with BIM. The BIM Basis ILS is (as an unwritten rule) always the minimal BIM requirement in any cooperative BIM project.

BIM knowledge cards

In 2014, BIR released a set of BIM 'knowledge cards'. Each knowledge card is a brief, two-sided A4 document about a specific BIM theme. In a time where BIM was rising among the Dutch industry, the knowledge cards provided a very clear and low-level support to companies who were starting out with BIM. Two knowledge cards were dedicated solely to legal aspects: 4A and 4B.[33]

Further research on BIM legal aspects

In 2013, TNO (Dutch organisation for applied scientific research) published a research article called 'Blueprint for legal agreements for collaboration in projects with BIM'. It consists of 2 parts: 1) Overview of the most important legal aspects for collaboration with BIM, 2) Identification of BIM related tasks. Annex 2 gave an extensive overview of the then applicable legal and regulatory factors. Annex 3 gave an overview of the status quo regarding international BIM guidelines.[34]

In 2018, BIMLoket executed research called 'Space for BIM in legislation' (BIMLoket, 2018), aimed towards exploration of short-term opportunities for BIM in legislation and regulations. The main conclusion was that investments in BIM by the construction sector could lead to better financial and social returns if existing barriers for BIM in Dutch legislation would be removed. The report provides recommendations for legal adjustments.[35]

Poland

BIM is still not mandatory in Poland, however BIM requirements appear in both public and private tenders. By the end of 2019, around 70 procedures were announced with BIM requirements (also used as a non-price

[30] https://www.rijkswaterstaat.nl/zakelijk/werken-aan-infrastructuur/efficienter-werken/bouwwerk-informatie-model
[31] https://dutchitchannel.nl/641269/rijkswaterstaat-moet-airbim-project-op-last-van-minister-aanpassen.html
[32] https://www.bimloket.nl/p/294
[33] https://www.bimloket.nl/p/114/Kenniskaarten
[34] https://www.bimregister.nl/actueel/documentatie/download/71_e2c420d928d4bf8ce0ff2ec19b371514
[35] https://www.bimloket.nl/p/118/BIM-in-wet--en-regelgeving

criterion for evaluating offers). Work on BIM standards has been carried out in recent years by various Polish ministries. The current work is led by the Ministry of Infrastructure. The construction market, seeing the potential of innovative technologies, including BIM, began to organize itself by establishing the following associations and foundations:

- BIM Cluster (2021 year);[36]
- BIM Association for the Polish Construction Industry (2014 year);[37]
- Foundation of the European BIM Certification Centre (2016 year);[38]
- BuildingSMART Poland (2019 year).[39]

In 2016, KPMG published an expert opinion commissioned by the Ministry of Infrastructure and Construction on the possibility of implementing the BIM methodology in Poland. [40] The market of designers and contractors declared high rates of awareness of the existence of the BIM methodology - 66% and 80% respectively. It is partially applied by 28% and 18% respectively. As many as 58% of designers and 62% of contractors believe that they would not be able to fulfil public procurement requirements that include BIM methodology. Within 5 years, the implementation of BIM was planned to be carried out by 42% of designers and 20% of contractors. Among the tools for exchanging information with the ordering party, e-mail dominated, cloud-based tools, including CDE systems, were used by very few designers and contractors. Almost 80% of respondents in 2016, believed that public procurers are not prepared to implement projects in BIM (38% believed that they lack basic knowledge). According to the respondents, the biggest barriers to implementation in Poland are its ignorance among contracting authorities and costs. BIM professionals also clearly indicated the lack of standardization.

The BIM Association for the Polish Construction Industry published the important BIM Standard PL[41] in 2020. This is handbook that includes templates and documents to support investors, including public procurers, in the effective and efficient preparation and implementation of investments in accordance with the BIM methodology. However, it should be remembered that this is a publication and not an applicable standard. The buildingSMART Poland association has already started activities aimed at developing construction classification for the needs of Polish investments.

