awakening | relevant | innovative | scalable | equitable

D.3.1 Desk research on maturity analysis of digitalization and sustainable energy skills

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D.3.1. Desk research on maturity analysis of digitalization and sustainable skills

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Publishable executive summary

This report includes a description of the research and results achieved by analysis of seven frameworks of digital and sustainable energy skills in the construction sector. These frameworks have been developed by the H2020 funded projects BIMcert, Net-UBIEP, BIMEET, BIMplement, NEWCOM, the Erasmus+ funded project BIMzeED, and the international brand BuildingSmart International.

The main objectives of the research were

1) to confirm the fundamental hypothesis of the ARISE concept of transactability of skills and competences across different frameworks,
2) to provide basis for development of the conceptual design of the ARISE framework and method of learning transactions,
3) to identify perspectives for continuous development of the ARISE framework, in order to meet the future demands for new competences

While analyses carried out within other projects strive to result in union of different skill frameworks into a common learning taxonomy, ARISE tendency is to establish a comprehensive framework that enables transactions of learning achievements and acquired / possessed competences, preserving and respecting thereby individuality, integrity and specifics of the included competence schemes.

As a basis for the overall approach applied in this research, the UNESCO and CEDEFOP *Comparative Methodology of Learning Outcomes* [22] was used.

The research was carried out in two stages: 1) A qualitative analysis of commonalities, differences and specifics of the schemes, 2) A quantitative analysis of potential for convergence of maturity models.

The three main findings of the research were:

1. All the analysed projects identified existing qualification frameworks on national levels in two important fields for the construction sector: sustainable energy (NZEB) nd digital skills (BIM).

2. They all saw the future of competences in construction by integrating sustainable energy and digital skills.

3. Despite the different objectives, focus and applied methodological approach, skills and competences developed by the analysed frameworks, presented by their learning outcomes, were comparable and recognizable, enabling learning achievements transactions, accumulation and recognition across the frameworks.

List of acronyms and abbreviations

BIM - Building Information Modelling

EE - Energy-efficiency

EPBD – Energy Performance of Buildings Directive

NZEB - Nearly Zero-Energy Buildings

RES - Renewable Energy Source

BSI – Building Smart International

ISCO-08 - International Standard Classification of Occupations) classification structure of professional profiles

NQF – National Qualification Framework

VET – Vocational Education and Training

HEI – High Education Institutions

SMEa- Small and Medium Enterprises

OCN – Open College Network

CPD – Continuous Professional Development

EQF – European Qualification Framework

CEDEFOP - European Centre for the Development of Vocational Training

CEN - European Committee for Standardization

KSC – Knowledge – Skills – Competence

BEM – Building Energy Model

PA - Public Administration

FM – Facility Manager / Facility Management

OM – Operation and Maintenance

AEC – Architecture, Engineering and Construction

LO - Learning Outcomes

LU - Learning Units

ULO – Units of Learning Outcomes

RIBA – Royal Institute of British Architects

BoK - Body of Knowledge

EIR - Exchange Information Requirements

BEP – BIM Execution Plan

CDE – Common Data Environment

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1. Introduction

1.1. Background

Importance of digital and sustainable energy skills, their continuous improvement, implementation, recognition and international transferability.

The construction sector is facing challenges to meet the requirements of ambitious energy efficiency objectives, and to provide cost effectiveness, climate neutrality and high productivity. At the same time, the industry is going through its digital transformation, with Building Information Modelling (BIM) technology having the leading role in it [8].

Sustaining global economic and social growth and supporting deployment of emerging technologies imposes the need of changing construction sector production and consumption patterns. In the transformation pathway, energy efficiency is considered of highest importance to meet the challenge of clean transition of the construction sector, towards its climate neutrality and resilience.

Reaching the global net zero targets requires a significant improvement in more efficient energy use. Considering that buildings are complex energy sub-systems occupying about 40% of the total energy consumption and contributing by about 36% to the carbon emissions, improving their energy performance will make a significant contribution to the construction sector clean transition.

The climate neutrality and sustainable use of energy targets will be hardly achievable without a digital operation environment and exchange of information and data among stakeholders involved in a building's life cycle. Avoiding the performance gap requires engagement of all involved roles and professions, promoting sustainable energy for all and by all.

Digitalization is recognized as the unavoidable and necessary tool to leverage clean transition of the construction sector, reshaping it towards the future targets and expectations

However, to enable the transition, there is a need to have all stakeholders upskilled in digital technologies supporting sustainable energy, in a triple helix model - synergy of public administration, industry, society [27].

The increasing complexity of buildings is reflected in the continuous introduction of new procurement paths and methods, construction technologies, materials and construction methods to meet various economic, environmental and societal challenges [4]. This requires the involvement of not only the traditional disciplines and roles (architecture, structure, mechanical and electrical, etc.) but also many new professions and skills in areas such as energy, environment, waste and connected objects / Internet of Things.

Skills connectivity is key, ensuring professionals are equipped, informed and skilled to deliver energy efficiency across the building sector. Connectivity will stimulate and inspire the demand for sustainable energy skills, augment access to appropriate upskilling transactions, recognition of upskilling, enhance smarter work practices and develop transformational competences [26].

As previous and current European projects identified through their surveys, research and analyses, there are gaps in education and upskilling in NZEB and BIM fields; moreover, there isn't a united and unified skills and qualification framework for both disciplines. That puts the construction sector in an unfavourable position, to stay behind the evident technology progress and social and economic demands for sustainability.

Hence, programs for qualifications for construction skills in sustainable energy, leveraged by digital skills, need to be developed in a way that will enhance wider market recognition, more intensive demand and more stimulating support provided by policy and regulatory framework, for construction sector workforce skilled and qualified to execute woks connected to achievement of sustainable energy performance of buildings.

The construction professions of the future sector will require a united and harmonized application of both sustainable energy and digital skills. In such a roadmap, transferability and international recognition of skills will play a crucial role [27].

This Report summarizes and compares findings and outputs of seven projects and frameworks, that have been made by developing common and pan European recognizable, sustainable energy and digital skills frameworks, intended for professionals in the construction sector,

1.2. Subject of the Report

This subject of the Report is to present research and analysis of seven projects that have developed learning and recognition frameworks of digital and sustainable energy skills and qualifications: H2020 funded projects: BIMcert, Net -UBIEP, BIMEET, BIMplement and NEWCOM, Erasmus+ funded project BIMZeed as well as relevant BuildingSmart International qualifications for BIM and BIM for EE.

All the analysed frameworks applied a specific approach to identify and unite NZEB and BIM skills, striving to design tools (digital skills passport, micro accreditation, learning record, digital data bases of competences, etc.) for a wide European recognition, transferability and compliance with national qualification frameworks in the subject fields.

Achievements, specifics, advantages and complementarity of the projects' outputs, were analysed, by a multi – criteria method, applying aspects that enable setting basis for i) development of a comprehensive qualification framework, ii) findings for further alignment and recognition, and iii) improvement of compliance and complementarity of the analysed frameworks, to align with national frameworks as well future construction sector needs.

1.3. Objectives of the Report

The objectives of the report are to provide:

- Comparison and levelling of the models of skill frameworks, developed by the analysed projects, by showcasing representative samples of competences,
- Confirmation of the ARISE concept of transactability of skills and competences across different frameworks,
- A basis for development of the conceptual design of the ARISE model of skills improvement, assessment and recognition,

- Identification of perspectives for continuous development of the ARISE framework, in order to meet the future demands for new competences in the sustainable construction sector.

1.4. Applied methodology

As a basis for the overall approach applied in this research, the UNESCO and CEDEFOP *Comparative Methodology of Learning Outcomes* [22] was used, leaning on consideration thereof that a systematic comparison of qualifications focussing on learning outcomes provides a reliable and scalable method for comparison, facilitates national and international recognition and promotes convergence of qualifications [24].

The research was carried out in two stages: 1) A qualitative analysis of commonalities, differences and specifics of the schemes, 2) A quantitative analysis of potential for convergence of maturity models.

