

# Digitalization Tools for Energy-Efficient Renovations <sup>†</sup>

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**Abstract:** Digital transformation in the built environment is a fact that will shape the industry, increasing its efficiency and improving its quality. However, there are many challenges still facing the industry to complete this transformation. Under this theme, during the Sustainable Places 2020 virtual conference on 28th October 2020, nine EU-funded research projects gathered in a workshop to showcase their projects and demonstrate some of the innovative solutions developed within their projects. This post-workshop report gives brief information about the participant projects. It outlines the main topics covered in the presentations and, moreover, highlights the main innovative tools presented in this workshop. The representatives agreed that strengthening the synergy among different their projects would be a benefit for all.

**Keywords:** digitalisation; BIM; IFC; energy; renovation; digital twin

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## 1. Introduction

Digital transformation is taking place at a slow pace in the European construction industry, which means a huge gap between theoretical digital opportunities and the realities of on-site construction. On the other hand, most of the EU building stock comprises existing buildings. Moreover, supporting the renovation interventions is a key challenge, since it may contribute to collaboration, cost efficiency, and time savings. At the same time, it guarantees process quality along with all the renovation phases, solving some of the hindrances due to the uncertainty of the process. Particularly, the use of Building Models allows storing and sharing the information about the existing building through Building Information Modelling (BIM). This is a crucial point to avoid uncertainties, since the models are fed and checked by all stakeholders.

This workshop has brought together nine EU-funded projects involving experts from the industry to present their research projects, highlighting the main challenges and demonstrating some of the solutions and methodologies used. The workshop was divided into two sections; in the first section, each project pitched their progress and intermediate achievements. In the second section, a selection of innovative tools was presented and demonstrated in a real application.

## 2. Speakers

Antoine Dugue	Nobatek Inef4, France
Asier Mediavilla	Tecnalia, Spain
Bruno Daniotti	Politecnico Di Milano, Italy
Bruno Fies	CSTB, France
Cecilia Bolognesi	Politecnico Di Milano, Italy
Eduard Loscos	IDP, Spain
Elisabeth OBrien	Limerick Institute of Technology, Ireland
Fenareti Lampathaki	Suite5, Greece
Giorgos Giannakis	Hyper Tech, Greece
Larissa De Rosso	Architects' Council of Europe, Belgium
Mikel Borràs	IDP, Spain
Mohamed Elagiry	R2M Solution, Italy
Otilia Werner-Kytölä	Fraunhofer, Germany
Riccardo Viaggi	CECE, Belgium
Sebastian Scholze	ATB, Germany
Timo Hartmann	TU Berlin, Germany

## 3. Participant Projects

### 3.1. BIM4Ren

BIM4REN [1] (Building Information Modelling-based tools and technologies for fast and efficient RENovation of residential buildings) is aiming to develop BIM tools for fast and efficient energy renovation. That starts from three workflows adapted to the construction sector segmentation (90% of companies are SMEs) presenting particular technical and organisational requirements and has adapted the project and consortium to provide adequate and innovative processes, methodologies, software, and hardware tools as well as BIM developments for each one of them. The BIM4Ren digital ecosystem will be accessible via a web-based One-Stop Access Platform, where, depending on each user profile regarding needs and orientation, best practice examples from a dedicated database and links to the different tools and services (from top grade to entry level) will be provided on differentiated access schemes underpinned by different business models. Inspired by the Open Innovation 2.0 paradigm, the project will set up a demonstration campaign with “pilots as Living Labs” integrating all stakeholders in three cities (Paris, San Sebastian, and Venice).

### 3.2. BIM4EEB

BIM4EEB [2] (BIM-based fast toolkit for Efficient rEnovation in Buildings) aims to foster the renovation industry by developing an attractive and powerful BIM-based toolset that is able to support designers in the design and planning phase, construction companies to efficiently carry out the work, and service companies to provide attractive solutions for building retrofitting. Additionally, public and private owners will be able to use a tool that eases decision making and asset management thanks to the exploitation of augmented reality and the use of updated digital logbooks. BIM4EEB will deliver an innovative common BIM management system with linked data and a set of tools. This toolkit is the basic instrument for increasing semantic interoperability between software and stakeholders involved along the overall renovation process (design, planning, construction, performance assessment, and management). End users of the entire renovation process will actively participate in the development phases ensuring the full matching of project deliveries with the market expectations and maximising the value of what is produced. In particular, two public administrations and two general contractor companies will validate the toolset in a social housing setting and private residential buildings in Italy, Poland, and Finland. Inhabitants will benefit from the increase of building performances, quality, and comfort.

