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# Deliverable 5.3: Learning, evaluation and testing materials for trainees and trainers

WP5: TRAINING MATERIALS AND TOOLS

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## Reviewer Requests for Revisions

| | Reviewers' Comments | Page Number of Updated Material |
|---|---|---|
| **1.** | Include List of Abbreviations | Pg. 3 |
| **2.** | Do an English check of the document | Entire document |
| **3.** | Update the following to access the provided model of case study link – erase "www" | Pg. 38 |



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# List of abbreviations

AEC - Architecture, Engineering and Construction

QA&QC - Quality Assurance and Quality Control

LO - Learning Outcome

ICT - Information and Communication Technology

WP - Work Package

LCA - Life Cycle Assessment

LCEA - Life Cycle Environmental Assessment

LCCA - Life Cycle Cost Assessment



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# 1. Introduction

This report presents the activities of BIMcert consortium for development of learning, evaluation and testing materials intended for trainees and trainers, in compliance with the designed curriculum.

The learning and evaluation materials were developed and gradually improved in line with the following deliverables:

1) D2.2: *Stage 2 Report – Directions and practitioner input to development of materials*
2) D4.2: *Training methodologies*
3) D4.3: *Pilot testing materials*
4) D5.1: *Blended learning methodology*
5) D5.7: *Implementation of workshop outcomes*
6) D6.2*: Report on end users workshops*
7) D6.3: *Report on validation of BIMcert methods and tools in terms of effectiveness, addressing construction industry needs and future outlook*
8) D7.1: *Programme specifications and accredited modules*

The activities for preparation of this report are related to the following tasks specified in the BIMcert proposal:

- Task 5.2: *Development of learning materials,*
- Task 5.3: *Development of ICT learning environment*,
- Task 5.4: *Development of the evaluation system and materials*,
- Task 5.5: *Development of a QA&QC Manual for the learning models and tools application*

This report is related to and is complementary with the reports: D4.4 *Final package of materials*, D5.7: *Implementation of workshop outcomes* and D6.3. *Report on validation of BIMcert methods and tools in terms of effectiveness, addressing construction industry needs and future outlook*

In order to use resources efficiently, the consortium partners shared the work on learning and assessment materials in accordance with their individual expertise. Therefore, BMC developed materials for the units: *BIM ready, BIM principles* and *BIM fundamentals*, TU Dublin developed materials for the unit


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*Digital Skills* and IECE developed materials for the unit *Introduction to Low Energy Building Construction*.

The developed models of delivery and training, as well as learning and assessment materials were tested in two rounds of trials, within WP6 activities, led by FAC:

1) The first round, conducted in the period February – April 2019, following the tests of concepts and methods, carried out in October 2018,
2) The second round, conducted in the period October – November 2019. The second round was carried out in several different sessions, targeting separately two different groups of end users:
   - Trainers
   - Trainees

Two forms of communication with target groups were used: webinars and face to face workshops.

The conducted trials had two objectives:

1) To test the efficiency of adequacy of the developed methods, models and tools of delivery and to provide feedback for improvement thereof,
2) To engage with various groups of end users, participants in AEC processes, in order to improve their awareness, capacity and skills for sustainable and energy efficient design, construction and operation of buildings.



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## 2. BIMcert objectives

BIMcert is the development of a series of training interventions using digital technology and improved blended techniques to support, enhance and maximize the impact of energy efficient skills at all operational levels within the modern construction industry. BIMcert will be an accessible portal for training the vast middle tier of the construction industry supply chain workers to improve their BIM access skills leading to better collaborative working that guarantees energy efficient, sustainable buildings and increased quality throughout the entire construction supply chain. BIMcert will enable participants to go beyond their current non-integrated construction functionality to an optimum digitally enabled energy efficient position where they can employ all the IT enabled functionality and the BIM tools, processes, services and products to deliver near zero carbon construction and renovation.

To meet the objectives that had been set, the consortium has:

1. Developed learning materials that were tailored to the initial levels of skills and to the needs of various stakeholders. Since one of the project's specifics is industry based training, testing of the training models and tools was carried out in permanent communication with construction sector professionals, companies and stakeholders.
2. Prepared learning content and presented it in the materials intended for testing, elaborating two basic items related to BIM as a leveraging tool for sustainable energy:
    - Collaboration among participants in each stage of a building's energy life cycle,
    - Energy performance optimization, maintenance and improvement throughout buildings design, construction, operation and renovation.
3. Applied progressively a more blended learning method, with online component enhanced, in order to comply with the professionals' available time and possible financial constraints.
4. Designed and aligned with recognized accreditation body, a set of micro qualifications as a combination of micro learning units, derived from the learning outcomes of the designed modules.
5. Demonstrated capacity of BIM to be used as a tool to achieve more efficiently and precisely, optimal energy consumption and reduction of gap between the designed and achieved energy performance of new as well as renovated buildings.
6. Demonstrated increase of energy supplied from RES in the buildings' operation, leading towards decarbonization of the construction sector.



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# 3. Learning materials

## 3.1. Rationale for selection of pilot learning materials

As a method of development of the learning materials, a pilot test package was adopted. A representative sample – a prototype of learning and assessment materials - was prepared and exposed to tests. The results from tests will be used to provide directions for development of the other materials encompassed by the curriculum.
The progress of trials was monitored permanently and used for improvement of the project outputs.

The consortium has carried out a comprehensive analysis to determine the most effective and purposeful scope of materials for tests. The analysis comprised:

1) A pan-European survey on industry needs, followed with face to face workshops in all partner countries; these activities were carried out within WP2, led by CITB NI, in the period April – May 2018. The results, findings and directions were summarized in WP2 Report *D2.2: Stage 2 Report – Direction and practitioner input to development of materials.*
2) A comprehensive analysis and overview of modern pedagogical practices and methods of teaching BIM, in academic and VET area, carried out within WP4, led by TU Dublin and summarized in WP4 Deliverable *D4.2*: *Training methodologies.*
3) Communication with stakeholders, presenting the BIMcert concepts and methods, within the WP6, led by FAC, and summarized in their report *D6.1: End user report.*

When selecting the scope and content of pilot testing materials, the consortium also took in consideration the following important aspects:

1. The project objective to improve awareness and capacity of AEC professionals in digital technologies and energy efficiency,
2. Through the process of project tests and trials, to engage with large number of AEC stakeholders and professionals, to get them familiar with the developed program and therefrom to provide their feedback that will enable directions for complete development of models and tools – to extrapolate the results of the tested sample up to the full range of materials.
3. Materials should be a representative sample that will enable applicability of their test results to the complete scope of materials.
4. Attention was paid to develop materials that will be appropriate for various stakeholders, and initial levels of skills.
5. The pilot package should enable testing of learning paths developed on micro accreditation principle and in line with provided qualifications.


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The results of surveys, analysis and communications with industry highlighted the necessity to raise awareness of BIM as a sophisticated sustainable, supportive software, not only for modeling and visualization, but furthermore by developing training modules that will enlarge the capacity for sustainable construction. The lack of BIM maturity within some of the partner's jurisdictions' informed the consortium that if potential users were going to understand how BIM is used for energy-related proposes that they would need a fundamental understanding of the core principles, as well as how to access information for review purposes. These findings influenced the consortium in the selection of training courses, as specified in further chapters.

## 3.2. Content and scope of pilot learning materials

The BIMcert curriculum was designed in the D4.2: *Training methodologies descriptions, including learning outcomes, suggested syllabi and delivery details* and further developed in more details in the D5.2: *Curriculum for all levels of courses*.

The Deliverable D4.2: *Training methodologies* determined the learning pathways, and recommended methods and concepts of delivery, in order to achieve the required learning outcomes.

The Deliverable D4.3 *Pilot testing materials*, determined the package of materials, in terms of learning outcomes, delivery method, assessment criteria, to be developed and exposed to testing through engagement with target groups.

