BIM-based EU -wide Standardized Qualification Framework for achieving Energy Efficiency Training

D3.2 – Definition of learning outcomes in the European level

WP 3	**Leader: INES Formation**
Task 3.2	**Leader: Metropolia University of Applied Sciences**
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Abbreviations

ALO	Achieved Learning Outcomes
BEM	Building Energy Model
BIM	Building Information Modelling
CA	Consortium Agreement
DoA	Description of the Action
EE	Energy Efficiency
EPBD	Energy Performance Buildings Directive
EPC	Energy Performance Certificate
EQF	European Qualification Framework
GA	Grant Agreement
HOTS	High Level Thinking Skills
ICT	Information and Communication Technologies
ILO	Intended Learning Outcomes
KSC	Knowledge – Skills – Competencies
LO	Learning Outcomes
LOTS	Low Level Thinking Skills
Mx	Milestone date designating the start of a given task
My	Milestone date designating the end of a given document delivery deadline
PC	Project Coordinator
PSC	Project Steering Committee
QA	Quality Assurance
RIBA	Royal Institute of British Architects
ToC	Table of Content
WP	Work Package
WPL	Work Package Leader

1 Executive Summary

The European Qualifications Framework is a common European reference framework whose purpose is to make qualifications more readable and understandable across different countries and systems[1]. The framework includes eight reference levels, which are defined in terms of learning outcomes.

The purpose of the common frameworks for learning outcomes is to enable the comparison of qualifications across national borders and stakeholders. The use of common language makes such comparison possible.

Learning outcomes discussed in this report refer to the intended leaning outcomes rather than achieved learning outcomes *"Learning outcomes are attributed to individual educational components and to programmes at a whole. Learning outcomes are specified in three categories – as knowledge, skills and competence* (KSC)*. This signals that qualifications – in different combinations – capture a broad scope of learning outcomes, including theoretical knowledge, practical and technical skills, and social competences where the ability to work with others will be crucial*."[2]

Building information modelling offers potential benefits for the better management of energy and other performance aspects of buildings. To enable and ensure the utilization of these benefits there is a need for the identification of the required KSC for the different roles in design, building and maintenance processes as well as to support in definition and creation of learning outcomes. Further, it is important to define the learning outcomes to support the planning and offering of training courses that fulfil the identified requirements.

Certain basic principles are important, when defining learning outcomes. The following list presents the recommendations from European guide book "*Defining, writing and applying learning outcomes"* [3]:

- Focus is always kept on the learner: what is (s)he expected to know or understand.
- Learning outcomes need to be defined and written in a way where there is room for individual and local adaptation.
- Too detailed statements should be avoided. Also overly complex statements prevent learners, teachers and assessors from relating to the statements.
- Learning outcomes cannot replace related knowledge, skills and competence statements.
- Learning outcome should start with an action verb, followed by the object of the verb as well as a statement specifying the depth of learning to be demonstrated, and complete with an indication of the context. Table 3 illustrates the system.
- Generally not more than one action verb for each learning outcome.

The objective of this work was to define the first draft of the learning outcomes for training courses that would provide the required skills and knowledge for the selected roles in design, building and maintenance processes in order to effectively utilize building information modelling for energy-efficient buildings.

[1] http://www.cedefop.europa.eu/fi/events-and-projects/projects/european-qualifications-framework-eqf
[2] Users'Guide, E. C. T. S. "Luxembourg: Publications Office of the European Union." DOI 10 (2015): 87192. https://europass.cedefop.europa.eu/sites/default/files/ects-users-guide_en.pdf
[3] CEDEFOP European Centre for the Development of Vocational Training. 2017. Defining, writing and applying learning outcomes. A European Guide Book. Luxembourg: Publications Office of the European Union, 2017. Web-source: < http://www.cedefop.europa.eu/files/4156_en.pdf > Referred 20th November 2017.

The report presents the summary of the deliverable D3.2 of BIMEET project and lists the proposed EU wide learning outcomes for different roles and stakholders. The identified intended learning outcomes package is expected to guide different training organizations to support in the development of BIM and EE course and course content development. To define the European learning outcomes related to BIM and energy-efficient building, six main categories were selected:

- Client & Clients advisors
- Architectural design roles
- Structural design roles
- Building services design roles
- Construction work roles
- Maintenance work roles

The document provides 6 - 8 specified groups of learning outcomes for the each selected main category role. Each of the groups consists of 4 - 14 learning outcomes that clarify and supplement the required qualifications. The specific order is intended to support in course planning phases as most training courses are based on modular structure.

2 About the BIMEET project

The aim of BIMEET is to (a) pave the way to a fundamental step change in delivering systematic, measurable and effective energy efficient buildings through BIM training with a view to effectively address European energy and carbon reduction targets; (b) promote a well-trained world leading generation of decision makers, practitioners, and blue collars in BIM for energy efficiency; (c) establish a world-leading platform for BIM for energy efficiency training nurtured by an established community of interest. These general aims translate into the following strategic objectives (STO):

- STO1: Screen and synthesize past and ongoing European, as well as national, initiatives and projects with a focus on assembling evidence-based quantitative / measurable scenarios and use cases that demonstrate the role of BIM in achieving energy efficiency in buildings across the whole value chain.

- STO2: Benchmark existing Europe-wide BIM trainings across the building value chain (including lifecycle and supply chain), highlighting energy efficiency linkages, as well as qualification targets, delivery channels, skills, accreditation mechanisms, while highlighting training gaps and enhancement potential.
  - ✓ This will include: (a) better determination of future capability needs; (b) clear routes of entry and clear career progression pathways; (c) clear, standard means of recognizing competence; (d) exploring the scope to make apprenticeships more flexible; (e) an industry review of the current skills and capability delivery mechanisms; (f) review of approaches to career planning, training and development with a commitment to rationalize.

- STO3: Harmonize energy related BIM qualification and skills frameworks available across Europe (Objective 1) with a view of reaching a global consensus through our BIM for energy efficiency expert panel.
  - ✓ The focus is on setting up a mutual recognition scheme of qualifications and certifications among different Member States supported by an effective strategy to ensure that qualification and training schemes are sustained after the end of the project.

- STO4: Map identified skills, qualifications, and accreditation into a BIM for energy efficiency overlay with a total lifecycle and supply chain (including blue collar) perspective.
  - ✓ There are country specific delivery and process variations that will be considered to ensure successful take-up of the BIMEET training program at a national level.

- STO5: Adapt the BIM4VET platform (delivered in the context of a related ERASMUS+ ongoing project) to provide a robust computer-based online and open-access environment for BIMEET.
  - ✓ The BIM4VET platform is already providing: (a) BIM stakeholder competence matrix, (b) classification of BIM training curriculums in Europe, (c) BIM qualification maturity assessment method, and (d) recommender system for BIM training selection.
  - ✓ The resulting BIMEET platform will be available on-line on an open-access mode, nurtured by an established community of interest underpinned by an adapted business model.

- STO6: Establish a governance, policy, and regulatory framework as well as adapted business models to ensure the long-term sustainability of the proposed BIMEET training agenda.
  - ✓ The consortium will be supported by a 200+ members of the BIMEET community of interest and a panel of experts (around 20 members).
  - ✓ The consortium members will adopt an incremental and participative approach engaging effectively all the above stakeholders.

- STO7: Disseminate within and beyond Europe the resulting BIMEET platform and training program.

BIMEET endeavours to enhance the skills, qualifications and capabilities of construction practitioners (from high professionals to blue collar workers), thus increasing market penetration and adoption of key technological development in BIM, given the timelines of the need for training in combined green and functional performance engineering. There are several areas that are key to the potential growth of BIM for energy efficiency and its impact on the green building marketplace:

- Multi-disciplinary integrative capacity of BIM: BIM provides a unique opportunity to integrate data, information and underpinning processes across lifecycle and supply chains. This will promote informed and energy efficient design interventions.
- Informed sustainability design: BIM contributes to sustainable lifecycle decisions and processes as it leverages on the capability of the complete construction value chain thus optimizing design decisions on complex issues such as energy efficiency.
- Modelling standards: BIM is currently promoting the development and adoption of a wide range of standards and best practice guide as evidenced by BIM adoption dynamics in Europe.
- Increase of BIM use for retrofit: there is an increasing trend for use of BIM in large as well as smaller projects with a sought benefit of maximizing energy efficiency and sustainable outcomes. Recognition of the appropriateness of BIM for small retrofit projects is also critical given the dynamic growth anticipated in the green retrofit market in the existing domestic stock across Europe.
- Using BIM for building performance monitoring: there is an increasing evidence of the value BIM tools during the operations and maintenance phase of a project, with the view of reducing the endemic gap between predicated and actual energy consumption in buildings.
- Training support & communication tool: As BIM embraces building products and processes, it constitutes a useful support for training, and to communicate the best practices for energy efficient and high-quality construction, in particular to on site staff.

This report focuses specifically on the strategic objective no.3.

3 Learning outcomes

Learning outcomes are the explicit statements of what a learner is expected to know, understand and is able to do after the completion of a learning activity. Learning outcomes discussed in this report refer to the intended leaning outcomes (ILOs) rather than achieved learning outcomes (ALOs). Learning-outcomes-based frameworks enable the comparison of qualifications across different types of institutions and stakeholders. By providing a common language makes it possible to compare qualifications over national borders.

