Network for Using BIM to Increase the Energy Performance

DELIVERABLE: D19 – D.3.6

Guideline for Professional on BIM Competences

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Net-UBIEP Project: Networking for Using BIM to Increase the Energy Performance

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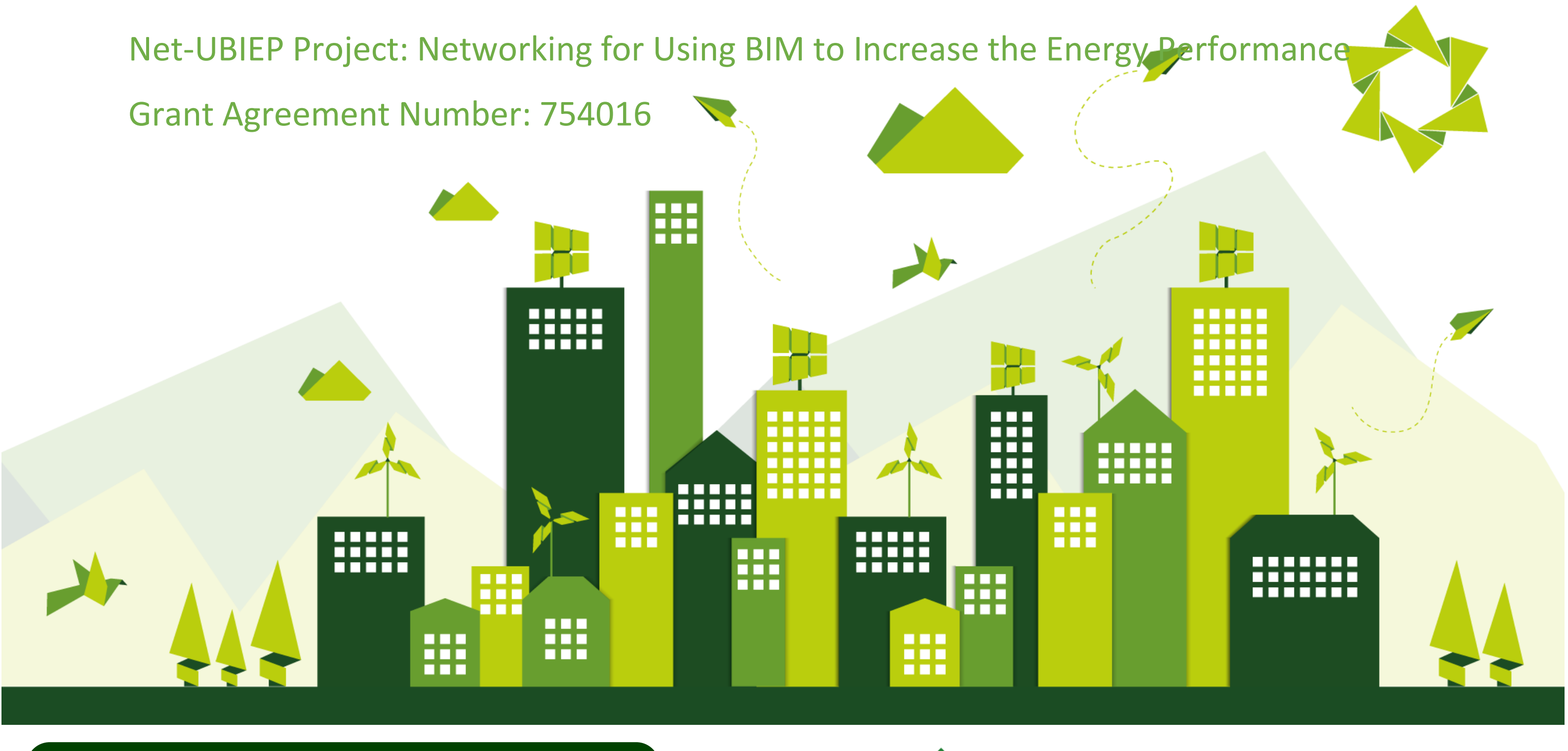

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Introduction

Why Net-UBIEP?

Net-UBIEP aims at increasing energy performance of buildings by wide spreading and strengthening the use of BIM, during the life cycle of the building. The use of BIM will allow to simulate the energy performance of the building using different materials and components, both to be used in the building design and/or in building design refurbishment.

BIM, which stands for Building Information Modeling, is a process that lasts for all the building life cycle from the design phase through the construction, management, maintenance, refurbishment and reuse/demolish. In each of this phase is very important to take into account all the energy aspects in order to decrease the environmental impact of the building during its life cycle.

Any professional needs to understand his/her role in the lifecycle of the building and has to gain additional competences related to the digitalization of the building process, that is to work to the development of the BIM model for any of dozens uses, which the customers will decide to entrust them.