When selecting the learning units and accompanying learning outcomes to be included in the pilot package, the content was selected in a way to address needs of all target groups. The following learning units were selected for the pilot package of testing materials:

1. BIM ready – for initial level or initial assessment
2. BIM Fundamentals and BIM Principles – introductory units intended for all professions
3. Digital Skills, intended for site workers
4. Low Energy Buildings – for all professions; including:
   - common learning materials for all trades (LO5),
   - and bespoke learning materials for: designers, construction site workers, investors and facility managers (LO6).


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Table 1 presents the learning units and learning outcomes that were selected to be subject of tests:

*Table 1: Selected pilot training units, associated learning outcomes and assessment criteria*

| Unit | LO | Descriptions | Assessment Criteria |
|---|---|---|---|
| **BIM Fundamentals** | LO2 | Define what BIM is and explain key terminology | Explain the basic principles of BIM and summarise the common terminology associated with BIM. |
| | LO3 | List the benefits & value of a BIM workflow | Summarise and list the overall benefits of BIM, particularly in relation to specific roles in the construction industry and energy management. |
| **BIM Principles** | LO1 | Explain the context and essentials of BIM. | 1.1 Explain key terms and definitions within BIM.<br>1.2 Summarise BIM maturity levels.<br>1.3 Explain the impact of BIM maturity Level 2 requirements for project delivery.<br>1.4 Illustrate the benefits of BIM to the construction sector. |
| **Digital Skills** | LO1 | Describe the use of digital skills and devices in construction. | 1.1 Analyse the use of digital skills and devices in construction including:<br>a) Advantages of site works and management.<br>b) Improvement of construction workflows.<br>c) Emergingt technologies.<br>d) Health and Safety considerations. |
| | LO2 | Define how to use digital skills and devices to access digital information. | 2.1 Apply Information and Communication Technologies (ICT) file management techniques.<br>2.2 Demonstrate the use of cloud-based storage and portable devices to access and exchange information.<br>2.3 Demonstrate the use of effective digital surveying techniques. |



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| **Intro to Low Energy Building Construction** | LO 5 | Outline the key principles of System Thinking. | 5.1 Explain how System Thinking, with regard to low energy building construction, can be applied to complex issues to deliver substantially better results than traditional methods. |
| | LO 6 | Illustrate how BIM can be utilised in Low Energy Building Construction. | 6.1 Illustrate the use of BIM tools to reduce energyloss. |

Table 2 presents the type of learning materials that were developed for the purpose of trials. The materials are available on the BIMcert platform.

*Table 2: Package of materials developed for the platform tests*

| Unit | LO Descriptions | Learning materials |
|---|---|---|
| **BIM Fundamentals** | Define what BIM is and explain key terminology | Power point presentations<br>Narrative videos<br>Case studies<br>Guided self-learning |
| | List the benefits & value of a BIM workflow | Power point presentations<br>Narrative videos |
| **BIM Principles** | Explain the context and essentials ofBIM. | Power point presentations<br>Narrative videos |
| **Digital Skills** | Describe the use of digital skills and devices in construction. | Power point presentations<br>Narrative videos<br>Case studies of application of BIM in construction companies |
| | Define how to use digital skills and devices to access digital information. | Power point presentations<br>Narrative videos<br>Case studies of application of BIM in construction companies |
| **Intro to Low Energy Building Construction** | Outline the key principles of System Thinking. | Course books<br>Power point presentation<br>Guided self – study |
| | Illustrate how BIM can be utilised in Low Energy Building Construction. | Course books<br>Power point presentations<br>Titled video<br>Case studies<br>Problem based learning (live energy BIM models of buildings)<br>Guided self – study |


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The materials listed in the table were prepared for the first round of tests (spring 2019), while for the second round (autumn 2019), they were upgraded and split to smaller units. Eventually, materials for 32 modules for trainees and trainers were developed (the list is given in Appendix), currently available on the BIMcert platform.

## 3.3. Learning methods implemented in the program

Selection of the most appropriate methods of training was an important phase in development of learning materials.

WP4 lead, TU Dublin, had undertaken a state of the art literature review of current BIM teaching initiatives that represented best practice for knowledge transfer. The report D4.1 had identified several potential training methodologies that were further used to develop BIMcert training program, courses, materials and models of delivery.

The following methods of learning have been selected for the BIMcert program (*in accordance with the conclusions from the WP 4 Reports D4.2 and D4.3):*

- **Problem Based Learning:** This method has been identified throughout the literature as a strong enabler in students learning outcomes, as it encourages them to interact with the material. It is compatible and complementary to other selected methods, such as narrative videos / interactive videos, live case studies. PBL also lends to mastery and scaffolding level, as it encourages the student to interact with the curriculum and based on the platform interact with the lecturer to discuss their findings. This method was applied in some of the units (were found appropriate), such as: micro teaching units: *Development of energy analytical model of a building, Digital Skills, etc.*
- **Narrative Videos:** Although this method wasn't ranked highly in the industry survey, it was selected for application in the program, taking in consideration the consortium's intention to deliver the program via the digital training platform and narrative videos are confirmed as a successful substitution for live teaching


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sessions. Narrative videos are applicable both in blended and classroom delivery mode. If the program is delivered in a face to face mode, narrative videos will be used as an opening segment of the module before a live webinar / lecture commences.

- **Guided Self Study:** This method encourages the students to explore and learn for themselves. This is an important element of mastery learning, especially if digital badging is used, as the students will need to master different levels before moving to the next. Therefore, all of the developed training materials included self-guided learning (references from used literature, quotations from reference sources and web links to further studying materials).
- **Web Based Tutorials:** The BIMcert survey reported that 46% of the respondents would favour this approach. To test this method, it was applied during the 1st session of trials (conducted in spring 2019) and positive feedback was received. However, application of web based tutorials may increase the costs of training, as it requires a tutor to be present to deliver all or part of the curriculum. The main advantage of this method is that it ensures a scaffold approach for the learner and in turn provides the interaction. The disadvantage of this method (in additional to its costs) is that it does not serve mastery learning well, as the student is required to master the majority of the module by themselves while web based lecturers would offer a more guided approach. Taking this in consideration, it was concluded that a possibility of incorporating this method on to the BIMcert platform could be found in including the delivery of a compulsory webinar(s) which will enable the student to interact with the lecturer. This approach was tested in the second session (autumn 2019) and received dominantly positive evaluation from the participants in the program
- **DFD**: This serves as an important element of the BIMcert curriculum, as it enables the students to view and interact with the model over a virtual time phase therefore allowing them to view the impact of their choices and to find easily the information they need. DFD can enable this as it will permit the user


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to interact with the model at a phase of the project that is important to them. A possibility of incorporating this on to the BIMcert platform was found (among others) in the learning unit *Illustrate use of BIM tools to achieve better results than traditional methods*, where BIM energy analytical models, developed for the project purposes, were made available for the students, allowing them to apply different materials in order to assess impacts of selections to overall energy performance. In addition, several micro units (e.g. the ones within the macro module *Introduction to low energy building construction*), included descriptions of basic principles of application of sustainable construction materials and methods, as well as principles of LCA, LCEA and LCCA.

- **Mastery Learning**: This type of methodology can assist in encouraging the users through PBL and self-guided learning to advance their learning in order to pass the module. This method will be incorporated on to the BIMcert platform by the users been requested to demonstrate a higher learning outside of the provided material if they wish to advance to the next digital badge. As the first step, links to reference source and self- studying literature were provided within all learning materials, In the second step, assessment materials will be upgraded with additional (extra) questions, related to the materials indicated by SGL.
- **Scaffolding**: The BIMcert survey has shown that this would be the required type of methodology as it will ensure a stepped learning curve for the student. This type of learning was applied by: 1) micro units development, 2) their composition in learning plans appropriate to learners' initial knowledge and individual aspirations and plans, 3) assessment provided after each learning unit, as a pre-condition to forward to the next unit, 4) possibility to repeat the assessment up to achieving the best planned result.
- **Case Studies:** Both the literature and BIMcert Industry Survey (in April 2018) highlighted the requirement to produce demonstrations of live BIM projects and lessons learnt. Therefore, two groups of case studies were developed and


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uploaded to the BIMcert learning platform: 1). Case studies of real life successful applications and benefits gained from BIM implementation in companies and in projects; 2) Case studies of development of BIM architectural and energy models, on real projects of buildings, providing opportunity for learners to practise and improve their skills.