> *"Learning outcomes are attributed to individual educational components and to programmes at a whole. Learning outcomes are specified in three categories – as knowledge, skills and competence. This signals that qualifications – in different combinations – capture a broad scope of learning outcomes, including theoretical knowledge, practical and technical skills, and social competences where the ability to work with others will be crucial*."[4]

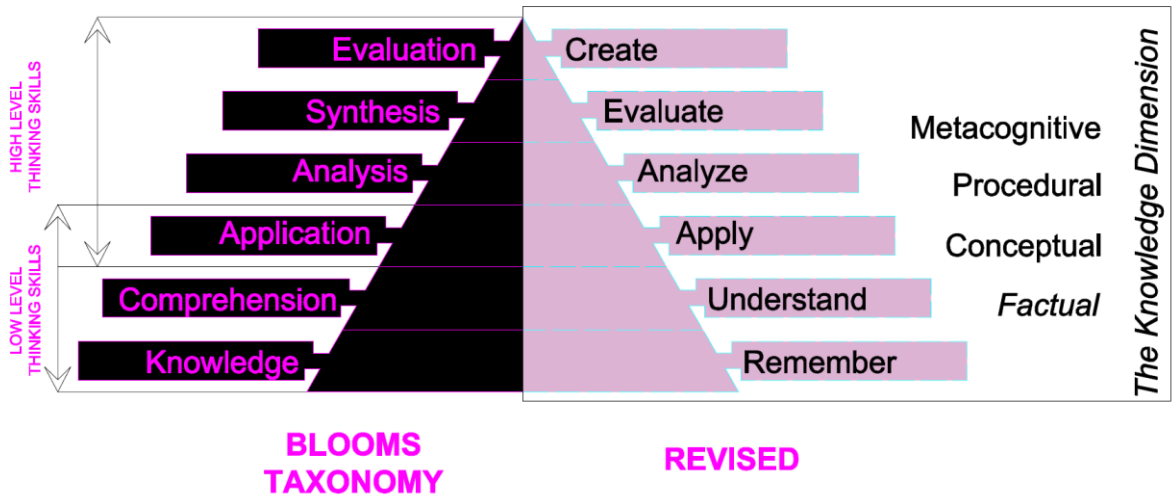

Figure 1: Bloom's taxonomy and revised Bloom's taxonomy hierarchical levels

Learning outcomes are valuable. Bloom's taxonomy and revised Bloom's taxonomy are the most often used frequent tools while developing learning outcomes. The cognitive domain of the Taxonomy comprises of six hierarchical levels of learning. *The categories are ordered form simple to complex and from concrete to abstract*[5] with a focus towards the level of cognitive processing required in the levels of learning particularly termed as low level thinking skills (LOTS) and high level thinking skills (HOTS) as shown in

[4] Users'Guide, E. C. T. S. "Luxembourg: Publications Office of the European Union." DOI 10 (2015): 87192. https://europass.cedefop.europa.eu/sites/default/files/ects-users-guide_en.pdf

[5] Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory into practice*, *41*(4), 212-218.

4 EU-wide intended learning outcomes

The following process (Figure 4) was used in development of harmonized EU-wide learning outcomes - First, BIM EE Roles/Responsibilities (R, R2) are identified. Skills (S), Knowledge (K), Competences (C) and Learning Outcomes (LO) are defined for the different roles in design and building and maintenance process by partners from their country perspective (France, Finland, Greece, Luxembourg and United Kingdom). Then all deliveries produced during BIMEET and other relevant EU-projects are mapped. Results of the same elements (R2, SKC and R (Roles) are collected and stored in Super Matrix. The first draft of EU-wide Learning Outcome Matrix is produced after the assessment of the most important and relevant learning outcomes. The so produced learning outcomes are then validated within the consortium and validated with the help of the expert panel of the project resulting to the final product of D3.2.

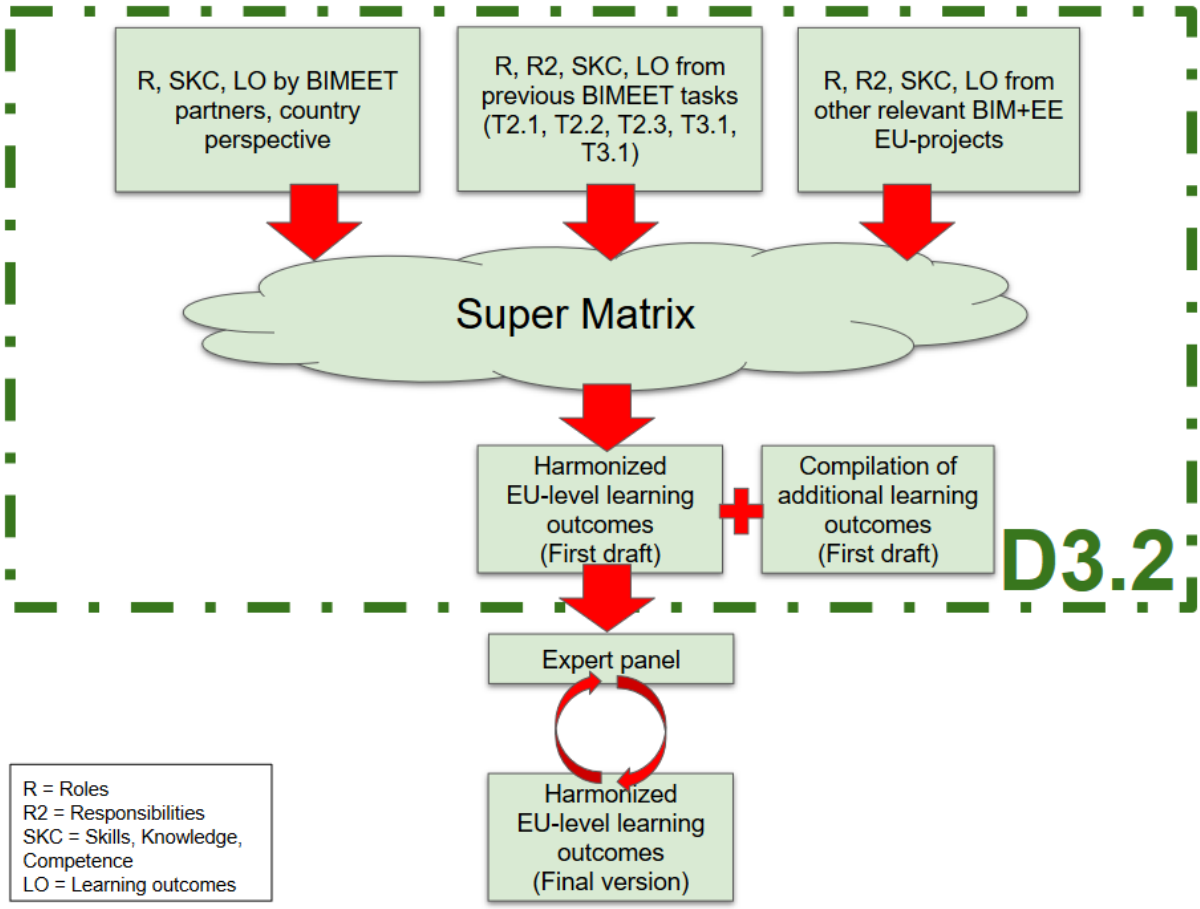

Figure 4: Structure and meaning of D3.2. Carefully established learning outcomes prioritize the application of knowledge and equally play an important role as their use within a unit of instruction primarily guides learning and assessment activities that enhances student engagement and learning. [6] The approach adopted to describe and develop EU wide learning outcomes is based on the principles of the EQF particularly focusing on the KSC framework and the use of action verbs in relation to what a learner should know, have skills and be

[6] University of Toronto. Centre for Teaching Support and Innovation, and Emily Gregor-Greenleaf. Developing Learning Outcomes: A Guide for Faculty. Centre for Teaching Support and Innovation, University of Toronto, 2008. https://teaching.utoronto.ca/wp-content/uploads/2015/08/Developing-Learning-Outcomes-Guide-Aug-2014.pdf

competent on. An example showing the basic structure of learning outcomes are presented in the Figure 2.

The basic structure of learning outcomes statements…			
… should address the learner.	… should use an action verb to signal the level of learning expected.	… should indicate the object and scope (the depth and breadth) of the expected learning.	... should clarify the occupational and/or social context in which the qualification is relevant.
Examples			
The student…	…is expected to present …	…in writing the results of the risk analysis	….allowing others to follow the process replicate the results.
The learner…	…is expected to distinguish between…	…the environmental effects…	…of cooling gases used in refrigeration systems.

Figure 2: Basic structure of the learning outcomes (22 p. original source Cedefop)

The process used to develop the learning outcomes furthermore also relates to the case based approach. It focuses on mapping the standard RIBA Plan of Work stages and identified stakeholders followed by the process to defining learning outcomes for the role based courses. The three categories of KSC should be collectively perceived and should not be read in isolation from each other. Figure 3 highlights some of the action verbs used to define the levels of taxonomy in the cognitive domain.