In the first stage (presented in Chapter 3), a comparative multi – criteria analysis of frameworks, was carried out, using the method of a sequential evaluation of all considered frameworks, in aspect of each of the adopted eight criteria: 1) Conceptual model, 2) Included professional profiles, 3) Considered phases of a building life cycle, 4) Implemented system of grading skills maturity, 5) Method of integration and consistency of digital and sustainable energy skills, 6) Number and content of developed learning modules, 7) Recognition / Certification of skills and 8) Method of delivery

The second stage (presented in Chapter 4) analysed maturity levels of skills and was carried out by development of levelling and alignment matrices for three professional profiles in the construction sector. Learning outcomes, taken over from the curricula and learning modules of the analysed programs, were evaluated in aspect of subject, content and level of proficiency of skills they provide, using thereby the Bloom's taxonomy applied in the description of learning outcomes., as a levelling and translating tool. As a reference point, *BIMcert* learning framework was used:

1.5. Content of the Report

The content of the Report has been classified in 7 Chapters:

1. Introduction – describing background, scope, subject, objectives and applied methodology

2. Overview of the seven skill frameworks included in the analysis

3. Comparative analysis of the frameworks, in multi criteria aspects

4. levelling and alignment matrices, to compare skills maturity models

5. Conclusions and recommendations for development of the ARISE model of skills framwork

0. References and literature sources used

7. Appendices – Extracts from alignment matrices for the four analysed professional profiles

2. Overview of the projects included in the analysis

2.1. BIMcert

2.1.1. Concept and approach

The BIMcert project developed a training model of skills and competences in BIM and sustainable energy skills (energy efficiency and application of renewable energy sources in buildings' operational stage), that included the entire construction sector supply chain and AEC professions involved in all stages of a building's life cycle.

The project concept of skills framework was guided by the principles of modernization of both the skills and the method of skills delivery and recognition, through the learning process accessibility, availability, alignment and acceptance by both supply and demand side.

By using segmented course content, ease of access and innovative delivery and accreditation, the project introduced an innovative approach to delivering training and raising the skill levels for those beyond traditional learning access routes.

The project promoted "bite-sized" learning modules, as a basis for micro-accreditation of knowledge and skills, applicable for recognition of existing and new skills. Sets of these Micro learning modules, based on particular learning outcomes, were designed to form combinations of achieved skills, leading towards fully recognized qualifications, compatible with existing national and international qualification frameworks and accreditation schemes

By this novel model of sustainable energy skills in construction leveraged by digital skills, BIMcert made significant contribution:

1) to the quality and content of skills, shaping them to the industry needs and bridging the gap between academic education and necessary modernization of AEC sector, and on the other hand,
2) to the method of learning, making it more accessible, effective and attractive for the users.

The bite-size learning modules and gamification features are found to be the project basic specifics. The gamification was particularly explored as a specific encouraging and stimulation tool for learning delivery.

In its mission to improve the learning process, the project consortium profiled the training methods and tools that would engage the learners and suit their needs as individuals and their professional roles. In this aspect, particular modules were developed for blue collar workers, adjusted to their surveyed preferences in learning.

A specific aspect is also comparison to traditional method of work – recall on participants' professional experience and encouraging the learners' autonomy and entrepreneurship by applying guided self-learning.

A key innovation of the learning method can be identified as its personalization: the system automatically adapts to the experience of learning professionals to get them familiar with new BIM tools and related digital technologies. Different modules exist for different participants (owners, facility managers, investors, public administration, etc.) and different construction activities (new or renovated buildings).:

The project also considered the concept of digital passport of skills, as an effective tool for a wide recognition of achieved competences and their transactions.

The developed method of training was tested in three rounds, in all partner countries, progressing from a classroom based, through a blended mode, towards autonomous e – learning. For the purpose of testing, pilot learning units were developed, supported by learning and assessment materials. Results of the tests and trials were used for final improvement of the learning content, methods and tools. They also confirmed the effectiveness of the applied method.

2.1.2. Background analysis

To develop the concept of skills and qualifications framework, the consortium carried out several types of analyses:

- Research of modern education methods, practices and tools in BIM and energy skills fields, worldwide
- Research and case studies of concept, methods and tools of delivery in the observed fields.
- State of the art of digital platforms and gamification features included,
- Industry needs, skill gaps, barriers and drivers, within partner countries
- Accreditation models

The basic findings were:

- BIM modules are currently part of some course curriculum at several levels of education, but not in an integrated and industry-driven way, and not based in a direct employability skill set that targets all key holders.
- One of the BIM implementation problems is the gap between academic focus on disciplinary principles and industry's need for proficiency in specific practical applications.
- At the core of BIMCERT is its industry focus; uniting professional skills for energy efficiency in construction with a modern construction method, including software tools and associated processes (BIM).
- The slow uptake of digital construction skills, due to lack of information, course offer, finance or time.

  Skills maturity, needs and gaps uncovered by current academic and VET offer were identified through the survey of around 500 participants from academia and industry, in all partner countries,

  BIMcert developed approach addressed all the problems identified through communication with relevant stakeholders, with a comprehensive curriculum and an easily accessible training and qualification platform.

  The project developed training packages that, instead of a lengthy and rigid multi-module accreditation process, follow a digital micro-accreditation process. Such bite-sized micro-accreditation allows learners to follow their own learning path rather than a prescribed standardised journey

Based on the findings of baseline analyses, BIMcert training materials were developed:

- to suit real work situations and included prototype case studies, thus making training more relevant to professionals,
- to provide an easily progressive way of learning and achieving skills and qualifications,
- to encourage and support learners who usually have difficulty accessing a suitable upskilling method, such as blue collars.

2.1.3. Skills and qualifications framework developed by the project

BIMcert developed a curriculum that consisted of a flexible framework of courses, with learning content divided into learning units with accompanying learning outcomes and assessment criteria; each of latter can be established as stand -alone learning units – micro modules.

The developed framework is applicable in HEI and VET, as well as for SMEs digital improvement pathway.

BIMcert introduced discretization of learning units into stand -alone micro modules.

For each of the courses, training methodology descriptors were prepared, including learning outcomes, assessment criteria, suggested syllabi and delivery details.

The BIMcert specific method of integration of sustainable energy skills and BIM skills lies in the fact that all courses include elements and appropriate learning content for both disciplines; however, explicit learning outcomes can be found in the courses of strides 2C, designed to provide focused and advanced knowledge and skills in use of BIM tools for low energy building life cycle. The modules are intended for several professional profiles (e.g., designers, contractors, facility managers).

BIMcert developed a programme comprising three strides of learning modules and a curriculum comprising learning outcomes for each of the modules (please refer to the figure below).

Stride 1 consists of initial learning module BIM Ready that is used to gain initial knowledge or measure prior level of knowledge in BIM, in order to provide learner with navigation towards next learning modules – to design a personal learning plan.

Stride 2a comprises 5 learning modules that provide knowledge and skills, starting from basic up to intermediate level of skills maturity, in:

a) fundamentals and principles of BIM (e.g., standards, workflow and procedures, advantages compared to traditional method, support to sustainable construction, etc.),

b) digital skills for site workers and

c) BIM modelling (development of a BIM 3D model of a building),

Stride 2b comprises 4 modules that provide further improvement of knowledge, up to advanced level of maturity, in BIM information management.

Stride 2c consists of 5 modules, 3 out of them deal with BIM and sustainable energy skills (basic to advanced level), while the other two are intended for specific professions in AEC (contractors and facility managers)

Stride 3 comprise 6 modules that integrate knowledge and skills for improved use of BIM and sustainable energy, intended for specific professions.