- **Instructor Led Learning**: The results from the WP2 survey (April 2018) have indicated that this would be the most beneficial choice to assist in learning. Given the nature of the BIMcert training program and its digital learning set course, this method was replaced gradually, through the process of trails, by live webinars, narrative videos and communications in form of face to face and web –delivered workshops equipped with trainers' presence.
- **Active Learning**: This will only work if the option for a live lecture is incorporated into the platform. This will create the environment for an active learning space between the lecturer and student. The consortium took this possibility in consideration, by development of learning materials that can be applied in both e-learning and classroom mode of delivery. Appropriate instructions for trainers in this direction are given in the Handbook for Trainers,

  When designing methods and tools of training delivery, findings and recommendations from the report D5.1: *Blended learning courses methodology* were also used to determine the optimal composition of blended approach and ratio of mix of e-learning and trainer led learning

  Based on recommendations of D 4.1*: Rolling matrix of concepts*, further developed with more details in D4.2: *Training methodologies* and D4.3*: Pilot testing materials*, it was found that the most suitable approach for industry target groups would involve a scaffolded learning environment guided by a series of instructor-led live lectures. This approach could be complemented through PBL, DFD and GSL which would create the active learning environment suggested in the results. However, this may prove difficult due to the nature of the project, and a more blended approach may need to be adopted. This could involve the inclusion of narrative videos and live lectures with a focus on the student doing self-guided learning through PBL before they advance.



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The recommendations and findings from the cited reports were used for shaping and development of the pilot training materials.

The training materials were designed and developed in forms that make them applicable both for e-learning and instructor led mode of training. Trainers were given instructions, within the Handbook for Trainers, for usage of various materials in blended learning method of training.

The developed pilot testing materials were gradually improved through the process of trials, using permanent communication with industry, within the WP2 and WP6 activities.

## 3.4. Methods of training used during trials

During the trials, blended learning was applied, progressing from face-to-face towards beyond blended approach, in the first and second round of tests, wherein e-learning was applied. Learners were provided access to the learning and assessment materials via the BIMcert platform.

When deciding to progress towards more blended method of delivery and more online learning in the final stage of tests and trials, the consortium took in consideration the survey finding that, in regards to method of training, 53% of respondents indicated they would prefer a person led course with practical demonstrations, while the other 47% reported they would prefer forms of online training.

Table 3 shows the training methods and appropriate learning materials that were developed for trials and tests of training models and tools, stage 1 (February – April 2019) and stage 2 (September – November 2019).



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*Table 3. Pilot learning materials developed and methods of delivery applied in 1st and 2nd stage of trials on training models and tools*

| Unit | LO Descriptions | Materials developed |
|---|---|---|
| **BIM Ready**<br><br>Methodology<br>Guided Self Study (GSL),Scaffolding | An introductory self- study tool Covering subjects such as: What is BIM, BIM process, BIM maturity levels, BIM terms, Benefits&Barriers, etc. | A free self-study and knowledge diagnosis tool to introduce you to BIM and / or provide assessment and recognition of prior knowledge, while getting on track to be ready for BIMcert upskilling and using BIM within your professional role. |
| **BIM Fundamentals**<br><br>Methodology:<br>Web-Based Lecture(WBL), Instructor-Led Tutoring(ITL), Scaffolding, GSL | Define what BIM is and explain key terminology | 1. Instructor Led Live Lecture presentation at all Workshops.<br>2. Presentation materials bedeveloped to explain the basic principles of BIM and summarise the common terminology associated with BIM. This presentation can be utilised for live web-based delivery (streaming) or recorded as a narrative video. |
| Methodology:<br><br>WBL, ITL, Scaffolding, GSL | List the benefits & value of a BIM workflow | 1. Instructor Led Live Lecture presentation at all Workshops.<br>2. Presentation material developed to summarise and list the overall benefits of BIM, particularly in relation to specific roles in the construction industry and energy management. This presentation can be utilised for live web-based delivery (streaming) or recorded as a narrative video. |


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| **BIM Principles**<br><br>Methodology:<br><br>WBL, ITL, Scaffolding, GSL | Explain the context and essentials of BIM. | 1. Instructor Led Live Lecture presentation at all Workshops.<br>2. Presentation material developed to explain key terms and definitions within BIM, summarise BIM maturity levels, explain the impact of BIM maturity Level 2 requirements for project delivery and Illustrate the benefits of BIM to the construction sector. Lecture presentation on BIM Principles, specifically to address LO1:"Explain the context and essentials of BIM." This presentation can be utilised for live web-based delivery (streaming) or recorded as a narrative video. |
| **Digital Skills**<br><br>Methodology:<br>GSL,<br>Mastery Learning (ML),<br>Case Studies (CS),<br>Narrative Videos (NV) | Describe the use of digital skills and devices in construction. | 1. Online guided self-learning training<br>2. Materials in form of presentations, narrative videos and case studies and links for GSL, developed to demonstrate how to analyse the use of digital skills and devices in construction. |
| Methodology:<br><br>GSL,<br>Mastery Learning (ML),<br>Case Studies (CS),<br>Narrative Videos (NV) | Describe how to use digital skills and devices to access digital infromation | 1. Online guided self-learning training<br>2. Materials in form of presentations and narrative videos developed to demonstrate how to access BIM models and information. |



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| **Intro to Low Energy Building Construction**<br><br>Methodology:<br>GSL, WBL, NV, CS | Outline the key principles of System Thinking. | 1. Instructor Led Live Lecture presentation at all Workshops.<br>2. Presentation material developed to demonstrate the key principles of System Thinking. This presentation can be utilised for live web-based delivery (streaming) or recorded as a narrative video. SGL links provided |
| Methodology:<br>WBL, Scaffold learning, GSL, NV, PBL | Illustrate how BIM can be utilised in Low Energy Building Construction | 1. Live demonstration of softwre and plug in(s) to show energy assessment/simulation to address the LO6 “Illustrate the use of BIM tools ton reduce energy loss”<br>2. Developed: course books, presentations, narative videos and two BIM energy models (of a new and of a renovated builing) to enable PBL; SGL links provided |



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# 4. Assessment materials

## 4.1. Assessment methods in the BIMcert program

In the first round of trials, quizzes were used for assessment of understanding and knowledge acquired during the training.
In compliance with the requirements of analyzed and selected accreditation schemes, that prescribe quality assurance and quality control of training, the following assessment methods were selected to be applied in the BIMcert program:

1) Portfolio of evidence:

- Learner notes / written work;
- Learner log / diary;
- Peer notes;
- Record of observation;
- Record of discussion.

2) Practical demonstration / assignment:

- Record of observation;
- Learner notes / written work;
- Learner log.

3) Coursework:

- Record of observation;
- Learner notes / written work;
- Tutor notes / record;
- Audio / video / photographic record;
- Learner log / diary.

4) E-assessment:

- Electronic portfolio;
- E-tests.


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## 4.2. Assessment methods and assessment materials used for tests and trials of pilot package

For the second round of the pilot materials tests, on-line assessments with multiple choice selections were applied for most of the learning modules. In order to meet the suggestions and recommendations of the tested groups, other more interactive forms of assessment were also introduced, where found appropriate according to the related learning content. Such were: (quizzes) and problem solving (practical assignments) prior to access the assessment section.

Learners were given access to the assessment materials after completion of the particular learning units.

Their progress and success will be measured via the learning platform, using gamification to enhance learner's motivation to progress.



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# 5. Materials for trainers

## 5.1 Introductory notes

Materials developed for trainers, included:

1) QA&QC Handbook,
2) ICT manual and
3) Handbook for Trainers.