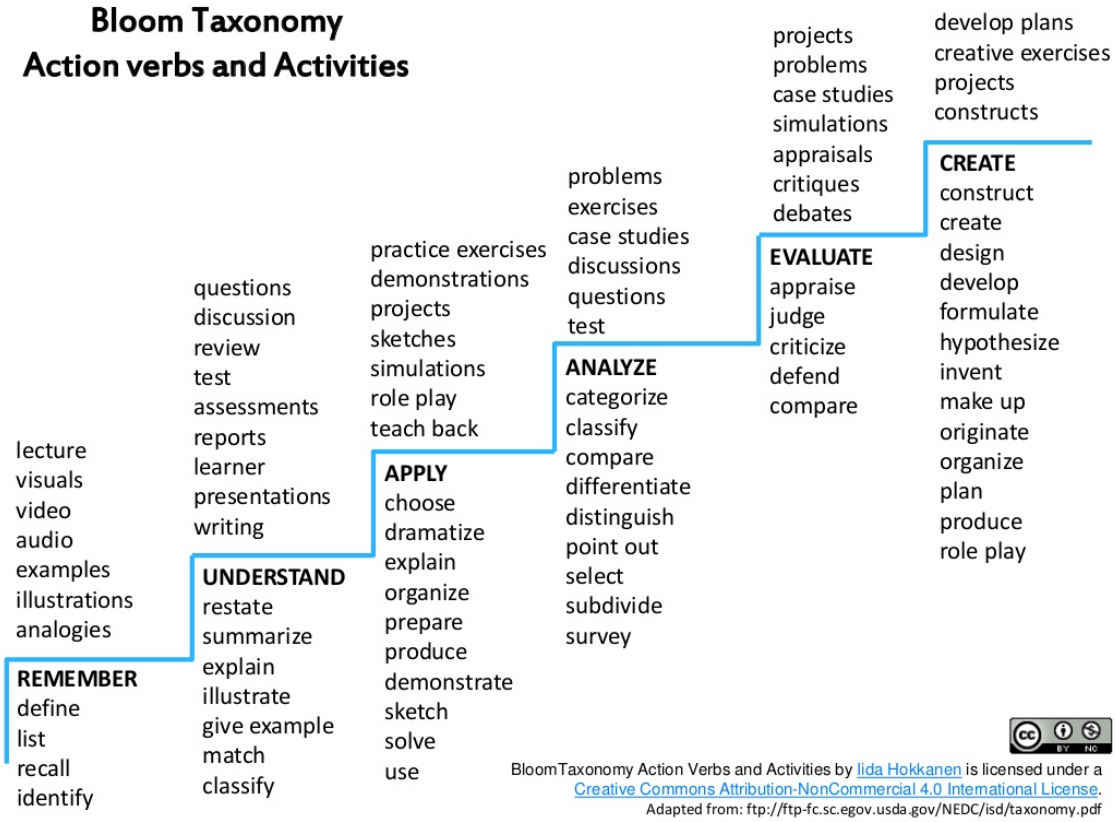

Figure 3: Bloom taxonomy action verbs and activities (Iida Hokkanen 2015) [7]

[7] https://www.slideshare.net/IidaHokkanen/bloom-taxonomy-action-verbs-and-activities

5 EU-wide intended learning outcomes

The following process (Figure 4) was used in development of harmonized EU-wide learning outcomes - First, BIM EE Roles/Responsibilities (R, R2) are identified. Skills (S), Knowledge (K), Competences (C) and Learning Outcomes (LO) are defined for the different roles in design and building and maintenance process by partners from their country perspective (France, Finland, Greece, Luxembourg and United Kingdom). Then all deliveries produced during BIMEET and other relevant EU-projects are mapped. Results of the same elements (R2, SKC and R (Roles) are collected and stored in Super Matrix. The first draft of EU-wide Learning Outcome Matrix is produced after the assessment of the most important and relevant learning outcomes. The so produced learning outcomes are then validated within the consortium and validated with the help of the expert panel of the project resulting to the final product of D3.2.

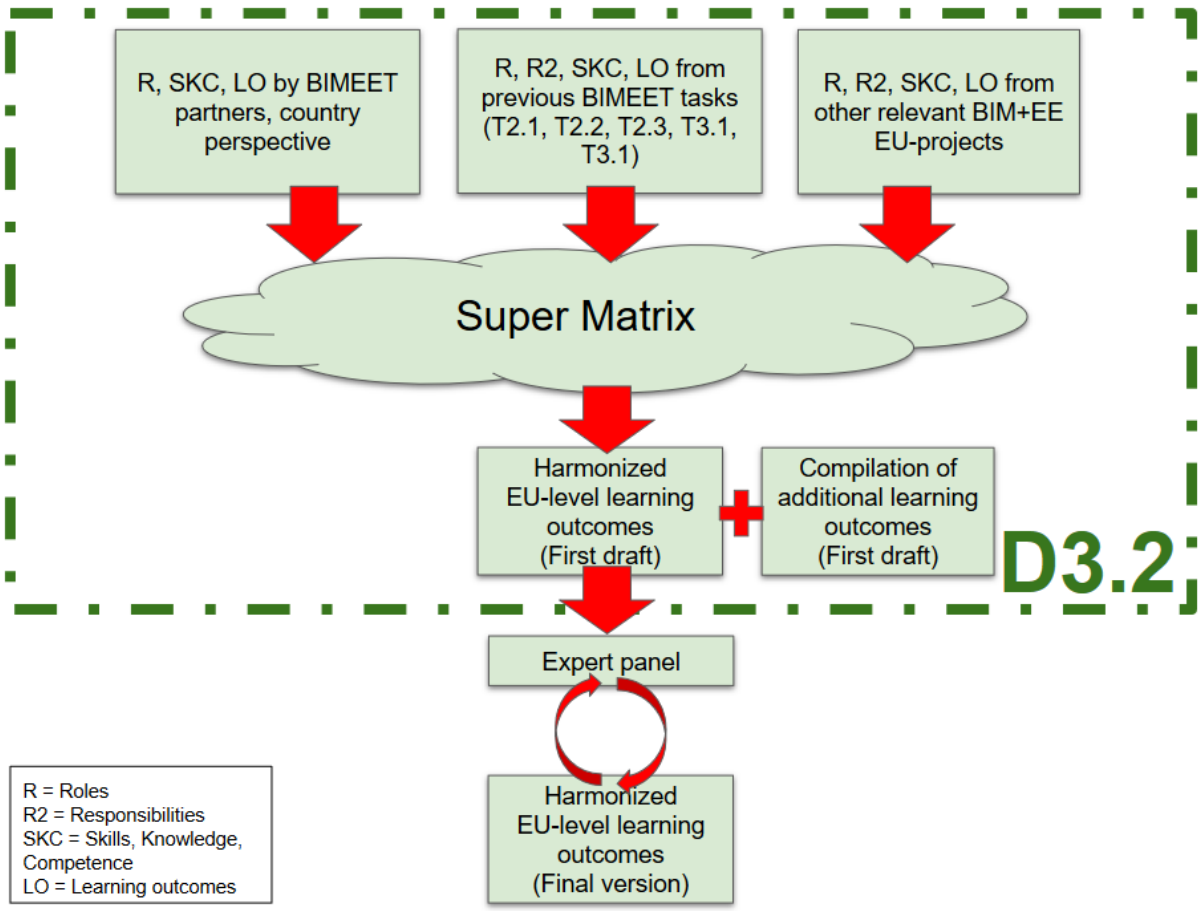

Figure 4: Structure and meaning of D3.2

6 Results

The work resulted in proposing 6 - 8 specified groups of learning outcomes for the each selected main category role (Table 1 - Table 6). Each of the groups consists of 4 - 14 learning outcomes that clarify and supplement the required qualifications. Tables 6 - 12 present the European level learning outcomes for the following roles along with the related EQF levels:

- Client & Clients advisors, specifically: Client, Project manager, BIM manager, BIM coordinator, Briefing consultant
- Architectural design roles, specifically: Architectural Design and BIM Coordinator, Chief Designer, Architect, Assistant designer
- Structural design roles, specifically: Structural design and BIM coordinator (structural), Assistant designer
- Building services design roles, specifically: HVAC and Energy design and BIM coordinator (HVAC), Assistant designer
- Construction work roles, specifically: Site manager, construction site workers and installers
- Maintenance work roles, specifically: Maintenance operator, property manager, care taker

Table 1 European BIM EE learning outcome matrix for Client & Client advisors i.e. Client & Project manager, BIM manager, BIM coordinator, briefing consultant

Learning outcomes are defined in specific order forming seven groups:

- Group 1 (LO1) Fundamentals of BIM and principles of its uses with respect to building life-cycle
- Group 2 (LO2) Fundamentals of sustainable and energy-efficient buildings and building performance
- Group 3 (LO3) Preparation of information management documentation and setting strategic targets for the project
- Group 4 (LO4) Early stage target setting for energy, sustainability and building performance
- Group 5 (LO5) BIM-based collaboration methods in project management and processes
- Group 6 (LO6) Quality management procedures for achieving set targets
- Group 7 (LO7) Skills for relevant software and interfaces between software.