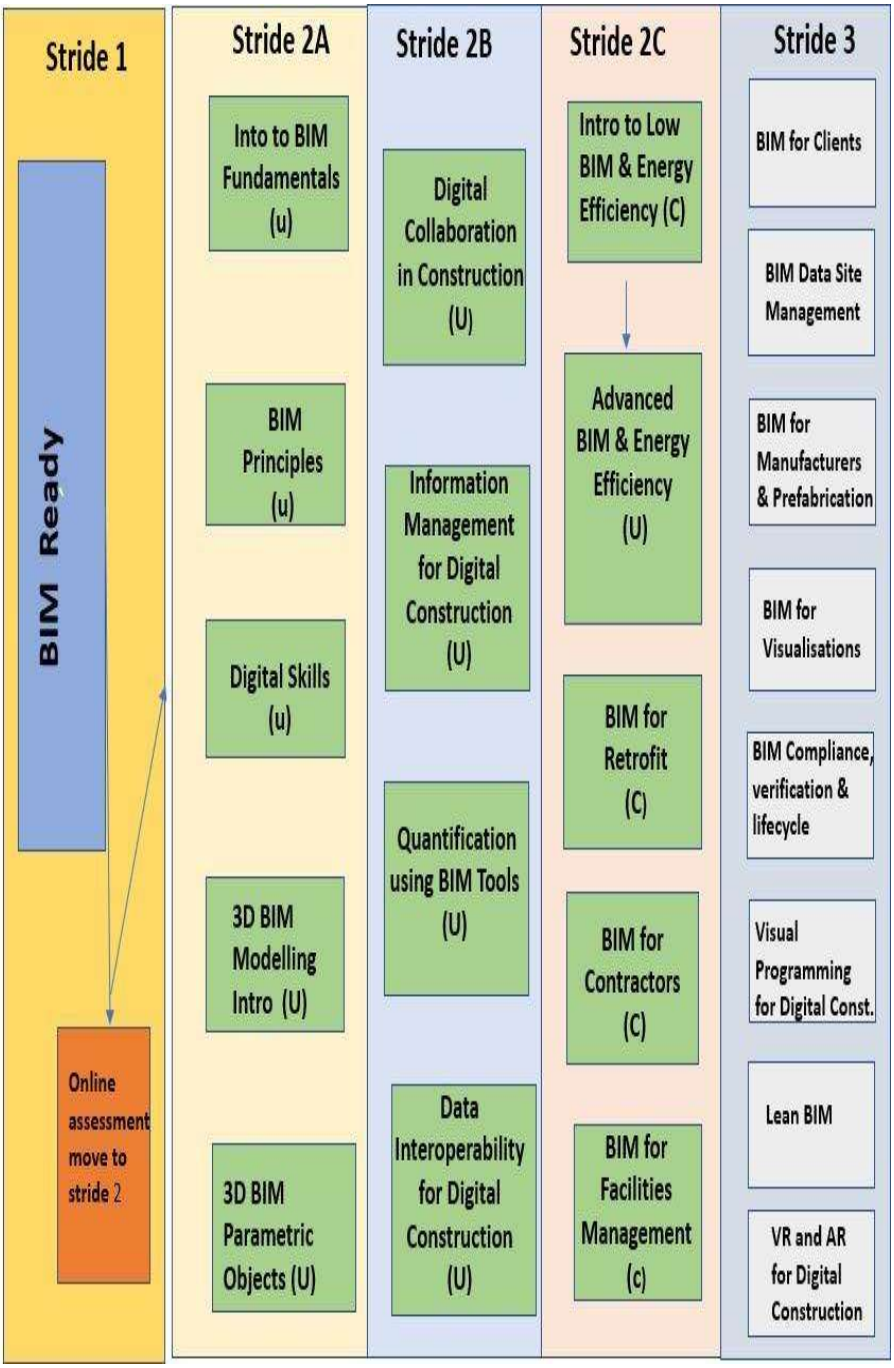
The modules have been designed as stand -alone learning units, prepared for a blended mode of delivery. Furthermore, particular learning outcomes (assessment criteria) of some modules can be used as micro modules, recognized by various national and international awarding schemes, Combinations of micro modules lead to particular qualifications. It was demonstrated through several qualifications certified at OCN during the project. The qualifications are transferable to the CPD system.

Figure 1: BIMcert concept of learning framework. (Source: BIMcert, Deliverable 4.2:)

- Learner accesses the BIMCert portal.
- **Stride 1: option A**: Learner takes BIM Ready plus online assessment; successful entry grants access to Stride 2.
- **Stride 1 Option B:** Learner directly takes online assessment; successful entry automatically grants entry to Stride 2.

Final Unit of BIM Ready assists the learner in the selection of the next module. Appropriate to their needs / roles.

- **Stride 2A:** Learner selects a stand alone Unit aimed at BIM novices.
- **Stride 2B**:Learner selects a stand alone Unit aimed at those professionals with a deeper BIM knowledge.
- **Stride 2C**: Learner selects a course (c) which contains a number of units. Successful completion of relevant units will enable learners access to advanced modules.
- **Stride 3:** Specialist modules to be developed



BIMCert has defined three Strides (levels) on each learner's pathway to qualification [1]:

- **Stride 1**: Each learner has the option of taking the BIM Ready unit or automatically progressing to the next stage by successfully completing an online evaluation. This unit provides learners with an understanding of BIM principles and associated terminology, as well as giving learners an appreciation of how BIM will affect them in their self-identified role. Learners can also use this unit to develop their understanding of the roles of other professionals in BIM projects and tasks. This unit will also assist learners in the selection of the next unit on their learning journey.
- **Stride 2A**: The learner can select a number of standalone units that will introduce them to BIM principles, digital skills and modelling techniques.
- **Stride 2B:** The learner can select a number of standalone units aimed at those more experienced BIM users who wish to advance their knowledge in BIM around e.g., interoperability, collaboration processes, etc.
- **Stride 2C**: Learners can choose one or more courses, which each contain one or more units. The purpose of offering the learning outcome as individual units is that BIMCert can then attract learners who require specific areas of knowledge but do not have the time to complete a standard unit (Stride 2A and 2B) consisting of a series of learning outcomes. The learner can take advanced units once they successfully complete the relevant Stride 2C course units, i.e., Advanced BIM & Energy Efficiency.
- **Stride 3:** Within the duration of project, the learning outcomes were developed for these set of units, which represent current specialisations of BIM usage, tools, and concepts. The range of units are planned to be expanded or adjusted in the next stage in response to market needs.

All units focus on achieving better energy management and are structured to provide gradual progression for novice learners, ensuring that they appreciate how BIM can impact energy management through a deeper understanding of digital processes and technologies. A package of pilot training materials was

developed for selected units and tested during the project. The results and feedback were used for improvement of the learning materials.

Designed in such form, the learning modules in strides 1, 2a and 2b are applicable for a number of professions, while the specifics of professional profiles and their role in a building's life cycle are considered in the advanced modules of strides 2c and 3.

To test the micro modules concept, the following pilot units were deployed in testing and trials [2]

Table 1 BIMcert 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 summarize the common terminology associated with BIM.
	LO3	List the benefits & value of a BIM workflow	Summarize 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. 1.2 summarize BIM maturity levels. 1.3 Explain the impact of BIM maturity Level 2 requirements for project delivery. 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: a) Advantages of site works and management.

			b) Improvement of construction workflows. c) Emerging technologies. 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. 2.2 Demonstrate the use of cloud-based storage and portable devices to access and exchange information. 2.3 Demonstrate the use of effective digital surveying techniques.
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 utilized in Low Energy Building Construction.	6.1 Illustrate the use of BIM tools to reduce energy loss.

BIMcert considered several options for accreditation, including CPD, and finally provided 3 OCN qualifications and had 8 modules accredited.

2.1.4. Project main outputs

Within its duration, BIMcert produced the following outputs:

- Digital platform, with a manual for its use
- Curriculum,
- Methodology of training and assessment,
- Learning modules (32),
- Training and assessment materials for micro units,
- Case studies for demonstration of energy impacts, based on BIM architectural and energy, models of a new and a renovated building (real life projects),
- Handbook for trainers,
- QA & QC procedure,
- Accreditation schemes analysis and report.

2.2. BIMzeED

2.2.1 Concept and approach

The BIMzeED project developed a training program that aimed at meeting needs for skills and competences for NZEB and BIM, in the current and future construction industry. The project was focused on integration of skills and competences for NZEB and BIM in a tailored way to meet needs of all professional roles in the construction supply chain, as well as construction students and trainers; thus, the developed curricula are adaptable to be integrated into HEI, VET and SMEs programme delivery. This approach of the project enabled strengthening the links between lecturers, industry and SMEs with innovative technologies and installations creating connected learning communities (viewing case studies, on-site site visits, industry demonstrations).

Through vast research carried out by the consortium partners, the knowledge and skills gap in BIM and NZEB within the HEI and VET for each partner country was identified. One of the effects achieved by the research was transfer of knowledge of BIM and NZEB among the partner countries.

In addition to the identified current gaps and future demands of skills, the project also recognized:

- the expected benefits of digitalisation skills for construction sector,
- the advantages of micro learning units
- the need for internationally recognized micro credentials - alignment with international skills recognition systems, such as CPD.

2.2.2 Background analyses

2.2.2.1 Analyses and reports

The developed learning framework was based on a vast analysis carried out by the consortium, on:

1) Literature review on BIM and nZEB needs in the construction industry, including NZEB definition, regulations and progress,
2) NZEB and BIM implementation in the BIMzeED partner countries

3) BIM training courses, in HEI and VET,
4) Current status of training skills for the construction industry
5) Report on Gap Analysis and Roadmap Plan

In the initial phase, the project partners carried out analyses to assist them in finding the optimal solution of training and qualifications scheme – Identification of state of the art and forecasts - analyses of needs and gaps of current and future construction industry

The research within the BIMzeED project, conducted across 4 partner countries, identified a number of gaps between the skills and needs of industry as well as the current availability of training.

The project team concluded that it is equally important to predict the future roles for the construction industry to determine the skills needs and new employment profiles needed to close the industry identified gaps. In many countries new occupations are emerging within the NZEB areas. BIMzeED analysed the current situation in the construction industry in several EU countries and reviewed a of EU projects and training programs and came to the conclusion that topics related to the NZEB and BIM were not adequately covered, or not covered at all, resulting with a lack of qualified workers and professionals.