The materials were intended to inform potential trainers about rules and propositions of BIMcert training program methods of delivery and to prepare them to apply for BIMcert certified trainers.

Materials for these guideline documents were developed in form of: textual guidelines, Power point presentations and narrative videos. Currently, they are available in English only, but prospectively can be translated to other languages. The materials are available on the BIMcert platform, within the module *Training for Trainers*.

## 5.2 QA&QC Handbook

The purpose of this Handbook is to explain the process and methods for quality assurance and quality control of BIMcert training program. It has been prepared on the basis of WP4 and WP7 deliverables. It includes description of approval standards for delivery, registration of learners, verification of assessment and certification, in accordance with the selected accreditation scheme.

BIMCert can only be delivered by register training institutions, and they will be notified in writing of any changes to this specification. This specification is provided online and as such is only valid on the day it was printed. The master and control version of this document will be managed by BIMcert (http://www.energybimcert.eu).

The QA&QC Handbook encompasses the following content, in form of instructions and guides:

1. Introduction

2 General description of the BIMcert training program


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3. Qualification Regulation Information
4. Qualification Aim
5. Qualification Objectives
6. Learner entry requirements
7. Recognition of prior and experiential learning
8. Learner registration policy
9. Delivery language
10. Measures to assure quality of training
11. Summary of the assessment procedures

## 5.3 ICT Manual

The BIMcert Platform provides unique learning environment that improves learners' knowledge and skills in BIM and energy efficient design, construction and operation of buildings. The purpose of the ICT Manual is to train and assist the learners in using the BIMcert platform.

The Manual covered the following content:

1. Overview of BIMcert platform
2. Log in instructions
3. Open /use previously created account
4. Completing / editing required details
5. Access the home page
6. Home page tabs
7. Personal data
8. Available courses
9. Module enrolment
10. Dashboard
11. Module processing
12. Learning materials access (presented access to energy modeling unit)
13. Assessment
14. Leaderboard
15. Log out



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## 5.4 Handbook for Trainers

The purpose of this Handbook, intended for potential trainers, is to explain the methods of delivery / training of particular modules of the BIMcert training program. As a representative sample, the package of pilot testing materials, subject of the project trials, was used. For commercial use of the Program, the Handbook will be developed to encompass the full range of delivery.

The program is designed to be delivered on line and as a blended learning (a mix of face to face and on –line learning)

The Handbook for Trainers encompasses the following content:

1. Introduction
2 General description of the BIMcert training program
3. BIMcert learning modules and strides
4. Applied learning methods
5. Assessment methods
6. Package of materials for pilot testing
7. Gamification feature of the BIMcert platform
8, Overview of micro learning units installed on the BIMcert platform



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# 6. Development and improvement of learning, evaluation and testing materials

## 6.0 Introductory notes

The learning, evaluation and testing materials were gradually developed and improved following the process of program tests and trials, conducted in three phases: 1) tests on concepts and methodologies, 2) tests on materials and tools and 3) tests of complete methods of delivery, including models, materials and tools.

The objectives of trials were:

1. to identify the most effective delivery methods, in terms of learning progress, as well as sequence and of course delivery,
2. to engage with the stakeholders and improve their capacity and skills in BIM and energy efficiency, through the training materials and tools developed and made available on the platform.

## 6.1 October 2018 – January 2019

During the period October 2018 to January 2019, along with the test on selected concepts and methods of delivery, a package of pilot materials was developed, ready for the trials in spring 2019. The materials consisted mainly of power point presentations, prepared to be live presented to the audience. These materials were exposed to trials in the period February – April 2019 and results thereof were used for improvement of learning and testing models and tools.

## 6.2 February 2019 – April 2029- The first round of trials on training models and tools

At the Spring Trials (i.e. the second round of End User Workshops), WP6 Lead, FAC, had presented the following agenda to participants at workshops covered in all five test sites:

- Demonstrate a sample of the training materials
- Simulate a live version of how to access materials on-line
- Simulate a BIMcert live webinars, including a live session with a tutor
- Facilitate Q&A sessions with demonstrators

Over the course of the trials thus far, the top findings were: (*in accordance with FAC's Report 6.2*)


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*Table 4: Summary of feedback received in the 1st round of tests of training methods, materials and tools*

| | |
|---|---|
| 1. | In general, feedback is well intentioned and provides good directions for recommendations for improving effectiveness. |
| 2. | Over 70% in all answers provide a very good overall assessment of the webinars conducted, training platform presented, learning materials developed and the method of delivery. |
| 3. | Reflecting on previous findings, the following have been improved:<br>3.1. Profiling the learning content to be more relevant to **different initial level of knowledge** – This has been achieved through the development of various **modules based on level of expertise**, ranging from beginners' level to advanced.<br>3.2. Profiling the learning content to be more relevant to **different professional** roles – This has been achieved through the **development of generic as well as specific modules** with **varying levels of skill expertise** ideal for across the construction industry supply chain to enrol onto. From managers to skilled tradespeople can access and attain BIM upskilling via the BIMcert training platform.<br>3.3. Replaced and amended the energy simulation video with a more appropriate learning modules **with case studies** and **3D models assessments** for higher ease of learning. |
| 4. | Positive feedback for inclusion of case studies, practical examples, such as a sample of a real-life project. |
| 5. | To reiterate and explain the way of progressing in the learning and **certification path**, specify the competencies that will be achieved in that progress and certifications to be acquired (particularly strong in Lisbon and Zagreb) |
| 6. | Improvements required to ensure easier usability of the platform and ease of navigation of the platform. |
| 7. | Provide a more detailed **comparison between BIM and traditional design**, to confirm BIM advantages |
| 8. | List more **European standards relevant to BIM** |
| 9. | **Tailor the training to national certifications** |
| 10. | Provide training curriculum in more regional languages |
| 11. | More specific and **practical education** on **BIM & sustainability & energy efficiency.** |



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## 6.3 May 2019 – August 2019 – Improvement of materials in accordance with the feedback and recommendations received in the 1st round of trials on training models and tools and their integration in the learning platform

The materials that were subject of this final round of tests, had been improved in period April – June 2019, on the basis of the D6.2 Report, on conducted trials in period February – April 2019. The improvements consisted of:

- Added more content on energy efficiency, in most of the learning units,
- Comparison and advantages of BIM compared to traditional method of design and construction, were included in related learning modules,
- Problem Based Learning was deployed in appropriate learning modules,
- Applied a more interactive principle of engagement of learners, through the learning process and assessments
- Guidance provided for self – studying,
- Two BIM models in form of case studies on real live projects developed (one for a new and the other for a renovated building),
- Case studies on BIM application in companies and projects provided,
- Learning and practicing environment in a BIM architectural and BIM energy analytical model provided, enabling PBL method in interactive principle of learning,
- List of applicable EN ISO standards on energy efficiency and sustainable construction of buildings extended,
- Assessment materials improved and completed in line with:
- the selected methodology of delivery and accreditation quality requirements,
- Users' requests for more interactive forms (e.g., quizzes were introduced for some learning units / courses; questions with multiple choice answers requested the learners to repeat procedures explained in learning materials for different input parameters)

In the period July – September 2019, the improved and upgraded learning and assessment materials were installed on the platform and integrated in the ICT learning environment.



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In the same period, micro learning units were developed, in accordance with the audience requirements from the previous round of trials as well as with the BIMcert unique approach of micro accreditation.

## 6.4 September 2019 – November 2019 – The second round of trials on training materials and tools

### 6.4.1. Preparatory works

At this final stage:

- The BIMcert learning environment (the learning platform) was completed and tested internally by the project team
- the learning materials were improved, extended, completed, split to micro units and installed in the platform,
- assessment materials were completed and installed in the platform
- descriptions of modules, courses, learning plans and qualifications were completed and integrated in the platform
- special modules in form of user guidance, separately for trainers and trainees, were developed (*Training4Trainers, Training4Trainees*)
- materials for trainers (guidance documents for conducting and . delivery of training) were developed,

This round of trials was run in a more blended way, encouraging and supporting the learners towards e-leaning mode, by using the developed BIMcert learning platform.