No	Learning outcome	EQF level			
Client & Client advisors	Client & Project manager (C), BIM manager (BM), BIM coordinator (BC), briefing consultant (Bc)	C	BM	BC	Bc
LO1	**Learner is able to explain the fundamentals of BIM and the underlying principles of uses with respect to building life-cycle.**	**4**	**6**	**6**	**4**
1.1	Recall essential contents, summarize and give examples of BIM terminologies, definitions and standards.	4	6	5	4
1.2	Explain added value of BIM for energy efficient and sustainable projects.	4	6	5	5

1.3	Explain the potentials of different BIM-compatible assessment, simulation and optimization tools in achieving good energy and building performance.	2	3	3	5
1.4	Summarize the ideas of digital space and asset management.	6	3	3	5
1.5	Explain the added value of using open file formats (i.e. IFC) to ensure interoperability.	3	5	5	2
1.6	Explain the main contents and apply relevant parts of national BIM guidelines.	4	6	5	-
LO2	**Learner is able to explain the fundamentals of sustainable and energy-efficient buildings and building performance.**	**3**	**3**	**3**	**5**
2.1	Explain and give examples of aspects and terminology related to energy and building performance.	4	4	4	3
2.2	Describe the aspects (financial and environmental) and related indicators of energy and building performance.	5	4	4	3
2.3	Explain relations between life-cycle costs, energy performance and building performance.	3	3	3	5
2.4	Summarize and illustrate the potentials of renewable energy sources including district-scale solutions.	3	2	2	5
2.5	List and explain the core concepts of sustainable building rating and certification systems.	3	3	3	5
LO3	**Learner is able to prepare BIM execution plan and explain essential aspects in setting strategic and project targets.**	**6**	**6**	**4**	**6**
3.1	Explain the importance and illustrate processes of collecting expectations and setting targets for building spaces, indoor environment and energy performance.	6	4	3	6
3.2	Explain the importance and illustrate processes of decision making with regard to the choice of building location, whether and when to renovate or build new.	6	3	2	6
3.3	Explain owners' strategic target setting processes to guide energy and performance requirement setting in business cases.	6	4	2	6
3.4	Explain how to identify most suitable organizational structure and range of consultants to be engaged for the project to reach the set targets and goals.	6	5	3	6
3.5	Explain and illustrate BIM process and related technologies especially in preparing the project plan based on owner's BIM strategy.	4	6	5	-
3.6	Describe the decision-making process about the use of BIM and defining modelling uses.	4	6	4	-
3.7	Demonstrate how to make process maps for the selected BIM uses and set information exchange requirements.	2	6	5	-
3.8	Explain how to define resources needed for design and defining competence requirements for designers and engineers.	4	6	4	-
3.9	Give examples how to formulate a clear definition of the BIM and EE related tasks, responsibilities and obligations to each party and implement them in calling for tenders, negotiations and agreements.	4	6	4	-
3.10	Explain and give example how to prepare BIM execution plan for the project.	3	6	6	-
3.11	Describe the procedure in defining project specific modelling requirements and define the level of information need for different phases.	3	6	4	-
3.12	Set requirements for modelling outputs in accordance with owner organization's information and asset management systems.	3	6	4	-

3.13	Assess and ensure that the model is fit for use for different construction activities as well as in operation and maintenance.	2	6	4	-
LO4	**Learner is able to explain about the procedures and importance of setting targets for energy, sustainability and building performance.**	**6**	**5**	**3**	**6**
4.1	Explain and give examples of different types of objectives, quality objectives, sustainability aspirations, targeted outcomes, budgeting and other constraints for building projects.	6	5	3	6
4.2	Include and explain the importance of energy analysis in the decision making starting from the earliest stages of the project and even on the basis of very simple and preliminary BIMs.	6	4	2	6
4.3	Assess potentials, feasibility and risks of different alternatives based on studies performed by consultants.	6	3	-	6
4.4	Use risk analysis and conduct feasibility (financial and technical) studies to make sure set objectives of the project are achievable.	5	-	-	5
4.5	Review BIM models and evaluate the functionality of spaces with regard to user needs, designed performance and set performance targets.	4	5	4	5
4.6	Set targets for the energy consumption of the realized building and demand clarifications and solutions in case of a mismatch between design and actual.	4	3	-	2
4.7	Explain the concepts of digital twin and its potential in the optimization of comfort and energy performance of building.	3	3	3	1
4.8	Explain how to define requirements for performance documentation (how and where the targeted, designed and achieved performance is documented to enable the continuous monitoring by the client?).	4	6	4	-
LO5	**Learner is able to explain and use BIM based collaboration methods for project management and processes.**	**3**	**6**	**5**	**2**
5.1	Describe the essential parts of the procedure for BIM based collaboration.	4	6	4	2
5.2	Describe different collaborative interdisciplinary and open BIM working methods, tools and processes.	-	6	5	-
5.3	Explain and give examples how to collaboratively design, execute and supervise BIM based project management.	3	6	4	4
5.4	Moderate and coordinate BIM-based collaboration amongst the stakeholders including design team, client, manufacturers, construction site and building authorities.	-	6	6	-
5.5	Moderate collaboration with the help of communication platforms and processes like CAVE (computer aided virtual environment) and Big Room working.	3	5	5	5
5.6	Explain the course of procurement process and give examples of collaborative procurement models to support interdisciplinary working practices resulting in best solutions for energy-efficient buildings.	6	4	3	6
LO6	**Learner is able to explain, implement and supervise quality management procedures in building project to achieve set targets.**	**6**	**6**	**5**	**2**
6.1	Describe requirement management approaches.	6	5	3	6
6.2	Describe clear and systematic commissioning and monitoring methods including check points for quality control to ensure compliance with the set targets.	6	4	3	6
6.3	Explain how to organize regular compliance checking meetings towards the energy strategy of the owner organization and energy performance regulations to follow through the whole project.	4	6	4	-
6.4	Define recurring situation picture with suitable visual medium to serve decision making with involved parties throughout the project.	4	6	4	-

6.5	Ensure that the models contain the right and accurate information required in different project stages.	-	6	6	-
6.6	Describe the decision-making process for the acceptability of the design concept, generic design and as-designed model.	4	6	4	-
6.7	Explain how to include the BIM and buildings' energy performance targets and related requirements in tendering and contractual documents.	4	-	-	4
6.8	Explain owner's role in the follow-up of and validate the construction work and quality.	5	6	4	-
6.9	Explain how to set requirements for BIM based commissioning, maintenance training, handover, future monitoring and maintenance.	3	5	3	-
6.10	Explain and give examples on how to support and train project stakeholders in the use of BIM for energy-efficient buildings.	2	5	5	-
LO7	**Learner is able to use different relevant software and interfaces between relevant software.**	**4**	**5**	**5**	**5**
7.1	Use information and communication technologies taking into account data security and protection requirements.	3	5	3	3
7.2	Use BIM and GIS tools for the site appraisal and explain about site-specific issues, evaluations and planning.	-	-	-	3
7.3	Use different tools for BIM-based collaborative working.	3	5	5	3
7.4	Use BIM compatible requirement setting tools.	4	3	3	5
7.5	Prepare and maintain the requirement model.	-	4	4	3
7.6	Create combination model and use model checking tools for design reviews and constructability.	-	3	5	-
7.7	Use visualization tools, viewers and dashboards.	5	5	3	5
7.8	Explain the use of spatial sketching and performance assessment tools and results for decision making.	2	1	1	5
7.9	Use digital space and asset management tools and systems.	6	3	3	6
7.10	Use tools for information extraction from the models to make informed decisions about the cost, quality, sustainability and building performance.	4	4	3	5
7.11	Use digital archive systems for documents and models.	3	4	4	
7.12	Use project data and file management systems.	5	6	6	5

Table 2 European BIM EE learning outcome matrix for Architectural design roles i.e. Architectural design and BIM Coordinator (arch), Chief designer (CD), Architect (ARCH), Assistant designer (ASS)

Learning outcomes are defined in specific order forming eight groups:

- Group 1 (LO1) Fundamentals of BIM and principles of its uses with respect to building life-cycle
- Group 2 (LO2) Fundamentals of sustainable and energy-efficient buildings and building performance
- Group 3 (LO3) Leading of design process, supporting the client and other stakeholders in decision making
- Group 4 (LO4) Implementation of energy performance, building performance and sustainability targets into design process.
- Group 5 (LO5) Production of BIM models with accurate and required information content for the different uses and phases of a building project.
- Group 6 (LO6) Collaboration, communication and visualization with help of BIM
- Group 7 (LO7) Implementation of target and quality management procedures in the building project.
- Group 8 (LO8) Skills for relevant software and interfaces between software.