The competences needed to implement BIM, taking into account the energy performance, vary depending on the phase of the building life cycle (1), on the target (2) and on BIM Profile (3).

This information has been put in a three-dimensional matrix which will be navigated through internet so that it will be clear, for instance, which competence an architect (2) whit specific BIM role (3) should have in the design phase (1) in the construction of NZEB and provide the Energy Performance Certificate.

There is the need for engineers and architects to be ready to increase their capability to simulate, through BIM, the use of new technologies and materials to improve the energy performance of buildings and satisfy the needs of their customers with better quality at reduced cost.

BIM has diffused into construction industry and new digital technologies allow competitors from other countries to enter markets. The first professional who will be able to respond to this challenge will gain important advantage in the building market.

The first step consists in a **preparatory phase**, where the engineers and architects need to rethink their processes to manage the BIM models together with any other player of the building life cycle. They need to go to specific training to learn the following subjects:

- To know what's BIM and why it is useful to know the terminology
- Recognize the advantages of BIM compared to traditional methods
- To know the life cycle of the project information; in particular how the information is specified, produced, exchanged and maintained
- To know the added value of using open solutions to ensure interoperability
- To know how to collaborate in the Common Data Environment
- To know the national legislation for the digitalization of the building sector
- To know which normative are considered important in their Regional/Local environment in relation to:
  - Sustainable Energy Action Plan (SEAP) or Sustainable Energy and Climate Action Plan (SECAP)
  - Thermal Plant cadaster
  - Energy performance certification cadaster
  - Green products comprehensive of energy carriers compulsory according to the green public procurement

The majority of SMEs working in the design and/or construction of buildings either as suppliers of big company and/or working autonomously, are not at all ready for this "digital revolution" and they need to acquire the right competences to put in place and manage the digital environment necessary for collaborating with other professionals along the life of a building starting with the preliminary design and lasting till the end of life cycle of the building.

The role of Professionals

Focusing on the energy aspects, the engineers and architects, need to be prepared for NZEB both in the case of new buildings as well as for the refurbishment of the existing one. To achieve this important result, they need not only to respect national, regional, local legislation, but they need to change their perspective and design and construct keeping the "end in mind". This means that they need to consider, since the beginning of the project, the request of the final users in relation to the energy performance and building comfort during the use, they also need to accomplish to the maintenance requirements and information for the end of the life cycle of the building and its components/equipment.

Preliminary phase

Tasks:

1. Know how to manage the geo-referenced territorial maps, seismic maps, climatic maps where the building will be built
2. Identify SECAP indicators applied in the specific territory and the required format
3. Identify the indicators that can be checked through code checking and their format
4. Identify the requirements according to minimum environmental criteria to define the building sustainability (as energy and water consumption, …) during the life cycle of the building
5. Define the methods to manage, exchange, store the files in the CDE
6. Prepare the PIM on the bases of EIRs

Preparation and brief

Tasks:

1. Identify the energy performance requirements defined in the EIRs
2. Identify the energy performance requirements foreseen in the location where the building will be built/refurbished
3. Define the requirements for the maintenance delivery plan to ensure the foreseen energy performance of the building
4. Identify the professional skills required to implement BIM for the best energy performance to obtain NZEB
5. Define the requirements for all the supply chain that will work within the project
6. Prepare the preliminary BIM Execution Plan (BEP)
7. Make highly accurate visual reference of the existing condition of an existing building
8. Make highly accurate relief of the plants of an existing building
9. Propose different solutions for improving the energy efficiency of a building

Concept design

Tasks:

1. Develop the design taking into consideration any new requirements proposed by the employer during the previous phase
2. Review the preliminary BEP to take into consideration any new issues coming from supply chain or from other professionals working in the same project
3. Review the building service design to ensure the maximum energy performance
4. Consider post-occupancy and operational issues for a better design of the plants
5. Foresee the best mixture of technologies like RES installations, HVAC systems, etc. for the best energy performance
6. Ensure the presence of a system for the management and integrated control of the HVAC services (BACS - Building Automation and Control Systems)
7. Ensure the presence of devices for the reduction of water consumption
8. Ensure the "dynamic" behavior of the building envelope, preferably adopting solutions with movable elements (shielding, sliding panels, etc.)
9. Represent the level of information maturity of the models according to predefined LOD/LOI indicators for each model object in relation to the detail required by the definitive design
10. Design the CDE for exchanging, sharing and storing the information coming from different professionals and suppliers

Developed and Technical design

Tasks:

1. Ensure the sustainability requirements for energy performance contained in the developed design
2. Ensure the handover strategy for the correct maintenance and operational instructions
3. Integrate into one federated model the designs coming from HAVC and any other plant installation
4. Review the BIM Execution Plan, if changed
5. Ensure that the supply chain is able to provide the right information for the final Information Delivery
6. Ensure the accomplishment of all the requirements for NZEB or for the refurbishment of existing building
7. Ensure that the continuity of insulation has been considered
8. Foresee the preparation of a non-technical guide for the energy performance control in a format that is readable for the end user
9. Develop BIM 3D and 4D for planning time and costs of the work to simulate different solutions and evaluate the RoI for any refurbishment work
10. Develop BIM 6D to simulate different plant and illumination systems to obtain the best comfort and the lowest energy use
11. Perform clash detection to avoid any interference among plants and building structure
12. Perform code checking to ensure the respect of all legislative and technical requirements
13. Provide a CDE for exchanging, sharing and storing the information coming from different professionals and suppliers.
14. Ensure the correct digitalization and management of all graphical and non-graphical information

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Construction

Tasks:

1. Transform the BIM model of the technical design in the "as built", that is, ensure that the information contained in the model correspond to the actual building.
2. Ensure that all the information of any building element, also provided by the suppliers, are correctly reported in the handover strategy

Handover and close out

Tasks:

1. Perform all activities foreseen in the handover strategy
2. Ensure the fine-tuning of the building services to ensure the best energy performance.
3. Control and verify that all the plants are correctly installed and that their user manual are provided together with the BIM model
4. Transfer the BIM model to the BIM facility manager and/or to the owner

In use and recycling

Tasks:

1. Check the in-use energy performance
2. Ensure the correct registration of the plants to the cadaster and to the owner
3. Ensure to provide the indicators necessary for SEAP and/or SECAP
4. Ensure the maintenance of the plant for the best performance
5. Ensure that any major modification is correctly reported in the BIM model
6. Ensure that recycling and dismissing of plants are performed correctly

Learning outcomes of Professional

The learning outcome can be viewed in the deliverable: D15.A – D3.2.A Requirements for Learning Outcomes for Target Groups. The deliverable can be downloaded by the web site www.net-ubiep.eu.

Contents

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1. Competences Required for BIM professional

As described in the Deliverable: D15.A – D3.2.A, there are several competences required for BIM professionals, with regards to this target group, the Learning Outcomes foreseen are the following:

- **PR.LO1**. identify advantages of using BIM during the construction, management, maintenance and refurbishment of nZEB or of existing buildings because of the decrease of the life cycle cost. Evaluate related BIM technologies, current BIM standards and new BIM trends;

- **PR.LO2**. evaluate economic / quantity take off in the decrease of the life cycle cost of the building, 5D cost estimation, RoI for refurbishment works establishing organization / project budgets and costs;

- **PR.LO3**. develop a 4D functional, volumetric and planning layouts with the definition of site utilization planning, the track for the effectively distribution of appropriate spaces and related resources, integrating life cycle concepts in different project phases, in order to set-up organized management systems;

- **PR.LO4**. identify requirements for the management of data in the Common Data Environment for any other professional involved in the design process, understanding the various participants and roles in the sustainable construction project and giving support on BIM tools to employees. Ensure the respect of the information requirements and of Information Delivery Manual through all the supply chain, manage data within the information model, keep records of implementation, monitor outcomes, ensure that the information provided is kept intact and not manipulated for any future use and transfer the BIM information model to the final use;

- **PR.LO5**. conduct feasibility studies, make digital production, design / 3D modelling of graphic and non-graphic information, develop the library of elements of a building needed for Common Data Environment, validate models, create a project visualization for users and reviewers. Federate different 3D models in order to verify the presence of interferences, applying quality management and coordinating team members of different disciplines. Consider 7D performance indicators while designing nZEB or refurbishment work depending on various technologies, their benefits versus costs, the use of the building, climate zone, etc.;

- **PR.LO6**. identify the requirements for nZEB in terms of RES (Renewable Energy Sources), energy saving installations, 6D sustainability requirements, communicating BIM design goals. Integrate different RES (Renewable Energy Sources) systems into buildings without clash detection, with knowledge on interplay between all aspects of building design, building use and outdoor climate, sustainable energy system, building energy demand and renewable energy production. Define sustainability of materials in tender documents and select companies with experience in those technologies;

- **PR.LO7**. conduct risk management, disaster planning (including planning of future climate changes), troubleshooting problems related to BIM systems, solving of the main critical points for obtaining nZEB and consequent modification of BEP;

- **PR.LO8**. produce a maintenance plan and a maintenance manual for the buildings plants in order to transfer management information to Owners;

- **PR.LO9**. evaluate the completeness of the handover strategy and verify the correspondence between the "as built" and the final BIM model of the building;
- **PR.LO10**. use a laser scanning for the producing of a point of cloud or a photogrammetry of existing buildings for their refurbishment, modelling, comparing and evaluating of new facilities and related systems and for the development of a 3D model in Reverse Engineering;
- **PR.LO11.** make technical supervision and verify the respect to predefined BIM standards, technical requirements and legislation (with code checking), being able to use the relative software and to establish quality management of BIM projects;
- **PR.LO12**. produce a correct decommission of the building and provide to recycle any part, in the respect of local, national and international laws.