The report (Output) 0.*2.4-Report-on-current-training-skills-of-the-construction-industry* identified the current and predicted skill needs, gaps, barriers and training in the field of BIM and NZEB within the construction sector in all partner countries (Croatia, Hungary, Ireland and Spain). It also included a review of available education and training programs in the field of BIM and NZEB, the identification of educators' current skills and preferable learning methodologies, leading to the creation of a Gap Analysis

2.2.2.2 Forecasts

Among the project's most important achievements are findings and forecasts of future needs of skills.

Based on BIMzeED *Output O2.5: Report on Gap Analysis Roadmap Plan and Learning Outcomes*, future [4], education programs in zero energy buildings using BIM need to include:

- BIM for a comprehensive facilities management, especially in light of the trend toward “smart” buildings,
- quality control system integrating NZEB principles in BIM. This subject needs to be addressed differently for different EQF levels, and it is very important to make it available for “blue collar” workers as instructions, quality checks for site supervisors and managers.
- development of information about materials and products to allow project managers and architects to specify and order materials through the BIM system and introduce them into the construction supply chain.
- BIM models to be used as a data source for energy analysis, especially dynamic energy analysis methods.
- Lack of automated processes (interoperability) for BIM (Building Information Modelling) to BEM (Building Energy Modelling) is one of the major gaps which technology needs to overcome in the near future
- Mechanical engineers, in charge of modern technology application in the field of HVAC systems,
- Management of information for further utilisation of BIM and FM tools.

The project found out that trend at the EU level indicates that the highest numbers of workers needing to be trained on energy efficiency and renewable energy are found in the following professions

· Electricians;

· Plumbers (including installers of heat pumps boilers, biogas systems, central heating, sanitary and thermic equipment);

· Carpenters and joiners;

· Bricklayers;

· Technicians (including Heating, Ventilation, and Air Conditioning - HVAC)

2.2.2.3 Development of integrated qualification frameworks

Literature review carried out by the BIMzeED consortium showed that there was no existing framework uniting BIM and NZEBs, but there were skills and

knowledge frameworks for both areas separate. Therefore, the main challenge of the consortium was to determine the overlapping part of the both frameworks.

The design of an integrated BIM and NZEB skills framework by BIMzeED was carried out in several steps.

I STEP: Identifications of roles and profiles for NZEBs and BIM

1) Identification of profiles and specializations for NZEBs

List of roles were identified at EU level, taking into account that there are 4 partners representing different professional environments and way of doing business (detailed definitions of each profession's role and responsibility were also described on the Output 0.4):

· Policy Makers
· Public Administrator
· Facility Managers
· Developers
· Project managers
· Consultants
· Architects and Designers
· Site Supervisors
· Site Engineers
· Construction Managers
· Technicians
· Craftsman
· Apprentices
· Students
· Specialists in Green Building
· Quantity Surveyors
· Workers
· Owners

Qualification requirements (EQF) for the target groups depending on their role in the construction process, were identified on partner countries level, using a survey within the consortium.

2) Identification of profiles and specializations for BIM

The consortium used the model of BIM profiles and specialization proposed by one of the partners (Croatian Chamber of Civil Engineers), which identified the roles / responsibilities (and provided definitions and required EQF level thereof) in BIM projects in relation to the standard roles in construction projects:

- BIM Consultant
- BIM Manager
- BIM Coordinator
- BIM Engineer
- BIM Technician/ Modeller

II Step: identification of skills frameworks for NZEB and BIM

For nZEB skills, the PROF/TRAC framework was used and for BIM knowledge and skills – the framework developed by BuildingSmart Australia was used [3].

PROF/TRAC framework identified 4 groups of skills:

· Energy Management (EM)

· Energy Production (EP)

· Energy Reduction (ER)

· Interdisciplinary Skills (IS)

Each group had a sub-group of skills for:

· General

· Predesign

· Design

· Tendering and contracting

· Realisation

· Commissioning

- Use/maintain

BIM skills framework have also skills grouped according to project phases:

· Introduction

· 2.000 Start Up

· 3.000 Initiation

· 4.000 Planning

· 5.000 Execution / Operation

· 6.000 Monitoring and Controlling

· 7.000 Closeout / Handover / Commission

Each Knowledge group is divided into several Process Groups and the skills and knowledge are connected to a concept which is explained by descriptors.

NZEB skills framework was identified for the 5 fields:

- general group of skills and knowledge (skills code: NZEB1.1-1.5)
- Pre-design NZEB group of skills and knowledge (skills code NZEB 2.1 – 2.11)
- Design NZEB group of skills and knowledge (skills code NZEB 3.1 – 3.5)
- Tendering/contracting NZEB group of skills and knowledge (skills code NZEB 4.1 – 4.3)
- Realization and commissioning NZEB group of skills and knowledge (skills code: NZEB 5.1 – 5.9)
- Use and maintaining NZEB group of skills and knowledge (skills code: NZEB 6.1 – 6.71)

An example of general nZEB group of skills and knowledge, as determined by BIMzeED, is given below:

NZEB 1.1. [Understand influence of heating and cooling generation on energy performance]

NZEB 1.2. [Understand specifics and basic parameters of heating and cooling]

NZEB 1.3. [Understand different energy production systems in relation to energy performance]

NZEB 1.4. [Understand importance of energy reduction systems in relation to energy performance] NZEB 1.5. [Understand the impact of architectural design on sustainability and energy performance]

NZEB 1.6. [Understand integrated design processes and concepts]

NZEB 1.7. [Understand the interaction of building location, design, use and outdoor climate]

BIM skills framework was identified for the following 8 fields:

1) Introduction to BIM (skills code: BIM 1.1 – BIM 1.5)
2) Group of BIM Knowledge and skills – Project start up (skills code: BIM 2.1 – BIM 2.15)
3) Group of BIM Knowledge and skills – Tendering (skills code: BIM 3.1 – BIM 3.7)
4) Group of BIM Knowledge and skills – Initiation (integration and communication) (skills code: BIM 4.1 – BIM 4.4)
5) Group of BIM Knowledge and skills –- Integration (skills code: BIM 5.1 – BIM 5.9)
6) Group of BIM Knowledge and skills –Scope, time, cost, quality, risks (skills code: BIM 6,1 – BIM 6.12)
7) Group of BIM Knowledge and skills –Monitoring and controlling (skills code: BIM 7.1 – BIM 7.5)
8) Group of BIM Knowledge and skills – Execution / Operation (skills code: BIM 8.1 – BIM 8.9)

III STEP: Union of both frameworks

After identifying these two areas of skills (BIM and nZEB), the consortium invited BIMzeED National Steering Group (NSG) to act as expert group to prioritize skills specific to the overlapping area of BIM and NZEB. The NSG consisted of representatives from education, industry and experts from these two fields. They identified the importance of each nZEB skill and how this can be improved by using BIM, and which BIM skills are needed to improve to achieve nZEB projects design/delivery.

Priority analysis was used to select important skills in BIM and nZEB, which was then used to identify training needs in the construction industry and to evaluate current training skills of educators involved in construction studies. Expert group members assessed the importance of each skill by answering two questions:

- Which BIM skills are important for NZEB delivery?
- Which aspects of NZEB design / delivery can be improved with BIM

BIM skills were assessed how important are they for nZEB design, and nZEB skills were assessed how important is BIM for improving nZEB skills. Skills that have importance equal and greater than average importance of each group were selected for further research.

The BIMzeED report *Output 02.4: Report on the current training skills of the construction industry* identified and specified the tasks that a specific professional role needs to complete successfully in a NZEB & BIM delivery process.

The primary goal and conclusions consequently of the report were to identify gaps in industry and education, providing the project team a target to achieve (*the result of the self-assessment part of the questionnaire was that average grade for nZEB was 2,62 and for BIM was 1,93. which inspired the consortium to rise average grades of knowledge and skills, through the project activities to at least to the 3 intermediate (practical application/proficient) level in order to bring the NZEB and BIM into practice). The* analysis in the report showed that

- in the NZEB field, the potential of existing education is almost exploited and needs to be upgraded to practical/proficiency level.
- On the other hand, the BIM field is not mature enough and education that is developed is still not exploited.