No	Learning outcome	EQF level		
Architectural design roles Architectural design and BIM Coordinator (arch), Chief designer (CD), Architect (ARCH), Assistant designer (ASS)		CD	ARCH	ASS
LO1	**Learner is able to explain the fundamentals of BIM and the underlying principles of uses with respect to building life-cycle.**	**6**	**6**	**3**
1.1	Recall essential contents, summarize and give examples of BIM terminologies, definitions and standards.	6	6	3
1.2	Recall essential contents, summarize and give examples of overall BIM process for a building's life cycle.	6	6	3
1.3	Explain and use standard information exchange processes for different design domains in general and especially in detailed technical design.	5	5	2
1.4	Explain the essential issues related to information management, data transfer and sharing.	5	5	2
1.5	Explain the added value of using open file formats (i.e. IFC) to ensure interoperability.	5	5	2
1.6	Recall, summarize and explain essential contents and relevant parts of national BIM guidelines.	6	6	3
LO2	**Learner is able to explain the fundamentals of sustainable and energy-efficient buildings and building performance.**	**4**	**6**	**2**
2.1	Explain and give examples of aspects and terminologies of energy and building performance.	6	6	2
2.2	Describe the financial and environmental aspects and related indicators, benchmarks and certification systems of energy and building performance.	2	6	2
2.3	Explain the issues that affect energy performance of buildings and demonstrate competence in domain specific solutions.	4	6	1
2.4	Explain relations between life-cycle costs, energy performance and building performance.	4	6	2

2.5	List and explain the core concepts of sustainable building rating and certification systems.	4	4	2
2.6	Summarize and give examples about the potentials of renewable energy sources applicable to buildings including district-scale solutions.	4	4	1
2.7	Point out legislation and regulations related to energy performance, thermal comfort and air quality.	6	6	3
LO3	**Learner is able to lead design process and support the client and other stakeholders in decision making.**	**6**	**5**	
3.1	Explain the overall design process for energy-efficient building.	5	6	2
3.2	Explain the flow of the collaborative interdisciplinary BIM process and point out essential issues of successful leadership.	6	5	-
3.3	Lead the team / participate in the preparation of presentation materials and presentation agenda to support owner's and other stakeholder's effective decision-making and opinion formation.	6	5	-
3.4	Explain how to add value for the decision making of the energy efficiency and other targets with preliminary massing alternatives and energy analysis in the early project stages.	5	6	-
3.5	Assist the client to set and specify information requirements.	5	5	-
3.6	Direct the design towards set targets utilizing the capacity of different kinds of assessment methods for architectural design.	6	6	-
3.7	Lead the design team / participate to prepare, compare and improve alternative design concepts.	6	6	-
3.8	Take care and lead the tasks related to the electronic building permission process including communication with the building authorities.	6	5	-
LO4	**Learner is able to implement energy performance, building performance and sustainability targets into design process.**	**5**	**6**	**1**
4.1	Apply the set performance targets related to architectural design into BIM-based design process.	5	6	-
4.2	Implement passive house design strategies for architectural design.	5	6	1
4.3	Point out essential issues related to consideration of the effect of position, orientation, volume and space design, and main product type selections on energy performance and building performance.	5	6	2
4.4	Explain about the principles of sustainable internal layout and flexible floorplan.	5	6	-
4.5	Consider options of renewable energy in architectural design and optimize its potentials.	4	5	-
4.6	Perform energy analyses, life cycle assessments (LCA) and life cycle cost analyses (LCC).	3	5	-
4.7	Produce, simulate and analyze what if scenarios for different energy efficient design alternatives and make feasibility studies based on the domain knowledge.	3	6	2
LO5	**Learner is able to produce BIM models with accurate and required information content for different uses and phases of a building project.**	**3**	**6**	**2**
5.1	Prepare architect's domain model on the basis of set targets and definitions given in the city plan, in case of refurbishment, with the help of initial data model.	3	6	2

5.2	Prepare digital (BIM-linked) building specification to reflect owner's quality and performance requirements.	5	6	2
5.3	Explain essential issues of the needs of initial data and the potentials of different inventory surveys in refurbishment projects.	5	5	1
5.4	Prepare initial data model based on the laser scanning and photogrammetry results.	3	6	2
5.5	Lead the process resulting in the publication of the merged model (as designed) together with all needed information.	6	6	-
5.6	Produce data needed for specific use cases such as bill of quantities.	3	5	2
5.7	Prepare/assist models for energy and indoor climate simulations and environmental assessments.	2	5	2
5.8	Prepare/assist models and information for planning authority and in required data format.	4	5	2
5.9	Prepare/assist models and information for procurement and construction.	3	5	2
5.10	Prepare/assist models to fulfil quality and data requirements for quality control and assurance processes in construction.	3	5	2
5.11	Prepare/assist models based on data and information requirements of sustainable care and maintenance processes.	3	5	2
5.12	Prepare/assist information for As-Built Models and Maintenance model for utilization of client and building management	3	5	2
5.13	Explain the procedure and assist in the digital formulation of care maintenance instructions (maintenance manual) reflecting owner's energy and performance requirements.	-	5	2
LO6	**Learner is able to collaborate and use collaborative approaches to support communication and visualization.**	**6**	**6**	**2**
6.1	Describe the essential parts of the procedure for BIM based collaboration.	4	6	2
6.2	Describe different collaborative interdisciplinary and open BIM working methods, tools and processes.	6	6	2
6.3	Lead and demonstrate how to work collaboratively with the project stakeholders including design team, client, users, manufacturers, construction site and building authorities.	6	5	-
6.4	Prepare relevant visualization models to enable information sharing, decision making and opinion formation.	3	5	-
6.5	Collaborate with the help of communication platforms and processes like CAVE (computer aided virtual environment) and Big Room working.	4	4	2
LO7	**Learner is able to explain and give examples about implementing target and quality management procedures in the building project.**	**6**	**5**	**-**
7.1	Assist / participate in systematic modelling in own organization ensuring that all information is provided in right order, right format and on agreed schedule.	3	5	2
7.2	Validate and point out essential issues of the domain model and manage and repair conflict along with its compatibility with other domain models and targets.	4	6	2
7.3	Verify the achievement of the targets on the basis of the results received with the help of different kinds of assessment methods relevant for architectural design.	6	5	-

7.4	Participate in the verification of the achievement of the targeted results and undertake site inspections in construction site.	5	4	-
7.5	Comment contractor's product selection and its impact on energy consumption to ensure the fulfillment of targets.	4	5	-
LO8	**Learner is able to use different relevant software and interfaces between relevant software.**	**5**	**5**	**3**
8.1	Prepare and maintain the requirement model.	3	3	1
8.2	Use BIM for reading GIS information or reference model for the site appraisal and explain about site-specific issues, evaluations and planning.	3	4	-
8.3	Use different tools for BIM-based collaborative working.	5	6	2
8.4	Use spatial sketching and performance assessment tools for decision making.	4	6	-
8.5	Use domain specific design authoring application for energy efficient architectural design and analysis.	4	6	3
8.6	Use relevant calculation and assessment tools in different design phases.	4	6	2
8.7	Use domain applications for preliminary energy simulations.	3	6	-
8.8	Extract energy analyses parameters from BIM to BEM for simulations and import results to BIM.	3	5	2
8.9	Create relevant reference/analytical model for detail simulations and assessment.	3	6	2
8.10	Create combination model and use model checking tools for clash detection.	4	5	2
8.11	Use BIM tools for visualization and utilize virtual and augmented reality tools to get feedback from users.	4	6	2
8.12	Use project data and file management systems.	4	6	2

Table 3 European wide BIM EE learning outcome matrix for structural design roles i.e. Structural design and BIM coordinator (structural), Assistant designer

Learning outcomes are defined in specific order forming eight groups:

- Group 1 (LO1) Fundamentals of BIM and principles of its uses with respect to building life-cycle
- Group 2 (LO2) Fundamentals of sustainable and energy-efficient buildings and building performance
- Group 3 (LO3) Leading of design process, supporting the client and other stakeholders in decision making
- Group 4 (LO4) Implementation of energy performance, building performance and sustainability targets into design process.
- Group 5 (LO5) Production of BIM models with accurate and required information content for the different uses and phases of a building project.
- Group 6 (LO6) Collaboration, communication and visualization with help of BIM
- Group 7 (LO7) Implementation of target and quality management procedures in the building project.
- Group 8 (LO8) Skills for relevant software and interfaces between software.

No	Learning outcome	EQF level	
Structural design roles Structural design (SD) and BIM coordinator (structural), Assistant designer (ASS)		SD	ASS
LO1	**Learner is able to explain the fundamentals of BIM and the underlying principles of uses with respect to building life-cycle.**	**6**	**3**
1.1	Recall essential contents, summarize and give examples of BIM terminologies, definitions and standards.	6	3
1.2	Recall essential contents, summarize and give examples of overall BIM process for a building's life cycle.	6	3
1.3	Explain and use standard information exchange processes for different design domains in general and especially in detailed technical design.	5	2
1.4	Explain the essential issues related to information management, data transfer and sharing.	5	2
1.5	Explain the added value of using open file formats (i.e. IFC) to ensure interoperability.	5	2
1.6	Recall, summarize and explain essential contents and relevant parts of national BIM guidelines.	6	2
LO2	**Learner is able to explain the fundamentals of sustainable and energy-efficient buildings and building performance.**	**6**	**2**
2.1	Explain and give examples of aspects and terminologies of energy and building performance.	6	2
2.2	Describe the financial and environmental aspects and related indicators, benchmarks and certification systems of energy and building performance.	6	2
2.3	Explain the issues that affect energy performance of buildings and can demonstrate competence in domain specific solutions.	6	1
2.4	Explain relations between life-cycle costs, environmental impacts, energy performance and building performance.	6	1
2.5	List and explain the core concepts of sustainable building rating and certification systems.	4	1
2.6	Summarize and illustrate the potentials of renewable energy sources applicable to buildings including district-scale solutions.	4	1