2. Sections and Title of Training Materials for Professionals

About the content of the Training Materials for Professional (Deliverable: D18 – D3.5), the Sections of which it is composed are structured as it follows:

0. Introductory Module – Basic BIM knowledge and skills
   - 0.1 Introduction: what is BIM?
   - 0.2 BIM Glossary
   - 0.3 Advantages and value of using BIM for different uses
   - 0.4 Open BIM tools and standard format
   - 0.5 The CDE (Common Data Environment)
   - 0.6 The BEP (BIM Execution Plan)
1. Module 1 – Diffuse BIM
   - 1.1 Return of investments
     - 1.1.1 Organization dimension of BIM ROI
     - 1.1.2 Stakeholder dimension of BIM ROI
     - 1.1.3 Maturity dimension of BIM ROI
   - 1.2 Strategies for a BIM diffusion
2. Module 2 – Apply information management
   - 2.1 Principle of data management in the CDE (Common Data Environment)
   - 2.2 3D Model of graphic and non-graphic information
   - 2.3 The maintenance plan in EPC (Energy Performance Contracting)
   - 2.4 The "as built" BIM Model for improving the energy performance of buildings
3. Module 3 – Apply procurement management
   - 3.1 Quality tender and contracts, guarantees and Change Management
   - 3.2 Green Procurement
   - 3.3 Selection of materials and products with BIM
   - 3.4 Training on Energy Efficiency
   - 3.5 The identification and collaboration among stakeholders
4. Module 4 – Use BIM technology
   - 4.1 Sustainable construction sector
   - 4.2 Automatic model checking
     - 4.2.1 Code checking

3. Relations between Competences and Training Materials

In the Training Materials for Professionals (whose Sections are listed above), the abovementioned Competences are spread throughout the document. Content and information linked to each of the Learning Outcomes are available in the Training Material as it follows:

- Competences related to **PR.LO1** are available in the **Section 0.3** of the Training Material for Professionals.
- Competences related to **PR.LO2** are available in the **Section 1.1**. and **Section 4.4.2.**
- Competences related to **PR.LO3** are available in the **Section 4.4.1**.
- Competences related to **PR.LO4** are available in the **Section 0.5** and **Section 2.1**.
- Competences related to **PR.LO5** are available in the **Section 2.2** and **Section 5.2.**
- Competences related to **PR.LO6** are available in the **Section 2.3, Section 3.4, Section 4.2** and **Section 5.2**.
- Competences related to **PR.LO7** are available in the **Section 3.5.**
- Competences related to **PR.LO8** are available in the **Section 2.3** and **Section 5.4**.
- Competences related to **PR.LO9** are available in the **Section 5.4**.
- Competences related to **PR.LO10** are available in the **Section 4.5**.
- Competences related to **PR.LO11** are available in the **Section 4.2.1** and **Section 5.3**.
- Competences related to **PR.LO12** are available in the **Section 4.1**.

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PR.LO1 – *"identify advantages of using BIM during the construction, management, maintenance and refurbishment of nZEB or of existing buildings because of the decrease of the life cycle cost. Evaluate related BIM technologies, current BIM standards and new BIM trends";* (see **Section 0.3** of the **Training Materials for Professionals**, Deliverable D18 – D.35).

Building Information Modeling (BIM) offers the advantage of time and budget savings for building and infrastructure projects. In the abovementioned section 0.3, the top 11 benefits of BIM are listed as follows:[1]

1) **Capture Reality**: with BIM, designers benefit from diverse inputs (aerial imagery, digital elevation, laser scans) compiled and shared in a model—in a way that paper isn't able to capture.
2) **Waste Not, Want Not**: with a shared model, there's less need for rework and duplication of drawings for the different requirements of building disciplines. The model contains more information than a drawing set, allowing each discipline to annotate and connect its intelligence to the project. BIM drawing tools have the advantage of being faster than 2D drawing tools, and each object is connected to a database.
3) **Maintain Control**: the digital-model-based workflow involves aids such as autosave and connections to project history so that users can be certain they've captured their time spent working on the model.
4) **Improve Collaboration**: sharing and collaborating with models is easier than with drawing sets, as there are a lot of functions that are possible only through a digital workflow. Much of this added project-management functionality is now being delivered in the cloud, such as Autodesk's BIM 360 solutions.
5) **Stimulate and Visualize**: another advantage of BIM is the increasing number of simulation tools that allow designers to visualize such things as the sunlight during different seasons or to quantify the calculation of building energy performance.
6) **Resolve Conflict**: the BIM toolset helps automate clash detection of elements such as electrical conduit or ductwork that run into a beam.
7) **Sequence Your Steps**: with a model and an accurate set of sub-models for each phase during construction, the next step is a coordinated sequencing of steps, materials, and crews for a more efficient construction process.
8) **Dive into Detail**: the model is a great end point for a lot of knowledge transfer, but there's also a need to share a traditional plan, section, and elevation, as well as other reports with your project team.
9) **Present Perfectly**: the model is the ultimate communication tool to convey the project scope, steps, and outcome. The fact that the design is fully 3D means that there are fewer steps to render impressive views and fly-through that can be used to sell commercial space or to gain necessary regulatory approvals.
10) **Take it with you**: having a model tied to a cloud database means having access to the model and project details from anywhere, on any device.
11) **Reduce Fragmentation**: by pulling all of a project's documents into a single view, BIM enables teams to collaborate and communicate more effectively.