Delivery methodologies employed by the BIMcert model of content dissemination include:

1. Problem/Project-Based Learning
2. Interactive Narrative Videos
3. Guided Self-Study
4. Web-Based Lectures/Tutorials (for some units)
5. Case Studies on successful implementation of BIM in various construction companies across Europe
6. Case studies on development of energy model of a new and renovated building



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The designed modules and training plans allow learners to gain skills required for their own professional needs, combine them to obtain a pre-established qualification.

As a form of communication and as the first stage of this round of trials, webinars were selected. The webinars were divided into 4 parts, in accordance to material delivery:

1. **Introduction to BIMcert –** included presentation of BIMcert objectives, scope and structure
2. **Preview of the BIMcert Training Platform –** included overview on how the training program works; curriculum, modules (courses), training pathways and qualifications; platform usage and navigation guidance; sample training plans and modules; BIMcert gamification aspect; delivery, tools and content
3. **Explanation with Practical Examples and Case Studies –** included explanation of case studies which played a crucial role in displaying examples of completed projects and evidence of successful application of BIM compared to traditional designs. Further, case studies were used to provide users blended and practical learning in relation to real-life models.
4. **Interactive Discussions, Feedback and Conclusion –** provided the attendees with the opportunity to simultaneously register on the platform, enroll on modules, discuss questions and provide feedback on the usability of the platform, learning materials and inputs on improvements to incorporate.

Webinars were organized and conducted separately for trainers and trainees. Materials developed exclusively for trainers (guidelines documents specified above) were accessible for the trainers only, while learning and assessment materials developed were accessible for all participants.

## 6.4.2 Webinar for trainers

### 6.4.2.1 Organization and conduction of the trainers' webinar

The webinar with trainers was conducted on 22nd October 2019, in all partner countries, and was open for trainers from other countries as well.



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12 trainers across Europe attended the webinar. Responses were provided from 10 trainers. The trainers were asked to provide their contact details (email address) and country of origin, wherefrom the data were collected on the group composition. Trainers from UK (NI), Portugal, Croatia, North Macedonia and Greece have completed the questionnaire.

During the webinar, the organizer (FAC) carried out discussions with the attended trainers. The following opinions were collected (most of them were repeated in written responses of the inquiry):

- Difficulties (technical issues) of registration should be worked out and registration process should be tested to run smoothly,
- Procedures for enrolment in modules and learning plans should be tested and improved in terms of simplicity,
- Level of handling of the platform and navigation through it should be explained in a simpler way, to enable site operatives and beginners to follow it,
- More practical examples, case studies and interactive content should be provided

After the webinar, the attendees were invited to complete the questionnaires about the quality of the webinar and the quality on the developed BIMcert methods, models and tools

### 6.4.2. 1. Key findings from the trainers' engagement

The feedback and recommendations tackled the most important issues and triggered project team's actions for improvement of the program. The following items should be noted:

- The program attracted interest of a great number of professional lecturers in partner countries and abroad,
- After the webinar, the consortium has received expressions of interest from trainers coming from countries beyond the project geographic limits,
- The trainers showed particular interest in the energy component of the program. This represents that BIMcert is on the best way to achieve its mission in raising awareness, capacity and skills of construction sector professionals for sustainable and energy efficient buildings


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- The trainers found the BIMcert program of high quality and their remarks showed that the project is on the right course of concepts, methods and tools of delivery and essential changes are not needed. Their recommendations are mostly in direction of: 1) making the program easier for implementation by beginners and lower level of initial knowledge and qualifications, 2) providing guidelines for training plans and qualifications and 3) providing tools for interactive engagement of learners during the learning and assessment process.
- The three guidelines documents (QA&QC Handbook, Handbook for Trainers and ICT Manual) were found understandable, sufficient and reliable for a high quality of training.
- The trainers recognized the learning materials applicability for both e-learning and blended learning approach.

#### 6.4.2.2 Implementation of outcomes from trainers' webinar

The trainers' responses were valuable for the team, providing suggestions for improvement prior to start of the trainees' webinar and tests of the platform with engagement of a wider audience of learners.
With deep appreciation of the trainers' assistance, the project team took in consideration and implemented the trainers' suggestions for improvement.
The improvements carried out by the project team included:

**1) Technical performance of the learning environment:**

- Technical tests of video and sound links were carried out before each web – communication session, in order to avoid technical issues and provide high quality broadcasting.
- Registration and operability of the enrolment were tested and improved.

**2) On learning modules, courses, qualifications explanations:**

- A more detailed explanation and step by step guidelines on modules, training plans and qualifications were provided, consisting of narration following live presentation of steps.
- The materials developed for this purpose were incorporated in a module *Train4Trainees*, placed on the platform.

**3) On webinars delivery method:**

- More interaction with attendees was provided; several Q&A sessions included in the webinars.


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- Discussions were carried out after each section of presentation, to keep the attendees' attention.

**4) On platform use:**

- Face to face workshops with practitioners were organized by all partner organizations in their countries, to explain use of the platform and materials installed.
- Description of courses and learning plans improved,
- ICT Manual included step by step guide for trainees to use the platform
- Technical issues detected during enrolment were solved and re-tested...

**5) On learning materials:**

- Case studies of implementation of BIM in real life projects by construction SMEs were prepared and presented
- Case studies on energy modeling of a new and a renovated building, in form of real life projects, were incorporated in the learning module Introduction to Low Energy Building Construction.
- A step by step guidance for energy modeling was completed and uploaded to the platform
- Access to the energy models was provided for learners, to enable practical work
- The content of the unit 'Implementation of BIM tools to improve energy efficiency of buildings' was split to suit better various target groups (e.g. designers, site workers, facility managers, maintenance personnel)
- The developed learning content was divided in smaller (micro) units, following the designed learning outcomes, to enable easier learning of smaller portions of material
- Assessments were organized after completion of each micro unit, as a precondition for further progress (scaffolding principle as defined in D4.1: *Concept and Methodologies*)

**6) On assessment methods:**

- Quizzes were prepared and included as assessment methods;
- the learning unit 'Development of energy model' required the learners to practice / to repeat the explained steps on a live BIM model of a building,
- other interactive forms of engagement of learners during the assessment were deployed.

After being improved and upgraded in line with the trainers' recommendations, as well as with the project team findings during internal


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tests, the platform and materials were launched to official trials and tests by a wide audience of learners, starting from 4th November 2019.

## 6.4.2. Webinar for trainees

### 6.4.2.1 Content of the webinar for trainees

The BIMcert webinar trials sample training plan selected titled **Training 4 Trainees,** addresses varying levels of expertise ranging from intermediate to advanced learning depending on already existing skills and includes the following modules:

1. Training 4 Trainees
2. What is BIM and Digital Construction?
3. BIM Terms and Definitions
4. What are BIM (Maturity) Levels?
5. BIM & Digitalization Benefits - Overview
6. BIM tools for Low Energy Building Construction
7. Energy System Thinking Key Principles
8. Intro to BIM Implementation – Impacts in Project Delivery – Overview
9. Digital Skills – Accessing Information through the Cloud
10. Digital Skills and Collaboration I – CDE & File Structure
11. Digital Skills and Collaboration II – Access BIM Models
12. Digital Skills and Collaboration III – Review BIM Models

### 6.4.2.2 Overview of responses received from the trainees

Apart from improvements of the delivery models, this project activity of trials and test had another important mission: improving capacity of various target groups across the supply chain of AEC professionals, in implementation of digital skills for more sustainable and energy efficient design, construction and operation of buildings.

Summary of key findings from the survey conducted after the trainees' webinar is presented below. More details are given in the FAC's Deliverable 6.3: *Final Report on validation of BIMcert models and tools*.