With this analysis the team identified which elements needed to be improved in education provisions in order to improve application of NZEB principles using BIM

IV STEP: Valuation of skills maturity

Grades of skill maturity levels were set by the expert group (NSG) as follows:

- 1 Fundamental awareness (basic knowledge)
- 2 Novices (limited expertise / basic level of competency)
- 3 Intermediate (practical application/ proficient)
- 4 Advanced (applied theory)
- 5 Expert (recognized authority)

2.2.3. Project model of skills and qualifications

BIMzeED developed a framework of 12 multidisciplinary learning units addressing nearly zero energy buildings (NZEB) and BIM, covering all target groups included

in a building life cycle, as well as construction students (the curricula are adaptable for HEI). The LUs planned to be delivered as blended, in-class/on-site or on-line training, were designed to be flexible as stand-alone units, combined as a group of LUs or integrated into existing curricula, taking into account EQF integration.

The gaps and needs identified have been set out in 12 Learning Units as groups of competences required by the construction industry to understand and implement skills in the field of NZEBs and BIM. Competences have been prepared in a generic mode and also as specific actions within the Learning Unit. These Learning Units focus on the importance of drawing cogent conclusions on the type, level and mode of training relevant to SME employees working in an active construction industry

Each learning unit description details the skills kind, level of competency, level of qualification, manner in which the skills are intended to be applied and the typical nature of the role in which it is expected to be deployed, more precisely, the descriptors include:

- EQF level correlated to the unit,
- Specification of target groups (professional profiles) for which the unit is intended,
- Description of the unit content,
- Learning objectives
- Generic competence
- Specific competence
- Recommended learning methodology and training methods
- Recommended assessment methodology

Learning plans (learning routes) that were designed by the projects comprise specification and sequences of learning units and associated learning objectives of particular units. Skills maturity is specified in line with the EQF system. Generic and specific competences to be achieved are based on roles and responsibilities of targeted professionals, in the construction process, providing them with capacity to carry out tasks related to their job position.

All learning units include BIM and sustainable energy skills, specific for the targeted group of learners.

The BIMzeED learning units were designed with the purpose to ensure a balance between theory and practice. BIMzeED structured the training material and content using common learning units (LUs) with flexible standardised delivery (in class, on-line and on-site) suitable for HEI, VET and SME training. The initial training content includes NZEB related subjects with BIM maturity. The training content covers and delivered in a Blended Learning format supported by an e-Learning portal. The following 12 mutually recognised BIMzeED Learning Units are designed for relevant target groups with 2 LUs common units open for everyone.

SPECIFICATION OF BIMzeED LEARNING UNITS [5]

LU1: Collaborative BIM to achieve NZEB (EQF 4-7) COMMON UNIT

Give all necessary tools and knowledge to all team members for BIM workflow generation and application and NZEB understanding.

LU2: BIM and nZEB for Workers EQF (4-5)

Inform workers on the BIM methodology used during NZEB project construction, and awareness to prevent and anticipate solutions.

LU3: NZEB Realization and Commissioning: Building Envelope and Air Tightness (EQF 6)

Understand the parameters affecting building envelope and air tightness, quality controls and create BIM objects suitable for nZEB design and the correct use within the BIM model.

LU4: NZEB Realization and Commissioning: Building Services & Smart Technologies (EQF 6) Understand the parameters affecting building services and smart technologies, quality controls and create BIM objects suitable for nZEB design and the correct use within the BIM model.

LU5: NZEB Realization and Commissioning: Quality Assurance (EQF 4-7) COMMON UNIT

Focuses on quality assurance of the elements for nZEB qualification of the building, using BIM methodology and other digital tools as communication tools.

LU6: BIM Model Uses during Construction (EQF 6)

Use of BIM models to provide optimization during construction and a digital twin design by anticipating and solving problems.

LU7: BIM Model Uses for specification and quantification (EQF 6)

Exploit model data through cost extraction, site planning and material listing, acquiring knowledge in the design of a construction model considering time (4D), cost (5D) and environmental aspects (6D). **LU8: BIM Model Standardization for nZEB Design** (EQF 6) Standardizing and validating the structure of the BIM model to achieve an nZEB design and optimize the workflow.

LU9: Building Energy Modelling (BEM) Design and Export (EQF 7)

Develop a BEM and understand how it affects the design of nZEB buildings and future needs.

LU10: Energy Simulation with BIM Tools (EQF 7) Analysis and interpretation of a Building Energy Model (BEM) to guarantee economic viability and nZEB requirements.

LU11: Nearly Zero Energy Building Facilities Management (EQF 5-6)

Maintain efficiency during facility management by preventing and anticipating future problems and guarantee nZEB qualification during its use.

LU12: BIM in Facility Management Software (CMMS) (EQF 6-7)

Create a BIM model for facility management systems focussing using CMMS software and standards like COBie

The LU, are designed to be flexible as stand-alone units, combined as a group of LUs or integrated into existing curricula. They are planned to be delivered as blended, in-class/on-site or online training

The stand-alone learning units enable selection of a short online training programme.

Grouping learning units (suggested Learning plans) allows the vocational and higher educational institutions to establish a new course for industry professionals and students.

The LUs can be grouped to create a new accredited programme relevant to the skills needs of the industry. Alternatively, the LUs can be integrated into existing accredited programmes to support and enable updating and improving the existing curricula.

Table 2: BIMzeED recommended learning route for each professional profile[2].

Profession	**Recommended Learning Units**
Apprentices	LU1, LU2, LU5,
Architect	LU1, LU3, LU4, LU5, LU6, LU7, LU8, LU9, LU10, LU12
Construction Manager	LU1, LU3, LU4, LU5, LU6, LU7, LU8
Construction Workers	LU1, LU2, LU5
Consultant	LU1, LU3, LU4, LU5, LU6, LU7, LU8, LU9, LU10, LU11, LU12
Craft Workers	LU1, LU2, LU5
Engineer	LU1, LU3, LU4, LU5, LU6, LU7, LU8, LU9, LU10, LU12
Facility manager	LU1, LU5, LU10, LU11, LU12
Project Manager	LU1, LU3, LU4, LU5, LU6, LU7, LU8, LU9, LU10, LU12
Quantity surveyor	LU1, LU5, LU6, LU7
Site Engineers	LU1, LU5, LU6, LU7
Site Supervisor	LU1, LU5, LU6, LU7
Specialist in Green Building	LU1, LU3, LU4, LU5, LU6, LU7, LU8, LU9, LU10, LU11, LU12
Specialized Workers	LU1, LU2, LU5
Technicians	LU1, LU5, LU11

[2] *BIMzeED website, https://bimzeed.eu/course-information/,*

2.2.4 Project main outputs

BIMzeED developed:

- 12 learning modules, with learning unit descriptors (translated to all partner languages)

- Training and assessment methodologies,

- E -learning platform,

- Learning plans for specific professional profiles,

- Train the trainer materials

- Research reports on current offer and demand, as well as future needs for skills

2.3. NetUBIEP

2.3.1. Concept and approach

Net-UBIEP aimed at increasing energy performance of buildings by spreading and strengthening the use of BIM, during the life cycle of the building. The use of BIM from the design phase through the construction, management, maintenance, and demolition were investigated to identify the competencies needed, in each phase, to decrease the environmental impact of the building during its life cycle. To achieve this objective, the role of collecting, managing and storing all the information required during construction, management, maintenance and decommissioning of a building was identified for each actor of the building supply chain.

The project Net-UBIEP thus promoted an increasing use of BIM during the life cycle of the building, giving in that way an opportunity to simulate the building's energy performance with different materials and components, form the building design to the building refurbishment/demolition.

BIM Qualification Models, proposed by the net-UBIEP partners tackled the problem of energy competences gap in the existing buildings sector.

The project consortium built the project on their vision that each phase of building is very important and it should take into account all the energy aspects in order to decrease the environmental impact of the building during its life cycle (construction, management, maintenance, demolish).

In order to accomplish this aim, the project focused on different target groups which took in consideration experts and skilled workers included in the building process, with the goal to increase the awareness and educate them of their part in the gathering, management and keeping of all of the information required during the whole building life cycle.

The materials produced by the net-UBIEP project intended to provide the necessary knowledge for each technician, public officer, designer, constructor, facility manager, supplier, etc. by underlining the importance of the right standard to allow the use of the information by any other individual during the lifetime of a building that goes far behind the duration of the computer who has generated the

information. Therefore, Net-UBIEP promoted the use of “openBIM” to ensure that all the different targets use the same language, the same dictionary, and the same data structure.

The information materials produced for the four targets have been adapted for the body of knowledge to get a building SMART qualification. At the same time the learning outcomes were used as base for the qualification schema to be approved by building SMART that is promoting the bSI qualification.

The use of BIM for simulation of building energy performance using different materials and components, was presented following these steps:

1. Professional profiles, involved in NZEB building sector with specific BIM related competences, were identified. Four target groups were selected according to the role they play in building processes, namely Public Administrations, Professionals (Engineers / Architects), Technicians (Installers / Maintainers), Tenants/Owners/Building Administrator.