[1] Matt Ball, Redshift Audotesk, Building Information Modeling for the Win: Top 11 Benefits of BIM, https://www.autodesk.com/redshift/building-information-modeling-top-11-benefits-of-bim/

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PR.LO2 – "*evaluate economic / quantity take off in the decrease of the life cycle cost of the building, 5D cost estimation, RoI for refurbishment works establishing organization / project budgets and costs*"; (see **Section 1.1. and 4.4.2**).

The economic value of BIM technology may be given measuring the ratio of Return on Investment (ROI). After more than a decade of experience with BIM, the design and construction industry are now realizing BIM's value and financial impact. The calculation of ROI is a necessary evaluation step before investing in BIM. However, ROI analysis is not always able to represent intangible factors that are important to a project or a firm, such as avoided costs or improved safety. In addition, the systems and staffing required to measure and track ROI can be time-consuming and costly. Currently, no industry-standard method for BIM ROI calculation exists and many firms have not adopted any consistent measurement practices, although there is interest in doing so and belief in the potential value of ROI for BIM investment decision-making.[2]

There are three types of BIM investments:

- Startup costs, successful to ensure technology implementation;
- Costs for tailoring BIM to a specific project;
- Longer-term outlays for strategic business changes, such as investing in standards development or customization.

Of course, calculating BIM ROI goes beyond these three types of investment. A nuanced view of ROI for BIM considers three dimensions:

- Organization dimension (are benefits measured at the project level or the firm level?);
- Stakeholder dimension (what specific role does the company occupy in the project ecosystem?);
- Maturity dimension (how much depth of BIM experience does the team and the company have?).

5D is that dimension of the application of the BIM methodology that explicitly corresponds to the estimation of costs. In the three-dimensional model, the economic variable is introduced for the valuation of the costs of the project in order to control them and estimate expenses (assigning the price to the different objects or modelled elements as the value of a parameter).

The time spent by the estimator on quantification changes project by project, but around 50-80% of the time needed to create a cost estimate is spent just on quantification. Given those numbers, one can instantly appreciate the huge advantage of using a building information model for cost estimating. Without requiring manual takeoffs, it is possible to save time, cost, and reduce the potential for human error. [3]

[2] Erin Rae Hoffer, Achieving strategic ROI measuring the value of BIM, https://damassets.autodesk.net/content/dam/autodesk/www/solutions/pdf/Is-it-Time-for-BIM-Achieving-Strategic-ROI-in-Your-Firm%20_ebook_BIM_final_200.pdf
[3] Autodesk, BIM and Cost Estimating, http://images.autodesk.com/apac_grtrchina_main/files/aec_customer_story_en _v9.pdf

PR.LO3 – "*develop a 4D functional, volumetric and planning layouts with the definition of site utilization planning, the track for the effectively distribution of appropriate spaces and related resources, integrating life cycle concepts in different project phases, in order to set-up organized management systems*". (see **Section 4.4.1**).

The use of tools and methodologies based on BIM 4D models provides a holistic view of the building to the technicians in charge of managing and planning the execution process of each one of the project's elements. Access to all this information and the ability to simulate different construction scenarios, make BIM 4D planning an integral tool for improving construction times and optimizing the purchase, delivery and commissioning of different materials, especially those which are critical to control and verify their correct execution. As a result, a 4D building information model provides an intuitive interface for project team and other stakeholders to easily visualize the assembling of a building over time. It enables 4D construction simulation, a key planning tool during preconstruction to evaluate various options. In summary, the use of BIM 4D models allows us to understand and visualize planning beyond the Gantt diagram, showing constructive sequences, relationships between elements, alternatives and anticipating interferences and conflicts during commissioning; in short, it is a matter of better planning to build in a way more efficient and sustainable.

PR.LO4 – "*identify requirements for the management of data in the Common Data Environment for any other professional involved in the design process, understanding the various participants and roles in the sustainable construction project and giving support on BIM tools to employees. Ensure the respect of the information requirements and of Information Delivery Manual through all the supply chain, manage data within the information model, keep records of implementation, monitor outcomes, ensure that the information provided is kept intact and not manipulated for any future use and transfer the BIM information model to the final use*"; (see **Section 0.5 and 2.1**).