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1. The participants understood the content of BIMcert training they had been engaged with (Q3 - 100% of affirmative responses)
2. They found the BIMcert courses, modules and learning objectives clearly explained. (Q9 - 100% of affirmative responses)
3. The learning objectives were identified as correlated with the learning content (Q12 - 100% of affirmative responses).
4. The learning objectives and topic content were found applicable for the responders' professional role and work duties (Q13 - about 90% of affirmative responses).
5. The presented BIMcert tools provided a good mix of theory and practice, for over 80% of responders (Q15).
6. The technical level of content was ranked at 4, on the scale from 1 to 5 (Q16).
7. The content was found suitable for all responders' learning and knowledge development (Q17).
8. The extent to which mixed training models and tools assisted their learning (Q21) was ranked at 4, on the scale from 1 to 5.
9. The level of acquired knowledge for BIM and energy efficiency (Q18) was evaluated as "A great deal" (12%), "A lot" (33%), "A moderate" (42%) and "A little" or "None at all" in total of 13%
10. The question Q25: "Are the training materials provided at the correct level for your needs and understanding?", was responded by 20% "Strongly agree", 50% "Agree" and 30% "Neither agree or disagree"
11. The online assessment process was found clear and easy to follow, by all respondents (Q31)
12. However, 20% of respondents (Q34) recommended other methods of assessment, with a more proactive approach.
13. The online assessment process was found satisfactory by about 85% of responders.
14. The range of provided materials was found correct and balanced (Q39) by all the responders.
15. All the responders were positive that the training experience, knowledge and skills acquired would be useful in their work and professional role (Q44).
16. About 95% of the responders gave affirmative answer to the Q46 "Did the BIMcert training modules you had selected enhance your understanding on how these skills can improve energy efficiency and sustainable construction processes?"
17. About 85% of participants responded that they were likely (35% of them very likely) to use the presented BIMcert tools in the future.


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#### 6.4.2.3 Key findings from the trainees' webinar

Summary of key findings from the survey conducted after the trainees' webinar is presented below. More details are given in the FAC's Deliverable 6.3: *Final Report on validation of BIMcert models and tools*

The following key findings were recognized by the project team:

1. **The participants appreciated:**

1.1. Applied micro learning unit micro accreditation principle.
1.2. Enlarged energy efficiency content covered in specific aspects in various learning units
1.3. Content that enabled improvement of capacity and skills in digital construction supported energy efficiency of buildings; they expressed willingness to apply the achieved skills in their work places
1.4. Design of learning modules and models intended for various levels and target groups.
1.5. Variety of developed learning materials

2. **The participants recommended:**

5.1 Further splitting of the learning content into smaller units, easier for studying and progressing, which results in shorter time needed for specific learning contents and assessments (shorter lessons and questions).
5.2 More interactive principles during learning and assessment, such as practical exercises and assignments
5.3 Video materials replacing live lecturer presentations
5.4 Communication among trainers and trainees, in form of forums, web workshops, chats, etc.,
5.5 More precise and simple instruction for selection and creation of learning plans, leading to micro accreditation
5.6 Translation to other languages
5.7 Improvement of the platform operability (check and correct links and operation instructions).

### 6.4.3. Workshops with practitioners

The face to face workshops with practitioners were organized and lead by FAC, during October and November 2019, in Dublin, Belfast and Skopje, and were facilitated by the local partners. During the workshops, the BIMcert platform, as well as developed learning modules, learning plans and accompanied


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qualifications, supported by developed training and assessment materials and tools were presented to the participants. The communication was interactive, with opinions provided during the workshops and additionally by completing the distributed survey. More details are presented in the FAC's Report 6.3
The following key findings were recognized by the project team:

1. There is a predominantly positive feedback, appreciation of the overall training methodology and materials presented and willingness to continue engagement with the BIMcert program.
2. Assistance of presenters in following and understanding of content presented was found beneficial.
3. This mode of presentation provided the most positive feedback and should be considered as a part of BIMcert method of delivery in future.

## 6.5 December 2019 – January 2020 – Final improvement of the package of pilot testing materials

In this period, the learning materials were further improved, taking in consideration feedback and suggestions provided in the final round of trials:

1. The learning content and accompanying assessment was upgraded, enlarged and split to smaller units that were thereafter installed on the platform and tested by the partners. They were therefore prepared for final delivery in the project exploitation phase.
2. Platform technical operability was improved and re-tested within the project team.

Other recommendations provided during the communication with end users will be taken in consideration within the project exploitation plan.



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# 7. Energy impacts achieved during the development and tests of learning materials

## 7.1. Primary goals

As stated in the proposal, one of the project objectives is confirmation of the following impacts in respect of the energy performance of buildings:

- Increased energy savings for at least 10%, in new building projects;
- Increased energy savings for at least 20%, in renovation building projects;
- Increased generation from renewable sources, in buildings, for at least 13%; and
- Reduction of gap between designed and achieved energy performances by at least 10%

From previous feedback, it was understood that participants had great interest in the **energy efficiency aspect of BIM** and desired case studies and examples to be implemented in the training materials to break down steps easily. As a result, practical examples and case studies were specifically used during the trials to facilitate ease of understanding and correlation to real-life examples. As part of Work Package 5, two live (prototype) case studies were developed to demonstrate energy saving techniques, one of a new building construction and the other for a reconstruction building project, based on real life projects that learners have access to, specifically to learn about and practice energy modelling with BIM tools. These case studies were emphasised in response to the request for them during phase two of the trials and as a teleological teaching aid. Real life examples facilitate the learning process and help participants engage with learning materials that project real situations during this phase of trials and testing via online webinars.

Exclusively for the project purposes, BIM architectural and thereafter energy models, of a new and renovated (real life project) buildings were developed and prepared in a form to be used by learners in a PBL training method.

The BIM architectural and energy models of both buildings are accessible on the BIMcert platform.

Additionally, a learning material: *A step by step guide on development of an energy model* was prepared. The material comprises problem based learning,


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inviting the learners to follow the steps described and repeat the energy simulation by varying indoor and outdoor conditions, as well as geometry and other features of the building envelope.

In addition, a video tutorial was prepared and uploaded to the platform, representing guidance for creation of architectural model, connection to energy modeling software. It was also a form of extended ICT manual for use of BIM model learning environment created by BIMcert.

Content related to sustainable construction principles, methods and materials as well as energy efficiency of buildings was incorporated in each pilot testing material. In more details, it was developed within the micro modules of the unit *Introduction to low energy building construction.*

## 7.2. Case study of a new designed building

### 7.2.1 Introduction

The objective of this case study was to demonstrate how BIM is used for calculation and optimization of energy consumption in a building with focus on creating sustainable and energy efficient buildings and collaborative environment.

Comparison to traditional method was also presented, pointing at advantages of BIM in achieving optimal energy performance.

For the purposes of this learning material, a BIM architectural model of a residential building had been developed in Revit, which was used as a basis for development of the energy model.

The BIM energy model of a new building is accessible on insight360.autodesk.com. Users can sign in using the account: projectbuilding360@yahoo.com / energyBIMcert1

This learning material was intended to upskill professional designers (architects, engineers), as well as to inform facility managers, owners, contractors, and site workers about the process of creating efficient buildings.

The learning content in the material was developed in accordance with the Learning outcome 6.1: *Illustrate the use of BIM tools in low energy buildings construction*, of the learning module*: Introduction to Low Energy Building*



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*Construction,* and provided intermediate level of knowledge of the encompassed content.

### 7.2.2 Basic features of the building model

Type: **5 Story Building**
Type of project: **New building**
Purpose: **Residential building that includes offices on the ground floor**
Number of dwellings: **32** (3 types: 46 $m^2$ / 37 $m^2$ / 74 $m^2$)
Total area of dwellings: **1.552 $m^2$**
Area of characteristic floor: 17.10 x 30.58 m = **523 $m^2$**
Total Area: **2.558 $m^2$**
Project Address: **D01 E065, Dublin, Ireland**
BIM Level of Development: LOD300

### 7.2.3. Methodology – Workflow of development of energy model of a building

The workflow of development of energy model and calculation of energy required is presented in the learning material *Workflow of creating energy model of a building*.
To demonstrate universal and software independent advantages of BIM compared to traditional methods, analyses were made by two different energy simulation software tools, Insight360 and Green Building Studio.