2.7	Point out legislation and regulations related to energy performance, thermal comfort and air quality.	5	2
LO3	**Learner is able to lead structural design team and support the client and other stakeholders in decision making.**	**6**	**-**
3.1	Explain the overall design process for energy-efficient building.	6	2
3.2	Assist client to set realistic and achievable energy and building performance target.	4	-
3.3	Assist the client to set and specify information requirements.	6	-
3.4	Explain how to support owner's effective decision-making and opinion formation of other stakeholders.	5	-
3.5	Illustrate how to direct the design towards set targets utilizing the capacity of different kinds of assessment methods relevant for structural design.	5	1
3.6	Explain the flow of design teamwork and demonstrate how to prepare, compare and improve alternative concepts.	5	1
3.7	Lead / assist the tasks related to technical documents (structural engineering) for the building authorities.	5	2
LO4	**Learner is able to implement energy performance, building performance and sustainability targets into design process.**	**6**	**2**
4.1	Apply the set performance targets related to structural design into BIM-based design process.	6	-
4.2	Implement passive design strategies for structural design.	5	-
4.3	Point out essential issues and take into consideration of the effects of air-tightness, insulation, thermal bridges, characteristics of windows and shading on energy performance and building performance.	6	2
4.4	Create different design concepts (flexible, modular, easily maintainable and recyclable structural solutions) and make feasibility studies based on the domain knowledge.	6	2
4.5	Use relevant methods to compare alternatives and iterate structural design with regard to engineering issues and structural physics, moisture physics.	6	2
4.6	Discuss and assess the effect of main building materials and main product type selections on energy performance and building performance to fulfil the set targets.	6	2
4.7	Produce, simulate and analyze what if scenarios for different energy efficient design alternatives and make feasibility studies based on the domain knowledge.	6	2
4.8	Present and visualize the results of analyses, calculation, simulations and assessments.	6	2
LO5	**Learner is able to produce BIM models with accurate and required content for different uses and phases of a building project.**	**6**	**2**
5.1	Create domain model on the basis of set targets and definitions given in the architect's model.	6	2
5.2	Create and update digital (BIM-linked) building specification with material and dimensional information to reflect owner's quality and performance requirements.	6	2
5.3	Explain essential issues of the needs of initial data and the potentials of different inventory surveys in refurbishment projects.	6	2
5.4	Support the process resulting in the publication of the merged model (As-Designed) together with all needed information.	6	2
5.5	Prepare/assist data needed for specific use cases such as bill of quantities.	5	2
5.6	Prepare/assist the domain model for simulation and assessment.	5	2

5.7	Prepare/assist models and information for planning authority and in required data format.	5	2
5.8	Prepare/assist models and information for procurement and construction.	5	2
5.9	Prepare/assist models to fulfil quality and data requirements for quality control and assurance processes in construction.	5	2
5.10	Prepare/assist models based on data and information requirements of sustainable care and maintenance processes.	5	2
5.11	Prepare/assist information for As-Built Models and Maintenance model for utilization of client and building management.	5	2
5.12	Prepare/assist in the digital formulation of care maintenance instructions (maintenance manual) reflecting owner's energy and performance requirements.	5	2
LO6	**Learner is able to collaborate and use collaborative approaches to support communication and visualization.**	**5**	**2**
6.1	Describe the essential parts of the procedure for BIM based collaboration.	5	2
6.2	Describe different collaborative interdisciplinary and open BIM working methods, tools and processes.	6	2
6.3	Demonstrate how to work collaboratively with the project stakeholders including design team, client, users, manufacturers, construction site and building authorities.	5	2
6.4	Prepare relevant visualization models to enable information sharing, decision making and opinion formation.	5	2
6.5	Demonstrate the flow of design teamwork with use of void provision model together with architectural and building services design.	5	2
6.6	Collaborate with the help of communication platforms and processes like CAVE (computer aided virtual environment) and Big Room working.	5	2
LO7	**Learner is able to explain and give examples about implementing target and quality management procedures in the building project.**	**5**	**-**
7.1	Participate/assist in systematic modelling in own organization ensuring that all information is provided in right order, right format and on agreed schedule.	5	2
7.2	Validate and check compatibility of the domain model and manage and repair conflict.	5	2
7.3	Verify the achievement of the targets on the basis of the results received with the help of different kinds of assessment methods relevant for structural design.	5	-
7.4	Participate in the verification of the achievement of the targeted result and undertake site inspections in construction site.	5	2
7.5	Comment building product providers' designs and the impacts of contractor's selections on energy consumption to ensure the fulfillment of targets.	5	-
7.6	Instruct and audit contractors on construction site on critical points.	5	-
7.7	Describe and assess quality assurance methods for energy-efficient building envelope (such as blower door -test, thermography) to verify achievement of set targets.	5	-
LO8	**Learner is able to use different relevant software and interfaces between relevant software.**	**6**	**3**
8.1	Use domain specific design authoring applications for structural design and analysis.	6	3
8.2	Use relevant structural calculation and assessment tools in different design phases.	6	2

8.3	Use different tools for BIM-based collaborative working.	5	2
8.4	Create combination model and use model checking tools for clash detection.	5	1
8.5	Extract energy analyses parameters from BIM to BEM for simulations and import results to BIM (material data).	4	1
8.6	Use relevant visualization tools for visualizing energy parameters from simulations and calculations.	5	2
8.7	Create reference model for detail simulations and assessments.	5	2
8.8	Use project data and file management systems.	6	2

Table 4 European BIM EE learning outcome matrix for building service design roles i.e. HVAC and energy design and BIM coordinator (HVAC), assistant designer

Learning outcomes are defined in specific order forming eight groups:

- Group 1 (LO1) Fundamentals of BIM and principles of its uses with respect to building life-cycle
- Group 2 (LO2) Fundamentals of sustainable and energy-efficient buildings and building performance
- Group 3 (LO3) Leading of design process, supporting the client and other stakeholders in decision making
- Group 4 (LO4) Implementation of energy performance, building performance and sustainability targets into design process.
- Group 5 (LO5) Production of BIM models with accurate and required information content for the different uses and phases of a building project.
- Group 6 (LO6) Collaboration, communication and visualization with help of BIM
- Group 7 (LO7) Implementation of target and quality management procedures in the building project.
- Group 8 (LO8) Skills for relevant software and interfaces between software.

No	Learning outcome	EQF level	
Building services design roles HVAC and energy design (HVAC+E) and BIM coordinator (HVAC), assistant designer (ASS)		HVAC+E	ASS
LO1	**Learner is able to explain the fundamentals of BIM and the underlying principles of uses with respect to building life-cycle.**	**6**	**3**
1.1	Recall essential contents, summarize and give examples of BIM terminologies, definitions and standards.	5	3
1.2	Recall essential contents, summarize and give examples of overall BIM process for a building's life cycle.	5	3
1.3	Explain and use standard information exchange processes for different design domains in general and especially in detailed technical design.	5	2
1.4	Explain the essential issues related to information management, data transfer and sharing.	5	2
1.5	Explain the added value of using open file formats (i.e. IFC) to ensure interoperability.	5	2
1.6	Recall, summarize and explain essential contents and relevant parts of national BIM guidelines.	6	2
LO2	**Learner is able to explain the fundamentals of sustainable and energy-efficient buildings and building performance.**	**5**	**2**
2.1	Explain and give examples of aspects and terminologies of energy and building performance.	5	2
2.2	Describe the financial and environmental aspects and related indicators, benchmarks and certification systems of energy and building performance.	5	2
2.3	Explain the issues that affect energy performance of buildings and can demonstrate competence in domain specific solutions.	6	2
2.4	Explain relations between life-cycle costs, environmental impacts, energy performance and building performance.	6	2
2.5	List and explain the core concepts of sustainable building rating and certification systems.	5	2

2.6	Summarize and give examples about the potentials of renewable energy sources and smart energy solutions applicable to buildings including district-scale solutions.	5	2
2.7	Point out legislation and regulations related to energy performance, thermal comfort and air quality.	6	2
LO3	**Learner is able to lead building services design team and support the client and other stakeholders in decision making.**	**6**	**2**
3.1	Explain the overall design process for energy-efficient building.	5	2
3.2	Assist client to set realistic and achievable energy and building performance target.	6	-
3.3	Perform preliminary energy analysis in the early project stages for both new and renovation projects to add value for the decision making.	5	-
3.4	Assist the client to set and specify information requirements.	6	-
3.5	Explain how to support owner's effective decision-making and opinion formation of other stakeholders.	5	-
3.6	Illustrate how to direct the design towards set targets utilizing the capacity of different kinds of assessment methods relevant for building services design.	5	1
3.7	Explain the flow of design teamwork and demonstrate how to prepare, compare and improve alternative concepts.	5	1
3.8	Lead / assist the tasks related to technical documents (HVAC engineering) for the building authorities.	5	2
LO4	**Learner is able to implement energy performance, building performance and sustainability targets into design process.**	**6**	**2**
4.1	Apply the set performance targets related to building services design into BIM-based design process.	5	2
4.2	Iterate the design solutions to meet the set targets of building performance and energy efficiency.	6	-
4.3	Consider options of renewable energy in HVAC design and optimize its potentials.	6	3
4.4	Create different energy efficient design concepts for HVAC and renewable energy systems.	6	-
4.5	Perform energy analyses including dynamic simulations.	5	2
4.6	Perform analyses of indoor air conditions with CFD (computational fluid dynamics), temperature conditions, comfort level, air quality, velocity, humidity and carbon dioxide level.	6	3
4.7	Perform lightning calculations, analyses and simulations.	6	3
4.8	Discuss and assess the effect of main building materials and main product type selections on energy performance and building performance and prepare alternative potential solutions to fulfil the set targets.	6	2
4.9	Use life cycle cost calculation including life-cycle studies changing influential design parameters.	6	2
4.10	Share the results of energy simulations, discuss the options and update domain BIMs.	5	2
4.11	Present and visualize the results of analyses, calculation, simulations and assessments.	5	2
4.12	Produce, simulate and analyze what if scenarios for different energy efficient design alternatives and make feasibility studies based on the domain knowledge.	6	2