The Common Data Environment (CDE) is an application, generally available in Cloud, from which it is possible to handle structured information for project management. The adoption of a CDE allows to overcome geographical barriers and allows to create extended work teams, for example, belonging to different countries or continents; the possibility to collaborate remotely using a shared technology platform lowers the management costs, allowing new business opportunities.[4]

In the Training Materials for Professionals six key points for building a successful CDE are listed and explained:

1. Choose the right team;
2. Define roles and responsibilities;
3. Define workflows;
4. Common language and data availability;
5. Data security first of all;
6. The BIM qualifying factor.

When implementing BIM, the CDE plays an important role to share the information among different disciplines and within the supply chain. Building Information Modelling deals with Data and Information only. Data sharing methodologies, amongst these modelers, can take many forms:

1. Data Exchange;
2. Data Interoperability;
3. Data Federation;
4. Data Integration;
5. Data Sharing Hybrid [5]

[4] Luca Moscardi, Building in Cloud, CDE – Common Data Environment – strategic tool for BIM process, https://www.buildingincloud.net/cde-common-data-environment-strumento-strategico-del-processo-bim/
[5] Luca Moscardi, Building in Cloud, 6 key points to build a successful Common Data Environment, https://www.buildingincloud.net/cde-common-data-environment-strumento-strategico-del-processo-bim/

PR.LO5 – “*conduct feasibility studies, make digital production, design / 3D modelling of graphic and non-graphic information, develop the library of elements of a building needed for Common Data Environment, validate models, create a project visualization for users and reviewers. Federate different 3D models in order to verify the presence of interferences, applying quality management and coordinating team members of different disciplines. Consider 7D performance indicators while designing nZEB or refurbishment work depending on various technologies, their benefits versus costs, the use of the building, climate zone, etc*.; (see **Section 2.2 and 5.2**).

BIM is the mean of creating, managing and sharing (digital) information in the life cycle of a structure. One of the aims of BIM is to promote cooperation between parties and to achieve a reduction of errors in the construction process and the associated failure costs. A project realized with BIM approach generates a building model composed of hundreds or thousands of BIM objects that can be monitored during the life of the building in which they are inserted. The digitized objects make up the BIM libraries of the manufacturing companies from which the designers can draw for each project. Making a BIM library correctly requires a deep knowledge of the brand, of the characteristics of the product and how it relates / associates with another object / product that makes up the constructed work. It is these relationships that define the level of geometric and non-geometric complexity of the object and its modes of representation, in addition to the type of three-dimensional tools and templates to be used.

PR.LO6 – “*identify the requirements for nZEB in terms of RES (Renewable Energy Sources), energy saving installations, 6D sustainability requirements, communicating BIM design goals. Integrate different RES (Renewable Energy Sources) systems into buildings without clash detection, with knowledge on interplay between all aspects of building design, building use and outdoor climate, sustainable energy system, building energy demand and renewable energy production. Define sustainability of materials in tender documents and select companies with experience in those technologies”*; (see **Section 2.3; 3.4; 4.2 and 5.2**).

In the EPC the maintenance for the duration of the contract is up to the ESCO proposing the refurbishment. It has been demonstrated that even a NZEB design can bring to higher costs than foreseen for two main reasons: the first is that during the construction some changes occurs that worsen the energy performance, the second reason is that inhabitants do not know how to use the technology and have higher management costs. In both cases the use of BIM will mitigate if not solve those problems. If BIM is correctly implemented, together with the physical building a twin virtual building will be realized and will be enriched with all the information needed for the maintenance. Besides, a remote control of the building functionalities such as a building automation system, will allow the building manager to intervene any time some misuse is identified.

Build sustainably ensure that the social, economic and environmental aspects were taken into account throughout a building's life-cycle: from extraction of raw materials to design, construction, use, maintenance, renovation and demolition.

The "BIM oriented" design guarantees the interoperability of the models related to the various disciplines allowing simultaneous control with different purposes: controls of the convergence of the models of the single disciplines, checks the elements coexistence of the different disciplines and checks regulatory on the multidisciplinary model. In general, the validation of the BIM model consists in the requirements and functionality verification carried out in a conceptually not dissimilar way from what is normally required in a traditional design approach. Operatively (and synthetically) this is carried out through the verification of adherence to the design and regulatory requirements (Code Checking) and the verification of the coherent design of what is expected (Clash Detection).

PR.LO7 – *"conduct risk management, disaster planning (including planning of future climate changes), troubleshooting problems related to BIM systems, solving of the main critical points for obtaining nZEB and consequent modification of BEP"*; (see **Section 3.5**).