### 3.3. BIMSPEED

BIMSPEED [3] (Harmonised Building Information Speedway for Energy-Efficient Renovation) aims to enable all stakeholders to adopt BIM to reduce the time of deep renovation projects by at least 30% by providing them with (1) an affordable BIM cloud platform, (2) a set of interoperable BIM tools, and (3) standardised procedures for as-built data acquisition, modelling, simulation, implementation and maintenance of renovation solutions. BIMSPEED relies on a trans-disciplinary approach comprising (i) process, (ii) ICT (Information and Communication Technologies), and (iii) social innovation with special attention to the stakeholders as a key success factor for BIM adoption. The interoperability of a full range of BIM tools for renovation will be accommodated on an innovative BIM cloud platform, which will be launched and available free of charge for all stakeholders immediately from the beginning of the BIMSPEED project. BIMSPEED will engineer the seamless integration and quick installation of building and HVAC (Heating, ventilation, and air conditioning) products for renovation into the existing buildings. Such “plug and play” solutions are crucial for overall time reduction. BIMSPEED will demonstrate the holistic solution in 12 real demonstration cases. An EU-wide BIM Competition will be jointly organised by the European umbrella organisations in all disciplines (architects, HVAC engineers, and construction firms) to kick off the first market replication in more than 200 BIM-based renovation projects.

### 3.4. ENCORE

ENCORE [4] (ENergy aware BIM Cloud Platform in a COst-effective Building Renovation Context) aims to increase the share of renovated stock in Europe and worldwide by providing effective and affordable BIM tools that cover the whole renovation life cycle (from data collection to project execution, and commissioning/delivery). It will tackle energy efficiency and comfort parameters, involving all the actors in the process (architecture studios, designers, constructors, tenants, or public administration), and facilitating information exchange among all the parties. To achieve this objective, ENCORE proposes the creation of a system that integrates services for data acquisition from the buildings such as static LiDAR (Light Detection and Ranging) setups, and LiDAR or photogrammetry equipment embarked in UAVs. (Unmanned Aerial Vehicle Scanning) It will also allow involving dwellers in the process by providing them with mobile tools to capture images or other indoors information. It also provides support to architects and designers in the creation of the 3D models from the acquired data, automatically identifying and classifying the constructive elements, and allowing them to complete the model with existing BIM resources. They will be able to modify the model, presenting the energy efficiency gains of different renovation alternatives, including the impact in the overall budget.

### 3.5. BIMERR

BIMERR [5] (BIM-based holistic tools for Energy-driven Renovation of existing Residences Building) will design and develop a Renovation 4.0 toolkit that will comprise tools to support renovation stakeholders throughout the renovation process of existing buildings, from project conception to delivery. It comprises tools for the automated creation of enhanced building information models, a renovation decision support system to aid the designer in exploring available renovation options through the accurate estimation of renovation impact on building performance, as well as a process management tool that will optimise the design and on-site construction process towards optimal coordination and minimisation of renovation time and cost. At the heart of the BIMERR toolkit lies an interoperability framework, which will enforce semantic interoperability among BIMERR tools as well as with third-party legacy ICT tools to enable seamless BIM creation and information exchange among AEC (Architecture, Engineering and Construction) stakeholders to enhance the rapid adoption of BIM in the renovation of the existing EU building stock. The BIMERR toolkit will be validated and demonstrated in four buildings in three European Member States.

### 3.6. RenoZEB

RenoZEB [6] (Accelerating Energy renovation solution for Zero Energy buildings and Neighbourhoods) aims to unlock the nZEB renovation market leveraging the gain on property value through a new systemic approach to retrofitting that will include innovative components, processes, and decision-making methodologies to guide all value-chain actors in the nZEB (nearly Zero Energy Building) building renovation process, including integrated solutions with the highest impact in the revalorization of the building. This will be achieved through the following: (a) development of an innovative holistic, cost-effective, and fast deep retrofitting methodology for nZEB; (b) supporting the methodology for nZEB renovation, through ICT tools; (c) development of a cost-effective and non-intrusive prefabricated multifunctional modular “plug and play” system for the renovation of buildings; (d) increasing the post-retrofitting property value through the transformation of buildings into an active energy; (e) nodes through a smart control and monitoring system; (f) new collaborative multi-value, multi-stakeholder methodologies and decision-making processes for selecting the best energy-efficient renovation strategy; (g) creation of new drivers of change for the real estate industry creating fresh post-renovated property value schemes; (h) demonstration to the market of the replicability of the holistic methodology and new technologies through (i) three virtual demonstration sites; and (j) boosting the nZEB market through training and awareness of the value chain.