### 7.2.4. Analyzed alternatives in terms of optimization of energy consumption

For the purposes of this learning material, the following 9 alternatives were analyzed:

**Alternative 0:** Baseline scenario derived from the Revit Model (BIM)

**Alternative 1:** Window / Wall ratio

**Alternative 2:** Window Shades – South Wall

**Alternative 3:** HVAC system

**Alternative 4:** Plug Load Efficiency

**Alternative 5:** Wall Construction

**Alternative 6:** Window Glass type

**Alternative 7A:** All changes – Alternatives 1,2,3,4,5,6


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**Alternative 7B:** All changes – Alternatives 1,2,3,4,5,6 and additionally applying **BIM** features:

- Simulation of varying indoor and outdoor conditions
- Visualization of heating and cooling loads and gains
- Processing changes made in the energy model immediately in other parts of the federated model, therefore fast and accurate optimization of energy and costs

**Alternative 8: Renewable energy sources included in the building consumption**

When selecting materials in alternatives, the environmental performance was also taken in consideration through EPD - Environmental Product Declaration. Thus application of sustainable materials was provided.



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### 7.2.5 Comparison of alternatives

*Table 5: Overview of results and comparison of alternatives in the case study*

| | EUI Min | EUI Mean | EUI Max | Cost Min | Cost Mean | Cost Max | Deviations from the amount of cost of the Basic model | Deviations from the amount of energy of the Basic model | Deviations from the amount of energy of the Baseline Scenario |
|---|---|---|---|---|---|---|---|---|---|
| Alternative | [kWh/m²/yr] | [kWh/m²/yr] | [kWh/m²/yr] | [EUR/m²/yr] | [EUR/m²/yr] | [EUR/m²/yr] | [EUR/m²/yr] | [kWh/m²/yr] | % |
| Base Run | 215 | 220 | 227 | 40.1 | 41.5 | 43.2 | 0 | 0 | 0 |
| 1 | 144 | 213 | 320 | 22.3 | 29.5 | 44 | -12,0 | -7 | 3.3 |
| 2 | 138 | 205 | 308 | 21.2 | 28.1 | 42 | -13,4 | -15 | 6,8 |
| 3 | 189 | 204 | 201 | 21.9 | 23.2 | 24.9 | -18,3 | -16 | 7,8 |
| 4 | 130 | 194 | 292 | 19.6 | 26.2 | 39.3 | -15,3 | -26 | 13,4 |
| 5 | 130 | 193 | 291 | 19.5 | 26 | 39 | -15,5 | -27 | 14,0 |
| 6 | 128 | 191 | 288 | 19.1 | 25.6 | 38.4 | -15,9 | -19 | 15,2 |
| 7A | 165 | 172 | 178 | 13.8 | 15.2 | 16.9 | -26,3 | -28 | 27,9 |
| 7B | 137 | 143 | 150 | 11.7 | 13.1 | 14.2 | -30,1 | -77 | 52,8 |
| 8 | 110 | 110 | 110 | 9.63 | 9.63 | 9.63 | -31,9 | -110 | 100 |

### 7.2.6. Achieved results

According to the results presented in Table 1, for the optimal design alternative (No. 8), the following results are achieved:

1) Total energy required for the building operation (heating + illumination): **110 kWh/m²/yr.**
2) Share of RES in total energy consumption: **43,277kWh** annual energy production or **33%** from total energy consumption.
3) Cost of the energy consumption for the optimal alternative: **9.63 EUR/m²/yr**.


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### 7.2.7. Summary

The prototype case study of a new construction building presents the step by step guidance and workflow of energy optimization of a building.

It also demonstrates the following advantages of BIM:

1) Simulation of varying outdoor conditions (orientation, air flow, daylight, analytical sun studies) to help designers and facility managers to best utilized available outdoor energy, while keeping indoor quality requirements.
2) Visualization of heating and cooling loads, occupancy and other indoor conditions.
3) Continuous control of mechanical, thermal and environmental properties of embodied materials as well as costs thereof.
4) Fast and accurate processing of a large number of design alternatives (what – if scenarios) and selection of the optimal variant based on multi criteria approach (energy, environmental and economy performance of the building), with collaboration of the design team, providing fast evaluation of feasibility of alternatives not only in energy, but also in architectural, structural, mechanical and other relevant aspects. The ability to carry out a large number of scenarios supports identification of the optimal design alternative, in aspect of energy consumption as well as capital and operational costs.

### 7.2.8. Confirmation of energy KPIs

**By the case study developed exclusively for the project purposes, the BIMcert project confirmed the energy impacts as declared in the proposal stage.**

The figures obtained by the case study are presented in the table below.



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*Table 6. Presentation of results of energy calculations of the prototype building*

| | | |
|---|---|---|
| 1 | Energy consumption in the baseline alternative – Alternative 0 | **220 kWh /m²/yr** |
| 2 | Energy consumption achieved by optimization by traditional method - Alternative 7A | **172 kWh/m²/yr** |
| 3 | Energy consumption achieved by optimization in BIM - Alternative 7B | **143 kWh/m²/yr** |
| 4 | Energy consumption from outsource, when including RES (photovoltaics) – Alternative 8: | **110 kWh/m²/yr** |
| 5 | Difference between the best CAD and BIM alternative – Alternatives 7A - 7B | **172 - 143 = 29 kWh/m²/yr** |
| 6 | Difference between the best BIM alternative and alternative with RES included ( *Alternative 7B – Alternative 8):* | **143 - 110 = 33 kWh/m²/yr** |

The study demonstrates the following overall energy effects of application of BIM due to the advantages specified previously:

1) **Increased energy savings by 16,86%**, compared to the best alternative that can be achieved by traditional method, based on CAD, which is equal to: **29 kWh/m²/yea**r (difference between Alternatives 7A and 7B).
For the total area of the building (dwellings + offices) of (1552 + 553) m², total energy saving in this sample project equals to: **29 kWh/m²/year × (1552 + 553) m² =61.045 MWh** energy per year, of savings due to applied energy calculations based on the BIM model.

2) Total share of energy generated by on – site renewable sources is: **43,277 kWh annually**, or **33 kWh/m²** per **year,** which is **30% of the total energy consumption** of the building.

3) The expected **reduction of gap** between designed and actual energy performance is over **25%**,due to accurately designed energy consumption and management system supported by BIM model (as presented in the simulation of 24-hour consumption, in the Chapter 5).



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## 7.3. Case study on a renovated building

### 7.3.1Introduction

The objective of this Learning Material is to demonstrate use of BIM in renovation projects in order to iillustrate potential of BIM in improving energy efficiency of renovated buildings, in their extended life cycle.
For the purpose of this learning material, a case study of renovation of a real building was developed. The case study was used to demonstrate comparison between BIM and traditional method of design applied in renovation and to confirm energy savings that can be achieved by applying BIM.
The learning material is intended to upskill designers and to inform other professionals in the supply chain (construction contractors, site workers, clients, facility managers, maintenance personnel) about the method of use of BIM for effective increase of the building energy performance by renovation actions.

The learning content in the material is developed in accordance with the Learning outcome 6.1: *Illustrate the use of BIM tools in low energy buildings construction*, of the learning module: *Introduction to Low Energy Building Construction*, and provides intermediate level of knowledge of the encompassed content.

The learning material in form of a case study of energy optimization of a renovated building also contains guidelines on how to use existing data of the structure, in form of CAD drawings or laser scanned views, to produce a BIM architectural model.