2. A three-dimensional matrix considering the three variables: target group, construction phases and competences was then developed. This matrix would allow, for instance, to know what competencies are needed for the user class of owner during the preliminary design to achieve the best energy performance of the building.

3. A BIM Qualification Models to tackle the problem of energy competences gap in the existing buildings sector was developed starting from the foreseen competences for each target. BIM Qualification Models were composed by a BIM Training Scheme and a BIM Qualification and Certification Scheme.

4. The qualification model was then adapted to the building SMART qualification system to ensure a broader dissemination.

2.3.2. Background analyses

To achieve its set goals, the project carried out a comprehensive desk research (Report on existing BIM professional profiles) for already available BIM profiles for each of the partner countries: Italy, Spain, Slovakia, Lithuania, Croatia, Netherlands

and Estonia. The analysis focused on the required EQF level, working fields, tasks and the necessary competences for BIM Managers, BIM Coordinators, BIM Experts, BIM Expert users, BIM Evaluators and BIM Facility managers. The harmonized results from the analysis were discussed on a national level.

The starting point of the project was the identification of all actors involved in the building sector. Four main target groups were selected and reported as relevant, those are the Public Administrations (including all governance levels), the Professionals (Engineering and Architects), the Technicians (Installers, Maintainers), and finally the fourth target group composed of Tenants, Owners and Facility Manager.

Net-UBIEP project took into consideration the specific needs of these four groups of actors in relation to energy performances implemented in a BIM model and defined actions aimed at upgrading their competences in an all-encompassing approach called BIM Qualification Models [12].

Figure 2: Flowchart of Net –UBIEP Framework development

The main steps of the project are identified in the above picture. The first steps were to identify competences that professionals, who were already aware of Building Information Modelling, needed to have to better manage the performance of buildings during all the phases: conceptual design, structural design, construction, delivery of the information model to the owners for a better use, maintenance, refurbishment and eventual demolish.

The idea behind the whole project was to describe the process in which intelligent modelling software used the BIM model to determine the best energy performance of a building. The use of engineering analysis could provide information needed by the owner and/or operator to make informed decision in the preliminary design and manage the building in the best way during operation & maintenance. These analysis tools and performance simulations can significantly improve the design of the facility and its energy consumption during the life cycle.

Potential Value:

- Automating analysis and saving time and cost
- Analysis tools are less costly than BIM authoring tools, easier to learn and implement and less disruptive to established workflow
- Improve specialized expertise and services offered by the design firms
- Achieve optimum, energy-efficient design solution by applying various rigorous analyses
- Faster return on investment with applying audit and analysis tools for engineering analyses
- Improve the quality and reduce the cycle time of the design analyses

In the BIM word this means to set up a team which considers the perspective/ requirements of each main stakeholder. To do that all the stakeholders need to be trained and/or to be aware of this new technology. These are the main capabilities required:

- Ability to manipulate, navigate, and review a 3D Model (all the targets)
- Ability to assess a model through engineering analysis tools (engineers and architects)
- Knowledge of construction means and methods (engineers)
- Design and construction experience (engineers)

Net UBIEP provided each target with specific knowledge and/or skills and/or competences.

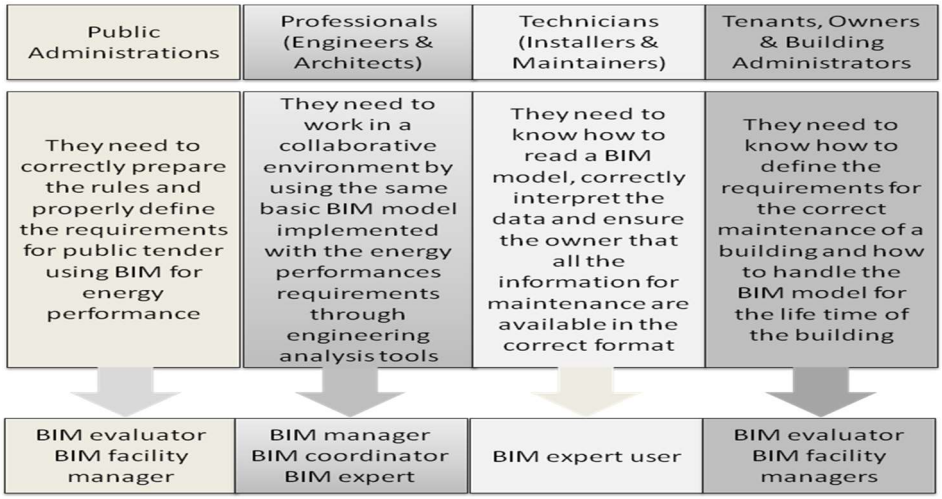


Figure 3: Professional roles identified by NETUbiep

The following BIM map for energy analysis, which has been obtained from one elaborated by the Pennsylvania State University, shows the implementation of a generic BIM model with further information like mechanical systems, energy tariff, thermal zone, etc. needed to be considered and customized for the building to optimize its energy performance. The partners implemented this basic map model and enriched it with the information deriving from the BUS initiatives to include different technologies and possibly links to existing schemas for the installers.

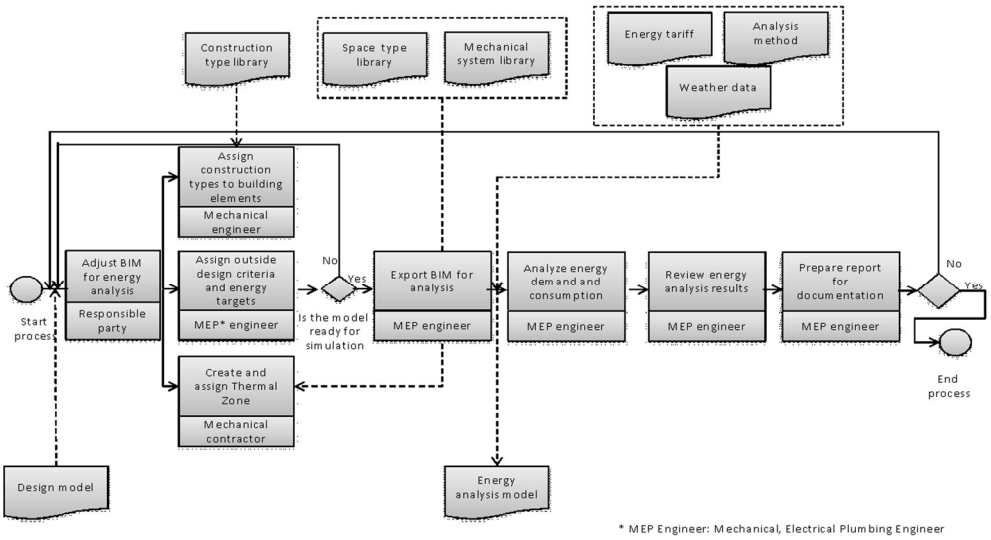


Figure 4: Development of a building design and energy model

The project scheme is presented in the Figure 5. On the left-hand side, the inputs considered are shown, on the top the rules which were followed, on the right-hand

side, the expected results and from the bottom the main actors/mechanisms which allowed to reach those results.

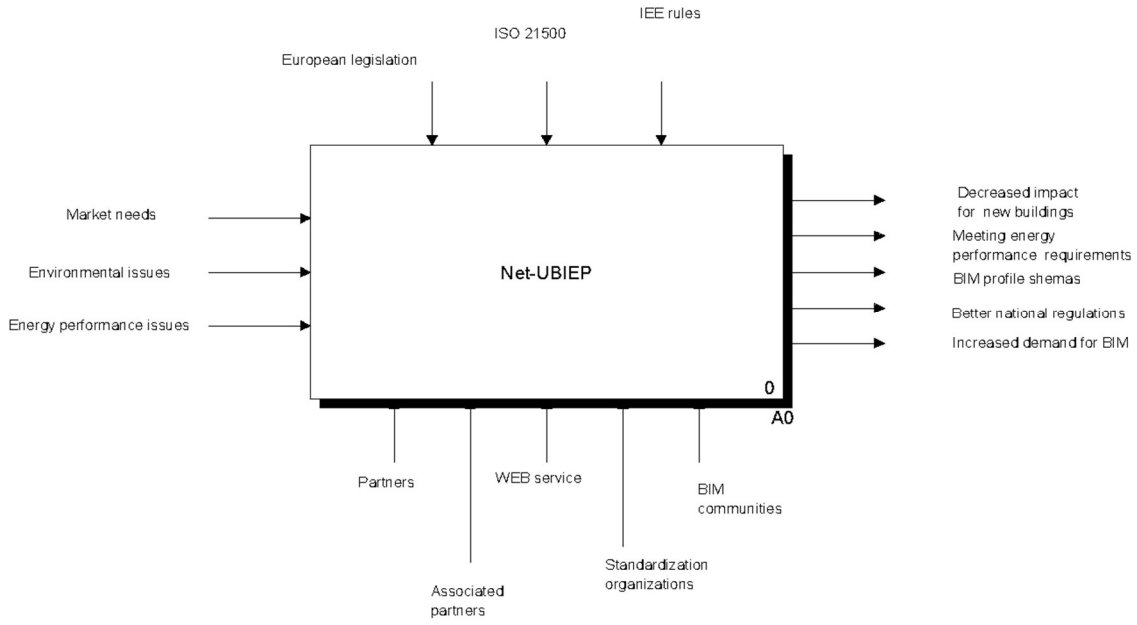


Figure 5: Net – UBIEP Project scheme

A comparative analysis was conducted for each of the above-mentioned BIM profiles and harmonized results were presented, including competences and tasks for each of the identified roles (see Figure 3).