BIM execution plan (BEP) is considered a priority aspect preceding BIM implementation; a precise BEP shall guarantee the compliance of project objectives and requests, shall reduce the uncertainty and clarify the role and responsibility in most of BIM enabled projects. Further, BEP is the key to the information management since it sets out protocols for interoperability, project delivery milestones, dimensional accuracy and other details. BEP specifies roles and responsibilities for team members and bring success to the BIM collaboration. It is an evidence that there are correlated relationships between BEP and BIM collaboration success. In terms of consequence of collaboration there is a relationship among overall project performance, inter-organizational teamwork and participants' job satisfaction.[6]

PR.LO8 – "*produce a maintenance plan and a maintenance manual for the buildings plants in order to transfer management information to Owners"*; (see **Section 2.3 and 5.4**).

Building maintenance is the responsibility of its owner which must use, whenever appropriate, a technician to perform the inspection. A good maintenance depends on the analysis of the anomalies detected during the inspection of the site.[7]

In the EPC (Energy Performance Contracting) the maintenance for the duration of the contract is up to the ESCO proposing the refurbishment. It has been demonstrated that even a NZEB design can bring to higher costs than foreseen for two main reasons: the first is that during the construction some changes occurs that worsen the energy performance, the second reason is that inhabitants do not know how to use the technology and have higher management costs. In both cases the use of BIM will mitigate if not solve those problems. If BIM is correctly implemented, together with the physical building a twin virtual building will be realized and will be enriched with all the information needed for the maintenance. Besides, a remote control of the building functionalities such as a building automation system, will allow the building manager to intervene any time some misuse is identified.

BIM provides owners with a multidimensional model of the as-built asset, but more importantly, with the opportunity to develop a structured digital information source of the asset so that the design can be modified and approved while testing its constructability. In the future, the facility manager will be able to influence the quality of the information they receive, including a complete digital representation, and a geospatial view, with all relevant project and handover information detail included. [8]

After delivery, the client has a digital data model (eg LoD 500). This can be elaborated in a 7D model whereby the maintenance of a structure is made transparent. At the moment there is limited software available that can display such maintenance and management information. For that reason, translating the data model into information for maintenance and management is laborious.

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[6] Wei Lu1, Dan Zhang and Steve Rowlinson, Department of Real Estate and Construction, The University of Hong Kong, Hong Kong, BIM collaboration: a conceptual model and its characteristics, http://www.arcom.ac.uk/-docs/proceedings/ar2013-0025-0034_Lu_Zhang_Rowlinson.pdf

[7] Diogo Gonçalves Simões, Building maintenance supported by BIM model, https://fenix.tecnico.ulisboa.pt/downloadFile/395145922990/ExtendedAbstract.pdf

[8] Steve Cooper, Aconex, The Value of BIM in Handover and Maintenance, https://www.ukconstructionmedia.co.uk/n ews/bim-handover-maintenance/

PR.LO9 – *"evaluate the completeness of the handover strategy and verify the correspondence between the "as built" and the final BIM model of the building"*; (see **Section 5.4**).

Design and construction teams are typically contracted to deliver a structured information handover package to support a client's asset operations and maintenance at a project's end. BIM and a collaborative approach to building design, construction and handover can play a crucial role in taking us even further along the path towards better executed built assets.

A diffuse use of the so-called "BIM object" will facilitate the handover. A BIM object is an element of the building both belonging to the structure and to the Heating, Ventilation and Air Conditioning (HVAC) plants and can even include piece of furniture and domestic appliances. The BIM object can contain any information like geometry, connection to the plants, instruction for maintenance, warranties, etc. Many producers are now converting their traditional catalogues into BIM objects catalogues so that designers can just take the object and insert into the model. The "plug and play" can be done with different "Level of Definition" (LOD) in the different phases of the life cycle of the building.

In the long term, the Facility Managers can realize the full value of their asset over its useful life through cost-, sustainability- and time- effective operation and maintenance. With BIM, facility managers can visualize facilities being created, helping them to understand project intent. BIM lets them see into the future – it lets them see the effect individual design features will have in the immediate future, that very evening and in the days following. [9]

PR.LO10 – "*use a laser scanning for the producing of a point of cloud or a photogrammetry of existing buildings for their refurbishment, modelling, comparing and evaluating of new facilities and related systems and for the development of a 3D model in Reverse Engineering";* (**see Section 4.5**).

Recent advances in hardware technology and building information modeling (BIM) are leading to a new level of scanning utilization for the building construction industry. Scanning for building construction is being applied most often to existing structures but is also seeing an advent of applications relating to new construction work. Scanning technology is becoming a critical function necessary to complete the integrated BIM cycle and provides a clear value-add for the integrated BIM workflow.

With regards to renovation of existing building, no digital model is available in most cases. The information must then be obtained and recorded on the basis of the existing physical situation: this approach is called reverse engineering.