### 7.3.2. Methodology

The primary objective for reducing the energy consumption of the building, by using BIM tool will be implemented through the following stages:

**Stage I**:Existing hand drawings, existing technical documentation of the project (CAD Drawings), civil survey;

**Stage II**:Perform an energy simulation for the existing building;

**Stage III**:Develop a renovation strategy;


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**Stage IV**:Perform an energy simulation for the renovated building;

**Stage V:** Compare the results.

### 7.3.3. Existing condition

In order to gain insight into the practical application of the use of BIM to implement energy saving practices in an existing renovation, we have selected a real existing building to serve as a Case Study (Figure 2).

Basic features of the model:

Type: **6 Story Building**
Type of project: **Existing Building**
Purpose: **Residential Building**
Address: **st. 'Petar Pop Arsov' No.36, Skopje, North Macedonia**
Latitude / Longitude: **42˚ / 21,42˚**
Number of dwellings: **11**
Area of dwellings: 10 x 66 + 1 x 75 = **735m²**
Are of characteristic floor: **193,4m²**
Total Analyzed Area: **806m²**
Summer Dry / Wet Bulb: **31C˚ / 24C˚**
Winter Dry Bulb: **-11C˚**
Mean Daily Range: **15C˚**

### 7.3.4: Energy optimization of the renovated structure

7,3.4.1. Varying parameters to set different scenarios

Collaboration in BIM: It is important to note that all of the changes made in the energy model are immediately processed and evaluated in other models (architectural, structural and MEP). This make the analysis of alternatives faster and more accurate than in the traditional method of delivery. For the purposes of this Learning Material, the following 6 alternatives were analyzed in the renovation strategy:

**Alternative 0:** Baseline scenario derived from the Revit Model – Existing building (BIM)


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**Alternative 1:** Minimizing the existing Plug Load Efficiency to 6,46 W/m$^2$*Changes adapted to the Baseline scenario.

**Alternative 2:**Change on the Wall Construction / Insulation – R38 Wood*Changes adapted to the Baseline scenario.

**Alternative 3:** Change on the Window Glass Type from Double Clear to **Trp LoE** *Changes adapted to the Baseline scenario.

**Alternative 4A:** All changes – Alternative 1, 2, 3 *Changes adapted to the Baseline scenario.

Applying the traditional method of optimization, based on CAD drawings and appropriate calculation software techniques (e.g. calculation model in Excel).

**Alternative 4B:** All changes – Alternatives 1, 2, 3,4,5,6 *Changes adapted to the Baseline scenario.and applying BIM features:

- Systemic calculation of the thermodynamics of all involved construction elements and materials;
  Simulation of varying daylight, to optimize illumination;
  Simulation of varying outdoor conditions (temperature, sun light analysis), to reduce radiative (solar) loads;
  Optimization of elements of the building envelope, to maximize usage of outdoor conditions (daylight, sun heat, air flow);
- Simulation of varying consumption due to occupancy schedule of rooms.

**Alternative 5:** Include renewable energy sources in the building consumption (PV) *Changes adapted to the Alternative 7B

When selecting materials in alternatives the environmental performance was also taken in consideration through EPD. Thus application of sustainable materials was provided.



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### 7.3.5. Achieved results

For the optimal design alternative (No. 5), the following results are achieved:

1) Total energy required (heating + illumination): **102 kWh/m$^2$/year**

2) Share of RES in total energy consumption: **14.927 MWh** annual energy generation or 23% from total energy consumption.

3) Cost of the optimal alternative: **24.9 EUR/m$^2$/year**.

### 7.3.6. Summary- Confirmation of energy KPIs

**By the case study of a renovated building (a real life project), developed exclusively for the project purposes, the BIMcert project confirmed the energy impacts as declared in the proposal stage.**

The figures obtained by the case study for a renovated buildings are presented in the table below:

*Table 7. Presentation of results of energy calculations of the prototype*

| | |
|---|---|
| Energy consumption in the baseline alternative (0): | **259 kWh/m$^2$ per year** |
| Energy consumption achieved by optimization by traditional method – (*Alternative 4A*):: | **157 kWh/m$^2$ per year** |
| Energy consumption achieved by optimization in BIM (Alternative 4B): | **124 kWh/m$^2$ per year** |
| Energy consumption from outsource, when including RES (photovoltaics), *Alternative 5*: | **102 kWh/m$^2$ per year** |
| Difference between the best CAD and BIM alternative (*Alternative 4A – Alternative 4B*): | **157-124 = 33 kWh/m$^2$ per year** |
| Difference between the best BIM alternative and alternative with RES included(*Alternative 4B – Alternative 5*): | **124-102 = 22 kWh/m$^2$ per year** |

The study demonstrates the following overall energy effects of application of BIM due to the advantages specified previously:


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1) **Increased energy savings by 21,02%**, compared to the best alternative that can be achieved by traditional method, based on CAD, which is equal to: **33 kWh/m$^2$/year** (difference between the alternatives 4B and 4A).
For the total area of the building (dwellings + offices) of 856 m$^2$ , total energy saving in this sample project equals to: **33 kWh/m$^2$/year * 806 m$^2$ = 26.6 MWh** energy savings per year, due to applied energy calculations based on BIM model;

2) Total share of energy generated by on – site renewable sources is: **14.927 MWh annual energy, or 22 kWh/ m$^2$ per year = 21,6 % of the total energy consumption** of the building**.**

3) The expected **reduction of gap** between designed and actual energy performance is over **25%,** due to accurately designed energy consumption and management system supported by BIM model (as presented in the simulation of 24-hour consumption, in the Learning material 6.5: Case study of a new building).



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## 8. Summary

1. This report presents the process of development of learning, evaluation and testing materials that were used in the process of project tests and trials.

2. The BIMcert consortium liaised with industry to select a package of pilot training materials from the full set of learning outcomes in the belief that these will have the fastest and most influential impact on the intended audience and will also be a representative sample of the program.

3. Tests of the [program were used for raising awareness, capacities and skills of AEC professionals from various target groups, for energy efficient and sustainable design, construction and operation of buildings. Communication with stakeholders was carried out through webinars, face to face workshops and self – learning via the BIMcert platform.

4. When designing materials, they were shaped to be used for both e-learning and for trainer led approach, respecting the survey results.

5. Results from testing confirmed that selected methods, tools and models of delivery of BIMcert program were well recognized and accepted by all stakeholders.

6. The developed materials confirmed advantages of BIM, compared to traditional methods, for achieving more energy efficient design, construction and operation of buildings, in measurable energy savings.

7. The consortium will use the results provided from testing of the selected sample to develop gradually the full scope of materials, planned for the project commercial exploitation.



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## 9. Appendix – List of developed modules available on the learning platform

- Training 4 Trainers
- BIM ready
- What is BIM & digital construction?
- BIM Terms & Definitions
- What are BIM (Maturity) Levels?
- BIM Dimensions
- Digital Skills- Accessing information through the cloud
- Digital Skills- Accessing Information with Mobile Devices
- Digital Skills & Collaboration I-CDE & File Structure
- Digital skills & collaboration II-Access BIM models
- Digital skills & collaboration III-review BIM models
- Intro to BIM Implementation- Impacts in project delivery -Overview
- BIM & Digitalization Benefits-Overview
- Intro to BIM Standards –Overview
- BIM Level/Stage 2 Requirements- EIR
- BIM Level/Stage 2 Requirements- BEP
- BIM Stage2 Requirements- Delivery Team's Mobilization Plan (former PIP)
- BIM Security
- BIM & Digitalization Benefits-for Project Management
- BIM & Digitalization Benefits-for supply chain Coordination
- BIM & Digitalization Benefits-Sustainability & Energy efficiency
- Concept & Definitions of Energy Use in buildings
- BIM Tech-Software & Hardware-Intro
- Key terms of Energy Use in building
- Overview of climate change and EU Policy.
- Energy usage and wastage in construction and operation of buildings
- Building Fabric & Energy
- Heating & ventilation systems vs Energy Consumption
- Energy system thinking key principles
- BIM tools for Low Energy Building Construction
- Training 4 Trainees
- BUILD UP Webinar - Digitalization of the Building and Construction Sector



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