### 3.7. SPHERE

SPHERE [7] (Service Platform to Host and Share Residential data) aims to improve and optimise the buildings' energy design, construction, performance, and management, reducing construction costs and their environmental impact while increasing overall energy performance. It will integrate two planes of research, innovation and improvement: (1) integration of the processes under the Digital Twin Concept involving not only the design and construction of the building but including also the manufacturing and the operational phases; (2) an integrated platform that will be achieved through an underlying ICT system of systems infrastructure based on Platform as a Service (PaaS) service to allow large-scale data, information and knowledge integration, and synchronisation, thus allowing better handling and processing. This Digital Twin Concept is a distributed but coordinated database, including geometrical objects information that forms a unique synchronised virtual model of the reality. The Digital Twin Concept, platform, and tools will be tested in four real pilots and finally validated both technically and especially with final social acceptance to accelerate market uptake.

### 3.8. BIMzeED

The BIMzeED project [8] focusses on the training needs for the current and future construction industry with the main purpose to encourage (1) better employability, (2) low-carbon growth, (3) green and nZEB skills, and (4) increase in youth employment. The challenge of the BIMzeED project is to overcome skills mismatching and improve employability in the current European construction market by improving and extending the existing skills of trainers, SMEs (Small and medium-sized enterprises), site managers, craftworkers, and other experienced operatives.

### 3.9. DIGIPLACE

DIGIPLACE [9] (Digital Platform for Construction in Europe) aims to create a common ecosystem of innovation, standardisation, and commerce to increase the construction sector's productivity and end products' quality in terms of buildings and infrastructure. It will also investigate what kind of digital transformation will improve productivity and efficiency. The project's results will impact the development and competitiveness of the construction value chain.

## 4. Presentations

This section will highlight the main topics covered in each presentation.

### 4.1. BIM4Ren

- Proposed workflow (data collection, data management, data-driven design)
- Main barriers: BIM2BEM interoperability, collaborative design, and differentiating the workflow and tools depending on needs and capacities
- Renovation scenario definition
- Need for common definition/standardisation

### 4.2. BIM4EEB

- Information requirements for an efficient renovation process
- BIM management system and toolkit CDE (Common Data Environment)

### 4.3. BIMSPEED

- BIMSPEED use cases, highway, and the platform
- Behavioural digital twin calibration
- Ontologies
- The BIMSPEED competition

### 4.4. ENCORE

- Overall ENCORE concept
- BIM creation using point clouds and photogrammetry acquired by UAVs

### 4.5. BIMERR

- Overall concept
- Preliminary results of the BIMERR toolchain

### 4.6. RenoZEB Asier Mediavilla

- Collaboration platform (workflow, issues, users/roles...)
- KPI (Key Performance Indicator) management and scenario comparison (decision support)
- Web IFC (Industrial Foundation Class) viewer with visual query/filter support

### 4.7. SPHERE Eduard Loscos (IDP)

- Building Digital Twins methodology: new definitions and roles
- BDTE (Building Digital Twin Environment) PaaS architecture, Open API and Ontology
- SPHERE Services (BDT Prototype and BDT Instances)

### 4.8. BIMzeED

- Upskilling workforce with an online/blended Learning Unities on BIM and nZEB
- How BIM can help to achieve nZEB compliance/Standard

### 4.9. DIGIPLACE

- Presentation of the objective of DigiPLACE: reference architecture framework for digital construction platforms in Europe and strategy roadmap
- Environmental performance is one of the underlying objectives and a focus of DigiPLACE
- Examples of topics identified in DigiPLACE and related to BIM for renovation and what is developed in the different projects presented

## 5. Innovative Tools

This section will highlight the main innovative tools demonstrated during the workshop.

- BIM4Ren LoD lifter tool: A tool to enrich BIM models
- BIM4EEB BIMMS tool: A tool for the BIM management system
- Interoperability Framework (BIF) tool: A tool consisting of four component (Semantic modelling—Collection and Enrichment—Query—Provisioning)
- BIMzeED E-learning platform: 12 learning units that combine BIM with nZEB and update the curricula of both blue and white-collar workers/upskill current and prepare the future workforce.
- RenoZEB Collaboration Platform: RenoZEB Collaboration Platform and Tools for energy renovation
- BIMSPEED tools: Performance model calibration, BIM use case database, BIM competition, machine learning approaches, BIM2BEM approaches, Scan2BIM approaches
- SPHERE: DT new roles and Definitions: Digital Twin new roles and definitions for buildings, open API, and Ontology.

**Supplementary Materials:** The recording of the workshop is available online at: <https://www.sustainableplaces.eu/home/sp20-workshops-events/sp20-digitalization-tools-for-energy-efficient-renovation-workshop-2/>.

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