Report on Roles of Target Groups in the Building Life Cycle and their role in NZEB implementation defines the BIM roles for the 4 types of actors: Public Administrations, Professionals (Architects – Engineers), Technician (Installers-Maintainers), Tenants/Owners/Building Administrators. The roles, tasks and competences are analysed for each different building life cycle phases, for each type of actor in several countries. An extract of the results from this Report is presented below:

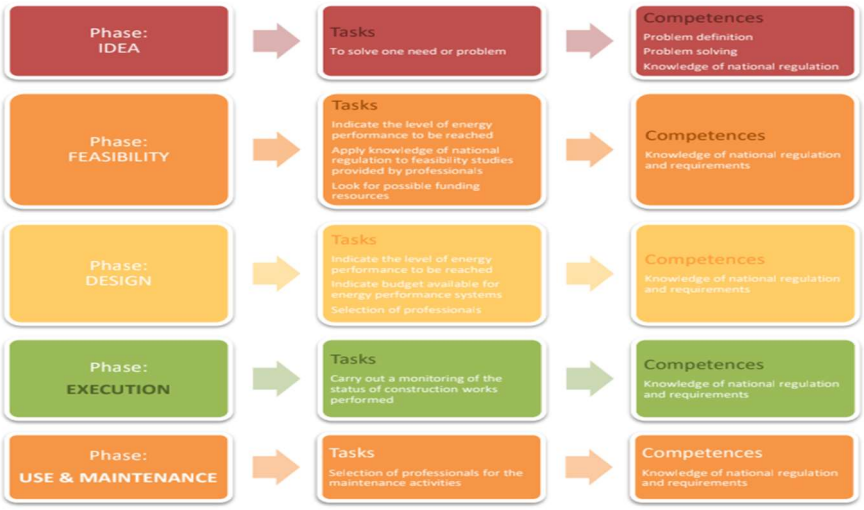


Figure 6: Extract – example for defining required tasks and competences through different building life cycle phases, (Source: Deliverable D11-D2.2 Report on Roles of Target Groups in the Building Life Cycle and their role in NZEB implementation)

Research findings from background analysis:

The results from the Report on existing BIM professional profiles showed that each country defines different task, competencies of each BIM profile, but there are similarities for profiles like: BIM manager, BIM Coordinator and BIM modeller (BIM expert). The findings showed that for roles such as BIM Facility manager and BIM Evaluator there is lack of reliable data.

Based on the findings from these Reports professional profiles involved in NZEB building sector were identified. This analysis served as foundation for defining specific BIM competences for each professional role for each phase of the building process and for the 4 types of actors: Public Administrations, Professionals, Technicians and Owners.

A three-dimensional matrix for the identification of competences required target groups during the lifecycle of the building to ensure the highest energy performance using the BIM model was developed.

2.3.3 Skills and qualifications framework developed by the project

The overall work methodology of the project was defined on the basis of the BIM approach. As clarification a graph is posted hereafter; it gives a general overview underlining the main steps of the logic of the project.

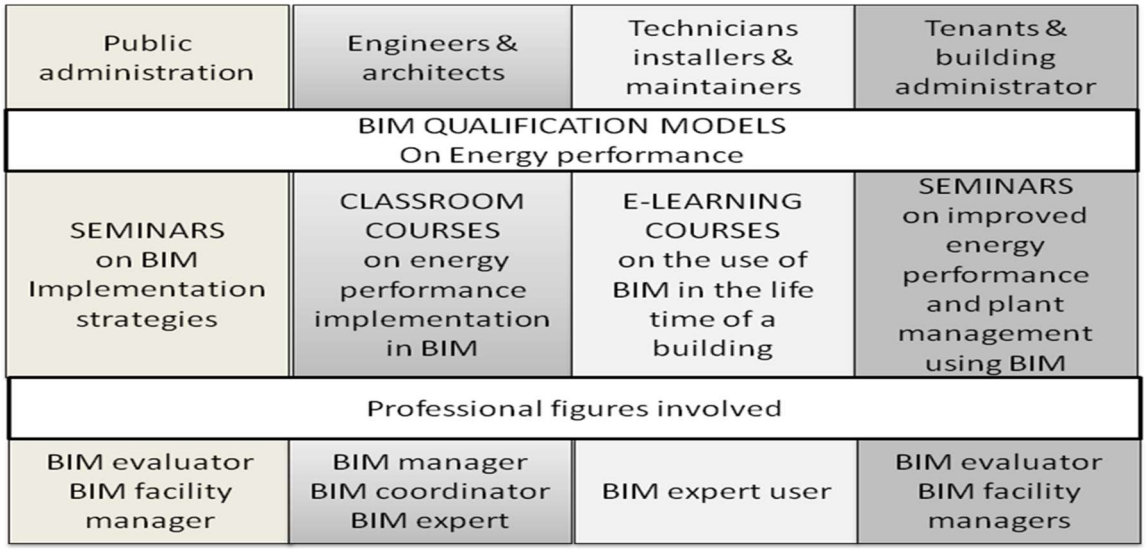


Figure 7: Net-UBIEP project methodology

Net-UBIEP Project increased energy performance related competences of 6 professional figures identified within four different target groups (PA, Engineers & architects, Technician installers & maintainers, Tenants & building administrators):

- BIM evaluator,
- BIM facility manager,
- BIM manager,
- BIM coordinator,
- BIM expert,
- BIM user.

The Tasks related to these six figures identified by the project have served as the basis for the Building Smart qualification framework on BIM for Energy efficiency. The details about these tasks can be found in paragraph 2.7. Building Smart qualifications on BIM and BIM for Energy efficiency.

Units of learning outcomes were defined for each of the 4 types of actors: Public Administrations (6 ULOs), Professionals (12 ULOs), Technicians (5 ULOs) and Owners (8 ULOs).

Table 3: Net-UBIEP List of units of learning outcomes

Public administration	
UL01	Identify the advantages of using BIM during the life cycle of the building seeing overcoming barriers with the purpose to have a successful adoption.

UL02	Ensure compliance with BIM standard, using code checking software to verify the respect of them and to list the requirements for automatic code checking.
UL03	establish requirements for the management, coordination and preserving of data related to energy performance in the Common Data Environment (CDE).
UL04	Use open standard formats for information sharing in the CDE, read the 3D model using viewers and identify various participants and roles in the sustainable construction project. Use quality checking software in order to verify the respect of requirements.
UL05	Define performance indicators depending on the use of the building, climate zone, influence on the global environment during its whole lifecycle calculation of nZEB energy performance and define the Quality Assurance monitoring methodology.
UL06	Evaluate the completeness of the handover strategy and verity the correspondence between the "as built" and the final BIM Model.
Professional	
UL01	Identify advantages of using BIM, evaluation related technologies, standards and trends.
UL02	Evaluate economic / quantity take off of the life cycle cost of the building, 5D cost estimation
UL03	Make a 4D phases planning, integrating life cycle concepts in different project phases in order to set-up organized management systems.
UL04	Identify requirements for the management of data in the CDE, ensuring the respect of the information requirements and of Information Delivery Manual. Manage those data.