To understand the applications of the scanning technology to the integrated BIM workflow it has to be clear which is the role of laser scanning and the basic functions it has to serve. At the highest level, scanners are used to send out a high density of laser beams for the purpose of positional measurement. Laser beams project outward from the scanning hardware and are measured in time of flight or phase shifts as they return to the source. The hardware measures the return time of the laser and can tell how far away a physical element is. Current scanning technology is able to send out thousands of beams per second. Scanners can also identify the R,G,B colour value for a more intuitive display of point cloud information. Resulting point clouds can include millions, even billions, of data that reflect the physical environment being scanned.[10]

[9] Ibid.

[10] Duane Gleason, Laser Scanning for an Integrated BIM, https://www.tekla.com/de/trimble-5d/laser-scanning-for-bim.pdf

PR.LO11 – "*make technical supervision and verify the respect to predefined BIM standards, technical requirements and legislation (with code checking), being able to use the relative software and to establish quality management of BIM projects"*; (see **Section 4.2.1 and 5.3**).

As it has been pointed out, the validation of the BIM model consists in the requirements and functionality verification carried out the verification of adherence to the design and regulatory requirements (Code Checking) and the verification of the coherent design of what is expected (Clash Detection).

About the phase of regulatory checks and compliance checks, specific rules are available for the so-called Code Checking, for different reference standards that automatically highlight the differences between the models and the standard, classifying them according to the severity of the discrepancy. The ranges of values that identify problems of low, medium and high differences can be customized by the user, thus managing any limit situations.[11]

It is important that the technical office where the building project has to be approved is equipped with hardware and software allowing the code checking, as far as possible in an automatic way. At BuildingSMART International (bSI) the "regulatory room" international IFC parameters to be used in any country are under development. This work will ensure that the software development is consistent with the need of any country.

The digitalization of the building sector implies the construction of twin buildings, one being the real one and the other being the virtual model, which has to be the exact copy of the real one. To achieve this objective, during the construction, the professional in charge of the supervision of the construction works need to ensure that any change made during the construction is correctly reported in the model. Besides, the technical schema of each installed equipment needs to be linked to the object for future maintenance. All the information of the real materials and equipment used during the construction will populate the model in IFC format so that can be view, in future by any software application. For bigger construction software for the building management can be used as well. The owner of the model will finally ensure that their customers will receive a model that can read and bring all the information requested, since the beginning through the EIR (Employer Information Requirements).

Throughout the duration of the construction the checking and documentation of the current state of works is needed, and any change has to be introduced in the BIM model of the building. In this way, after completion of construction, the investor receives the BIM model being precise replica of the existing building. This model can be the basis for facility management, as well as the further modernization works.

[11] BibLus-net, BIM and Model Checking: what is and what are the data validation processes?, http://biblus.acca.it/il-bim-e-lattivita-di-model-checking-il-clash-detection-e-il-code-checking/

PR.LO12 – "*produce a correct decommission of the building and provide to recycle any part, in the respect of local, national and international laws*"; (see **Section 4.1**).

Construction activities and buildings have negative impacts on the environment because of the land use, the consumption of raw materials, water, the production of energy and waste and the consequent air emissions. Globally, buildings are responsible for:

- 40 % of annual energy consumption;
- 30 % - 40 % of CO2 emissions.
- 12% of consumption of water;
- 42% energy consumption - heating and lighting of buildings accounts for the largest single share of energy use (which 70% is for heating);
- 35% greenhouse gas emissions;

Currently 80% of the European population live in urban areas and people spend more of 90% of their lives within the built environment (considering the home, workplace, school and leisure time). In this environment, construction activities, largely affects the wellbeing and comfort of the people and buildings also have impacts in human health.

The concept of Sustainable Development is operated during the whole life cycle of the building and should:

- Reduce consumption of resources (save water and energy);
- Reuse of resources during the refurbishment or disposal of existing buildings or use of recyclable resources of new buildings. The wrong environmental management of the site encourages the generation of waste that could have been avoided;
- Eliminate toxics and ensure the healthiness of buildings, applying nature protection (climate change mitigation, biodiversity, ecosystem services);
- Put emphasis on the quality of the buildings, maximising the durability because, in general, it is more sustainable renovate existing buildings than to demolish and build new;
- Use eco-efficient materials (without processing) and local materials;
- Increase the comfort of life (increase the quality of outdoor areas and indoor air).

It is widely known that the construction sector is a key sector for achieving sustainable development. Because of that, systems for description, quantification, assessment and certification of sustainable buildings have been developed at international level and in Europe. CEN/TC350 "Sustainability of Construction Works" – has the task to establish the European set of rules for sustainability of construction works.

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The present deliverable will be update during the project in order to align the outcome to the market needs as well as to other BIM related projects realized within Horizon 2020 program.

The updated version of the deliverable will be only available in the website of the project www.net-ubiep.eu.

Some deliverables could also be translated in partners national languages and could be find in the respective national web pages. Click on the flags to open the correspondence pages:

International web page

Italian web page

Croatian web page

Slovak web page

Spanish web page

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