LO5	**Learner is able to produce BIM models with accurate and required content for different uses and phases of a building project.**	**5**	**2**
5.1	Prepare the HVAC/MEP engineer's domain model on the basis of set targets and definitions given in architect's domain model.	5	2
5.2	Create and update digital (BIM-linked) building specification with material and dimensional information to reflect owner's quality and performance requirements.	5	2
5.3	Explain essential issues of the needs of initial information and the potentials of different inventory surveys in refurbishment projects.	5	2
5.4	Support the process resulting in the publication of the merged model (As-Designed) together with all needed information.	5	2
5.5	Prepare/assist information needed for specific use cases such as bill of quantities.	5	2
5.6	Prepare/assist the domain model for simulation and assessment.	5	2
5.7	Prepare/assist models and information for planning authority and in required data format.	5	2
5.8	Prepare/assist models and information for procurement and construction.	5	2
5.9	Prepare models to fulfil quality and information requirements for quality control and assurance processes in construction.	5	2
5.10	Prepare models based on data and information requirements of sustainable care and maintenance processes.	5	2
5.11	Prepare information for As-Built Models and Maintenance model for utilization of client and building management.	5	2
5.12	Prepare/assist in the digital formulation of care maintenance instructions (maintenance manual) reflecting owner's energy and performance requirements.	5	2
LO6	**Learner is able to collaborate and use collaborative approaches to support communication and visualization.**	**5**	**2**
6.1	Describe the essential parts of the procedure for BIM based collaboration.	5	2
6.2	Describe different collaborative interdisciplinary and open BIM working methods, tools and processes.	6	2
6.3	Demonstrate how to work collaboratively with the project stakeholders including the design team, client, users, manufacturers, construction site and building authorities.	5	2
6.4	Prepare relevant visualization models to enable information sharing, decision making and opinion formation.	5	2
6.5	Demonstrate the flow of design teamwork with use of void provision model together with architectural and structural design.	5	2
6.6	Collaborate with the help of communication platforms and processes like CAVE (computer aided virtual environment) and Big Room working.	5	2
LO7	**Learner is able to explain and give examples about implementing target and quality management procedures in building project.**	**5**	**2**
7.1	Assist / participate in systematic modelling in own organization ensuring that all information is provided in right order, right format and on agreed schedule.	5	2
7.2	Validate and check compatibility of the domain model and manage and repair conflict.	5	2

7.3	Verify the achievement of the targets on the basis of the results received with the help of different kinds of assessment methods relevant for building services design.	5	-
7.4	Participate in the verification of the achievement of the targeted result and undertake site inspections in construction site.	5	2
7.5	Comment product and system providers' designs and comment the contractor's equipment selection impacts on energy consumption to ensure the fulfillment of targets.	5	2
7.6	Instruct and audit contractors on construction site on critical points.	5	-
7.7	Describe and assess quality assurance methods for energy-efficient building service solutions to verify achievement of set targets.	5	-
LO8	**Learner is able to use different relevant software and interfaces between relevant software.**	**6**	**3**
8.1	Use domain specific BIM authoring applications for building services design and analysis.	6	3
8.2	Use relevant HVAC and energy design calculations and assessment tools in different design phases.	6	3
8.3	Use different tools for BIM-based collaborative working.	5	2
8.4	Create combination model and use model checking tools for clash detection.	5	3
8.5	Extract energy information from BIM (MEP, ARCH and Structural model in different LOD-phases) to BEM for simulations and import results back to BIM.	5	2
8.6	Use relevant visualization tools for visualizing design solutions and output from HVAC and energy simulations, calculations.	5	3
8.7	Prepare the domain model for simulation and assessments	5	3
8.8	Use tools for environmental impact analyses.	5	3
8.9	Use tools for MEP system design and analyses.	6	3
8.10	Use project data and file management systems.	6	3

Table 5 European wide BIM EE learning outcome matrix for Construction work roles i.e. Site manager, Construction site workers and installers

Learning outcomes are defined in specific order forming eight groups:

- Group 1 (LO1) Fundamentals of BIM and principles of its uses with respect to building life-cycle
- Group 2 (LO2) Fundamentals of sustainable and energy-efficient buildings and building performance
- Group 3 (LO3) BIM-based construction processes, supporting client and other stakeholders in decision making
- Group 4 (LO4) Implementation of energy performance, building performance and sustainability targets into construction process
- Group 5 (LO5) Utilizing models and information content for accurate execution of building
- Group 6 (LO6) Collaboration, communication and visualization with help of BIM.
- Group 7 (LO7) BIM in quality management, commissioning and handover procedures
- Group 8 (LO8) Skills for relevant software and interfaces between software.

No	Learning outcome	EQF level	
Construction work roles Site manager (SM), Construction site workers and installers (CW)		SM	CW
LO1	**Learner is able to explain the fundamentals of BIM and the underlying principles of uses with respect to building life-cycle.**	**4**	**1**
1.1	Recall essential contents, summarize and give examples of BIM terminology and definitions and standards.	4	1
1.2	Recall the basic idea of building information systems.	3	1
1.3	Recall essential contents, summarize and give examples overall BIM process during building life-cycle.	3	-
1.4	Explain the essential issues related to information management, data transfer and sharing.	3	-
1.5	Demonstrate knowledge of national guidelines for building information modelling during construction.	3	-
LO2	**Learner is able to explain the fundamentals of sustainable and energy-efficient buildings and building performance.**	**4**	**-**
2.1	Explain and give examples of aspects and terminologies of energy and building performance.	4	-
2.2	Describe the financial and environmental aspects and related indicators, benchmarks and certification systems of energy and building performance.	4	-
2.3	List basic issues that affect energy performance and thermal comfort of buildings from the viewpoint of construction tasks to be performed.	4	2
2.4	Explain relations between life-cycle costs, environmental impacts, energy performance and building performance and the quality of construction work.	4	-
2.5	Point out legislation and regulations related to energy performance, thermal comfort and air quality.	4	-
LO3	**Learner is able to manage BIM based construction processes and support the client and other stakeholders in decision making.**	**5**	**-**
3.1	Explain the objectives, benefits and describe the overall workflow of using BIM for construction project management.	5	-

3.2	Help the client to set and specify information requirements relevant to construction activities.	5	-
3.3	Utilize 4D for schedule visualization and communication to provide project team understanding of project milestones, schedule, and construction plans.	5	-
3.4	Explain how to assess constructability related issues with the design team, give examples of typical issues and explain how to provide requirements of needed BIM information content.	5	-
3.5	Use construction production model for scheduling, management, control, monitoring and commissioning, visualization, planning procurements, planning construction site.	5	-
LO4	**Learner is able to implement energy performance, building performance and sustainability targets into construction process.**	**5**	**-**
4.1	Explain the overall BIM based construction processes to achieve best results in energy-efficient design and construction.	5	-
4.2	Explain how to utilize BIM for reducing, reusing, recycling and managing construction and demolition waste.	4	-
4.3	Explain how to evaluate building products and suppliers if they meet the demands and specifications of given sustainability and quality aspects.	5	-
4.4	Identify and report any changes occurred during construction and submit the as-built production information to designers who compile as-built models for use of maintenance phase.	4	-
LO5	**Learner is able to utilize BIM models and information content for accurate execution of building construction.**	**5**	**2**
5.1	Use BIM in contractor meetings for the work stages for visualization, viewing/studying the building and structures.	5	-
5.2	Learner is able explain and perform the techniques of model based information take-off and check technical specifications of products and components.	5	2
5.3	Use BIM for planning procurements.	4	-
5.4	Utilize the 3D model and BIM viewers for supporting assembly and instructing installers.	4	-
5.5	Perform the assigned tasks with the help of 3D environment, report the status of the activities and input needed information (text, photos, videos) to the system correctly.	-	2
5.6	Illustrate situations during construction where changes of geometry and building parts are needed from the information defined and explain allowable ways for solution.	5	-
LO6	**Learner is able to collaborate and use collaborative approaches to support communication and visualization.**	**5**	**-**
6.1	Describe the essential parts of the procedure for BIM based collaboration.	5	-
6.2	Describe different collaborative interdisciplinary and open BIM working methods, tools and processes.	5	-
6.3	Demonstrate how to work collaboratively with the project stakeholders including the design team, client, users, manufacturers, construction site and building authorities.	5	-
6.4	Explain possibilities of augmented reality and virtual reality for supporting the construction work.	3	-
6.5	Collaborate with the help of communication platforms and processes like CAVE (computer aided virtual environment) and Big Room working.	2	-
LO7	**Learner is able to use BIM for quality management, commissioning and handover procedures.**	**5**	**-**