The Ministry of Development created the official government application[42] for submitting applications in the construction process. It is possible to download and complete building forms online and submit them electronically to the public office. Legal changes related to the BIM methodology planned for the end of 2021 have not yet happened. Some templates and materials that in the meantime should support the work in BIM have been published by the Ministry of Development.[43]

[36] https://www.bimklaster.org.pl/en/
[37] https://plbim.org/
[38] https://eccbim.org/
[39] https://buildingsmart.org.pl/
[40] KPMG Report, 2016 www.gov.pl/web/rozwoj-technologia/cyfryzacja-procesu-budowlanego-w-polsce--zakonczenie-projektu
[41] https://drive.google.com/file/d/1DYsSj9MKNBLE2K23b9pyxQ7VxG27VSSn/view
[42] https://e-budownictwo.gunb.gov.pl/
[43] www.gov.pl/web/rozwoj-technologia/cyfryzacja-procesu-budowlanego-w-polsce--zakonczenie-projektu

Lithuania

The Ministry of Environment of the Republic of Lithuania has decided to implement project No. 10.1.1-ESFA-V-912-01-0029 "Development of tools for increasing the efficiency of the life cycle processes of public sector structures using information modeling of a building" (the so called "BIM-LT" project). This project is funded by the European Social Fund according to the 2014–2020 Operational Programme for the European Union Funds' Investments under measure "Promoting National Reforms and Improving the Performance of Public Institutions" and is supposed to run till beginning of 2022.[44] The main goal of the project is to increase the efficiency of the use of resources allocated for the planning, design, construction, operation and management of construction of public sector buildings by applying BIM.

While implementing BIM-LT project, the following activities are being performed:

- Preparation of draft provisions of BIM application in public procurement,
- Preparation of BIM-LT project implementation guidelines,
- Preparation of a national classification information in construction sector,
- Implementation of training related to BIM application.

In May 2020, the Lithuanian Government decided that the application of BIM must become the basis for construction and installation of buildings and / or related objects implemented by the public sector and accordingly rules of public procurement related to them.[45] Point 3 of the decision sets out mandatory use of BIM as of 1 January 2021 when designing, constructing new objects, installing, and rearranging special movable objects that meet the following criteria:

- The customer of design, construction and installation works is one of the following entities: Lithuanian Road Administration, Lithuanian Railway Infrastructure, State Enterprise "Turto Bankas", Lithuanian Electricity transmission system operator "Litgrid", Lithuania's natural gas transmission "Amber Grid", Lithuania's electricity distributor "ESO";
- the preparation of the project lasts 12 months or more;
- the estimated construction price or the planned installation and investment amount is equal to or exceeds:
    - for buildings - EUR 5,000,000;
    - for engineering structures, movable objects - EUR 10,000,000.

On 15 April 2021, the Parliament of Lithuania adopted amendments to the Law of Public Procurement. They foresee an obligation to use BIM methods in the design, construction and installation of public sector buildings and movable objects (gas pipelines, electricity networks, etc.) as of 1 December 2021.[46] Application of BIM in public procurement will be determined gradually, more detailed rules should be set

[44] https://statyba40.lt/titulinis/bim-lt-projektas/
[45] https://statyba40.lt/wp-content/uploads/2020/08/LRV_2020_05_20_pasitarimo_protokolo_Nr_25_2_kl_israso_kopija.pdf
[46] https://e-seimas.lrs.lt/portal/legalAct/lt/TAP/1fafd0b08d5311eb998483d0ae31615c

out and authorised by the Government by the end of August 2021. These public law amendments are considered as an important step in digitalization of construction sector and one of the key elements in promoting BIM methods.

Spain

In Spain, the use of BIM started in 2010, when large companies in the sector (construction and engineering companies) had to use it in large international projects, especially in countries in the Middle East, the United States and Northern Europe. As in other European Union countries, as a result of the Public Procurement Directive and the emergence of government strategies for the implementation of BIM, the main national actors began a series of initiatives that promote the implementation of this process.