7.1	Validate and check compatibility of the domain model and manage and repair conflict.	4	-
7.2	Prepare reports of any evidence of the errors or omissions in the building information model to the respective designer and the project's BIM coordinator.	4	-
7.3	Explain about the techniques and technologies like laser scanning and photogrammetry to validate that construction is in accordance with the BIM(s).	3	-
7.4	Utilize BIM to perform fine-tuning of the building services to ensure the optimal energy performance.	3	-
7.5	Explain the main tasks and requirements how to compile care and maintenance instructions and link these with the model (maintenance model).	3	-
7.6	Utilize BIM for educating facility management and users for how the systems and the equipment are operated.	3	-
7.7	Utilize BIM for commissioning and handover of the building.	4	-
LO8	**Learner is able to use different relevant software and interfaces between relevant software.**	**5**	**2**
8.1	Use digital construction management tools and systems.	5	-
8.2	Create combination model and use model checking tools for clash detection.	5	-
8.3	Use different tools for BIM-based collaborative working.	5	-
8.4	Use tools for information take-offs from the models.	5	1
8.5	Use tools for 4D and BIM based site management plan.	5	-
8.6	Use BIM viewers with tablet devices.	4	2
8.7	Use project data and file management systems.	5	-

Table 6 European BIM EE learning outcome matrix for Maintenance work roles i.e. Maintenance operator, Property manager, Care taker

Learning outcomes are defined in specific order forming six groups:

- Group 1 (LO1) Fundamentals of BIM and principles of its uses with respect to building life-cycle
- Group 2 (LO2) Fundamentals of sustainable and energy-efficient buildings and building performance
- Group 3 (LO3) Supporting the client and other stakeholders in decision making to achieve energy and building performance targets in operation and maintenance
- Group 4 (LO4) BIM for facilities and utilities management, operation and maintenance
- Group 5 (LO5) Implementing energy performance, building performance and sustainability targets into operation and maintenance
- Group 6 (LO6) Skills for relevant software and interfaces between software.

No	Learning outcome	EQF level		
Maintenance work roles	Maintenance operator (MO), Property manager (PM), Care taker (CT)	MO	PM	CT
LO1	**Learner is able to explain the fundamentals of BIM and the underlying principles of uses with respect to building maintenance.**	**3**	**3**	**2**
1.1	Recall essential contents, summarize and give examples of BIM terminology and definitions and standards.	2	2	-
1.2	Recall the basic idea of building information systems.	1	1	-
1.3	Recall basic issues of overall BIM process during building operation.	2	2	-
1.4	Explain the essential issues related to information management, data transfer and sharing in maintenance processes.	3	2	-
1.5	Demonstrate knowledge of national guidelines for building information modelling related to facility management.	2	2	-
LO2	**Learner is able to explain the fundamentals of sustainable and energy-efficient buildings and building performance.**	**4**	**4**	**2**
2.1	Explain and give examples of aspects and terminologies of energy and building performance.	3	3	1
2.2	Describe the financial and environmental aspects and related indicators of energy and building performance.	3	3	-
2.3	List basic issues that affect energy performance and thermal comfort of buildings from the viewpoint of care and maintenance work.	4	2	2
2.4	Explain basic relations between life-cycle costs, energy performance and GHGs and building performance and the quality of care and maintenance.	4	3	-
2.5	Summarize and give examples about the potentials of renewable energy sources and smart energy solutions applicable to buildings including district-scale solutions.	3	3	-
2.6	Point out legislation and regulations related to energy performance, thermal comfort and air quality.	3	2	2
LO3	**Learner is able to support the client and other stakeholders in decision making to achieve energy and building performance targets in operation and maintenance.**	**4**	**3**	**2**
3.1	Explain how to assist client with setting control and monitoring requirements (including monitored history data of energy performance) of the HVAC and MEP-systems for energy-efficient usage of the building.	4	4	-

3.2	Assist the client to set and specify information requirements required from BIM for operation and maintenance phase.	3	3	-
3.3	Assist client to set requirements for building performance from the maintenance and monitoring point of view.	3	3	2
3.4	Review the design with respect to maintenance requirements such as accessibility to devices to ensure designers that maintenance is feasible.	2	2	2
3.5	Set requirements for information on construction elements, equipment and materials, such as manufacturer, type, technical specifications, etc. in the format compatible with facility management software.	3	3	-
LO4	**Learner is able to use BIM for facilities and utilities management, operation and maintenance.**	**4**	**4**	**2**
4.1	Explain the BIM-based and intelligent FM information workflow for different kinds of care and maintenance tasks.	4	4	-
4.2	Explain the use of the maintenance model in property management and doing short term and long term planning.	2	4	-
4.3	Utilize BIM(s) for successful maintenance program over the operational life of the facility (including structures and equipment) to improve and maintain building performance, energy efficiency and sustainability.	4	2	-
4.4	Transfer as-built model information and other maintenance information data into operational and maintenance systems (also in case of change of ownership) and ensure that the models contain the required information.	4	3	-
4.5	Extract needed information such as collecting initial information for briefing repairs, replacements and in renovation/refurbishment.	4	4	-
4.6	Explain how to use maintenance BIM in the case of malfunctions to support in resolving their causes and comparing repair options.	4	3	1
4.7	Make task descriptions and describe how to execute care and maintenance tasks with the help of BIM based digital devices.	4	-	-
4.8	Perform the assigned tasks with the help of 3D figures and making the notice for work done and input needed information (text, photos, videos) to the system correctly.	-	-	2
4.9	Update as-maintained model and linked maintenance manual in cases of care, maintenance, repair and refurbishment.	4	4	-
4.10	Explain possibilities of augmented reality and virtual reality for supporting the care and maintenance work.	3	2	-
4.11	Explain the concepts of digital twin and its influence on optimization of comfort and energy performance of building.	2	2	-
LO5	**Learner is able to implement energy performance, building performance and sustainability targets into operation and maintenance.**	**4**	**4**	**-**
5.1	Use BIM-compatible maintenance manual to operate buildings according to targets both in terms of comfort and energy efficiency.	4	4	-
5.2	Analyze building performance by comparing energy and indoor climate simulations to actual consumption.	4	2	-
5.3	Utilize energy analyses in case of malfunctions and in resolving their causes and comparing repair options.	4	3	-
5.4	Update energy targets of the building by calibrated energy analyses taking into account changes in the operation.	4	2	-
5.5	Collect and use customer feedback and define different principles of continuous improvement and influencing techniques.	3	4	-
5.6	Explain and give examples how to use monitored digital operational data in continuous energy and performance management	4	2	-

5.7	Report owners on energy performance and implement energy awareness and motivation programmes and their associated communication strategies for reduced energy use.	3	4	-
5.9	Assess and implement quality management into facility management.	4	3	-
LO6	**Learner is able to use different relevant software and interfaces between relevant software.**	**4**	**4**	**2**
6.1	Use BIM-based facilities management tools and systems.	4	4	-
6.2	Use different tools for BIM-based collaborative working.	4	4	-
6.3	Use tools for information extraction from the models.	4	4	-
6.4	Use of BIM viewers with tablet devices.	2	2	2
6.5	Use model based maintenance manual for management of technical information, service requests, contracts, documents, various maintenance tasks, maintenance history etc.	3	3	-
6.6	Use digital archive systems for documents and models.	3	3	-

7 Conclusions

This report presents the first version of EU wide learning outcomes defined and developed for selected roles and activities related to BIM and energy efficiency. Due focus was provided towards the EQF and its relative knowledge, skills and competencies based on the partner organizations.

During this procedure, national guides for plans of works for different roles and national guides for common BIM requirements were made use of in defining phases, tasks and roles. For example in Finland guides for plan-of-work were formulated for architectural design, structural design, HVAC/MEP design, and management of building projects. In addition learning outcomes from previous stages of BIMEET and other relevant BIM EE EU-projects were made use of in harmonizing the established European level frameworks.

Construction industry and building projects has several roles and stakeholders. To define the European learning outcomes related to BIM and energy-efficient building, six categories were selected:

- Client & Clients advisors
- Architectural design roles
- Structural design roles
- Building services design roles
- Construction work roles
- Maintenance work roles

The learning outcomes include requirements about understanding of BIM terminologies and definitions, BIM processes and BIM technologies and relevant guidelines for building information modelling. In addition, the learning outcomes also include requirements about performance based building and the factors that have direct and indirect impacts. Although this work focuses on BIM and energy-efficiency, it is important to simultaneously pay attention to other important performance aspects. When designing and operating low energy buildings, energy consumption is never a separate aspect but is always closely linked to the aspects of indoor environment. Thus learning outcomes for the management of energy performance with the help of BIM need to consider the overall building performance.