At the national level, in 2015, the Ministry of Public Works set up the esBIM Commission, made up of representatives from public and private organisations. It promotes the use of BIM through the publication of a series of guides and informative documents. During this period, the Public Sector Contracts Act is published, which, as will be seen later, introduces the possibility for public bodies to require the use of BIM in projects and works, although not on a mandatory basis. At regional level, it is worth highlighting the initiatives launched in Catalonia, led by the Government of Catalonia. The government is launching a mandate whereby BIM becomes mandatory from 11 June 2019 for projects and works of a certain size.
Although BIM is not mandatory in Spain (with the exception of Catalonia), an increasing number of public bodies at any level (national, regional or local) have decided to require the use of BIM in their projects and works, either as a requirement or as a valuable element in the offer. Among these organisations, it is worth highlighting those that have also started an internal BIM implementation process, such as ADIF, AENA, Renfe, Correos, Puertos del Estado or Ferrocarrils de la Generalitat Valenciana. This is reflected in the increasing number of public tenders with BIM requirements, reaching 351 by the end of 2019, which represents a growth of more than 70% compared to the previous year, according to data provided by buildingSMART Spain and the Public Tenders Observatory of esBIM.

Italy

BIM was first introduced in Italy in 2016, with the New Procurement Code (Legislative Decree 50/2016). From the following year, the Baratono Decree (or BIM Decree) sanctions its progressive compulsoriness, from 2019 to 2025, for public works of increasing complexity. In implementation of the BIM Decree, the obligation to adopt BIM methodologies in Public Works from 1 January 2019 can be summarised as follows:

- from 1 January 2019 for complex works with a contract value of EUR 100 million or more
- 1 January 2020 for complex works with a value of €50 million or more on the basis of a call for tenders
- from 1 January 2021 for complex works relating to works with a value of EUR 15 million or more as a basis for tenders
- from 1 January 2022 for works with a contract value equal to or greater than the threshold set out in Article 35 of the Public Contracts Code

- from 1 January 2023 for complex works relating to works with a value of EUR 1 million or more as a basis for tenders
- from 1 January 2025 for complex works relating to works with a contract value of less than €1 million.

With the entry into force of Ministerial Decree 312 of 2 August 2021, which amends and updates the BIM Decree of 2017, new methods and timeframes have been defined for the gradual introduction of electronic modelling methods and tools in public works contracts in the construction and infrastructure sectors. The new Ministerial Decree 312 then introduces a partial relaxation of the constraints on the entry into force of the mandatory nature of BIM, with the exclusion of ordinary and extraordinary maintenance works and works below €1 million. This new timeframe will allow companies to make up for the delays caused by the pandemic, and Public Administrations to prepare themselves as best they can and overcome the criticalities that have so far held back the integration of the BIM methodology in their processes.

As far as standardisation processes are concerned, UNI 11337 is the first real Italian technical standard on BIM. UNI 11337 applies the international standards established by ISO 19650, adapting them to the Italian context. The standard consists of several parts and currently six have been published (parts 1-3-4-5-6-7). Furthermore, at the end of 2019, UNI/PdR 74:2019 was published, which is the reference practice for the definition of a BIM Management System (SGIBIM) that an organisation must implement to improve the efficiency of the process of planning, design, production, operation and eventual decommissioning of the work. The objective of this document is to provide essential elements for the certification of the organisation's BIM management system, whether the organisation is a client or a contractor.

Hungary

In Hungary, there isn't any legal framework or national guidelines in place for BIM-based procurement or building renovation. The use of BIM is not mandatory, but national authorities require it in almost every national project and it is up to the client/contractor whether they will use it or not.
In terms of BIM guidelines, there is a publication called the BIM handbook (BIM KÉZIKÖNYV) developed by Lechner Knowledge Center . It is publicly available and introduces BIM without providing any specialized information. However, some progress is expected soon with more chapters becoming available. Also, it is worth mentioning that the international standard for BIM, EN ISO 19650-1: 2019 has been translated in Hungarian by the Hungarian Standards Board.