UL05	Produce and manage digital data for the design of nZEB and consider 7D performance indicators for the analysis of data.
UL06	Select energy efficiency solutions (and their suppliers) integrating different RES systems into buildings without clash detection.
UL07	Conduct risk management and disaster planning troubleshooting problems related to BIM.
UL08	Produce a maintenance plan and a maintenance manual for the building plants in order to transfer management information to owners.
UL09	Evaluate the completeness of the handover strategy and verify the correspondence between the "as built" and the final BIM model of the building.
UL010	Use Reverse Engineering methods for the definition of models of existing buildings for their refurbishment.
ULO11	Make technical supervision and verify the respect to pre-defined BIM standards, technical requirements and legislation (with code checking).
ULO12	Produce a correct decommission of the building and provide to recycle any part in the respect of local, national and international laws.
Technicians	
UL01	Identify the advantages of using BIM during the life cycle of the building and evaluate related BIM technologies
UL02	List several stakeholders who participate in the sustainable construction project distinguishing their role and needs
UL03	Distinguish between different RES solutions and technologies and select products that fit specifications, avoiding interferences with other technologies installed.
UL04	Provide maintenance information to preserve the foreseen energy performance, assuring the completeness and correctness of the maintenance plan.

UL05	Evaluate the completeness of the handover strategy and verify the correspondence between the "as built" and the final BIM model of the building.
Owner	
UL01	Evaluate a plan for ROI distinguishing between different mechanism for financing energy efficiency measures
UL02	Select energy efficiency solutions taking into consideration the place of relevant government program and regulation and costumer's needs
UL03	Understand the global environmental impact of different building products during the whole life cycle of the buildings
UL04	Identify which information and requirements are necessary for a better management and maintenance of the building
UL05	Evaluate the completeness and correctness of a maintenance plan in order to preserve the foreseen energy performance
UL06	Evaluate the completeness of the handover strategy and verity the correspondence between the "as build" and the final BIM model of the building
UL07	Identify participants and their roles in the sustainable project, training them for the correct maintenance and management of the process.
UL08	Apply quality Building Management System and data Security Risk Management

The project analysed the market requirements the target group requirements as basis for defining the skills and qualifications framework. On top of that, the project used findings from the European PROF/TRAC project, which is an open training platform for NZEB professionals. With this symbiosis, a NZEB skills and qualification scheme was developed.

The competence levels were graded as linear rating scales from 0 (no knowledge and competence) to 5 (specialized knowledge and problem-solving competencies).

Table 4: Definition of the competence levels by PROF -TRAC

0	Not applicable / no knowledge and competencies required
1	Has little knowledge and competencies with respect to the relevant field / technology (mostly outside the own field of expertise). Understands basic principles and is able to take part in project team discussions
2	Understands basic knowledge and has practical competencies within the field / technology, is able to solve simple problems by selecting and applying basic methods, tools, materials and information (mostly outside the own field of expertise)
3	Has comprehensive, factual and theoretical knowledge and competencies within the field / technology, is capable of solving standard problems within the field
4	Has advanced knowledge involving a critical understanding of theories and principles and competencies, required to solve complex and unpredictable problems in the field and is aware of the boundaries
5	Has specialized knowledge and problem-solving competencies, partly at the forefront of knowledge in the field, in order to develop new knowledge and procedures and to integrate knowledge from different fields

(Source: Net-UBIEP D2.3 and 2.4)

In building the skills and qualifications framework a relationship between the target groups and the BIM profiles was established:

Table 5: Relationship between the target groups and the BIM profiles

Target group	**Public Administrations**	**Professionals (engineers & Architects)**	**Technicians (Installers and Maintainers)**	**Tenants, Owners & Building Administrators**
Role	They need to correctly prepare the rules and properly define the requirements for public tender using BIM for energy performance	They need to work in a collaborative environment by using the same basic BIM model implemented with the energy performances requirements through engineering analysis tools	They need to know how to read a BIM model, correctly interpret the data and ensure the owner that all the information for maintenance are available in the correct format	They need to know how to define the requirements for the correct maintenance of a building and how to handle the BIM model for the life time of the building
BIM profiles	**BIM Evaluator** **BIM Facility manager**	**BIM Manager** **BIM Coordinator** **BIM Expert**	**BIM Expert User**	**BIM Evaluator** **BIM Facility Manager**

Source: Deliverable D10-D2.3/2.4 Identified requirements for the development of the BIM Qualification Models.

Based on the methodology of the PROF/TRAC project, the NZEB skills and qualification scheme contains a list of 35 technologies and interdisciplinary competences in 5 categories: energy management, energy production, energy reduction, sustainable integrated design and interdisciplinary competences. Complete list can be found in Annex 1.

Based on this determines, a required competency level for each target group and profile with each technology is defined. An example is shown in Figure 7.

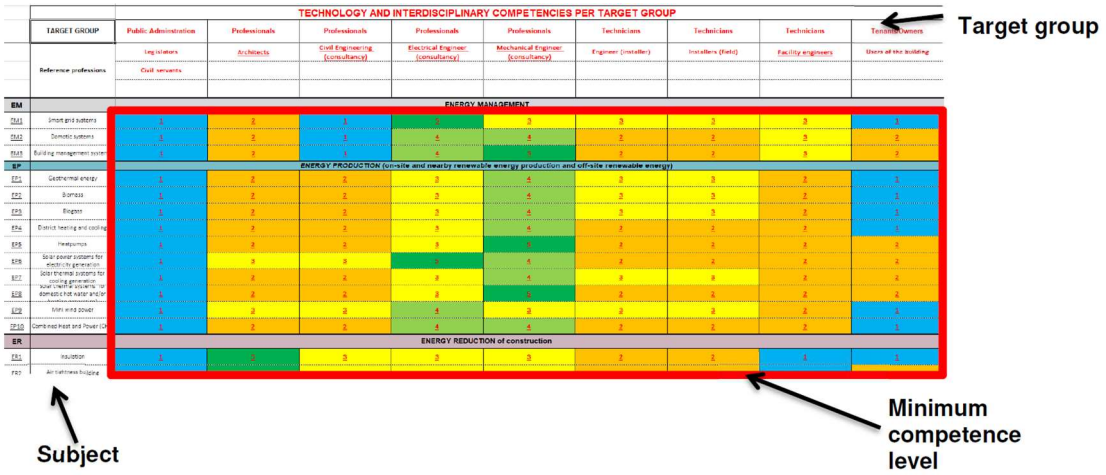


Figure 8: Extract – example for competence levels of each target group, Source: Deliverable D10-D2.3/2.4 Identified requirements for the development of the BIM Qualification Models

Based on the ULOs a specific requirement for the qualification each of the 6 BIM targeted professionals (BIM evaluator, BIM facility manager, BIM manager, BIM coordinator, BIM expert, BIM user) was created. An example of the minimum access requirements for the role BIM MANAGER's Qualification and Certification path are shown on Table 1, containing the criteria: Education, General Work Experiences and Specific General Work Experiences.

Table 6: Extract – example for defining minimum access requirements for one targeted professional by Net 0 UBIEP

Minimum access requirements	BIM MANAGER (or equivalent)
Education	**EQF7** (or higher) ✓ **Level of knowledge**: BIM MANAGER has highly specialised knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research. He has critical awareness of knowledge issues in a field and at the interface between different fields. ✓ **Level of skills**: BIM MANAGER has specialised problem-solving skills required in research and/or innovation in order to develop new knowledge and procedures and to integrate knowledge from different fields into BIM modelling process. ✓ **Level of responsibility and autonomy**: BIM MANAGER manages and transforms work or study contexts that are complex, unpredictable and require new strategic approaches. He takes responsibility for contributing to professional knowledge and practice and/or for reviewing the strategic performance of teams. He may be a Project Manager (at organizational level or at project level) as well or support the project Manager in charge.
General Work Experiences	To access to the Qualification and Certification path as "BIM MANAGER " (or equivalent) it is necessary to document an appropriate work experience, in the last years as specified below: • work experiences of at least five years in architectural, construction or engineering role as lead designer
Specific Work Experiences	To access to the Qualification and Certification path as "BIM MANAGER" (or equivalent) it is necessary to document an appropriate specific work experience, in the last years as specified below: • proven experiences of at least three years in management of new nZEB projects or the refurbishment of existing buildings up to nZEB level, with particular attention to energy efficiency and using of BIM • proven experiences in management of projects with IT skills • great verbal and written skills acquired during previous experiences

Source: Deliverable D15.A – D3.2.A Requirements for Learning Outcomes for Target Groups

After the Qualification and Certification path is completed, a minimum requirement reached are set. These are presented in Table 7 and they are defined according to the correspondent phase of the Building Life Cycle and are based on the knowledge and skills the professional has.

Table 7: Extract – example for minimum requirements after the Qualification and Certification path, by Net -UBIEP

BIM MANAGER	Phases							
	Strategic Definition	Preparation and Brief	Concept Design	Developed Design	Technical Design	Construction	Handover and Close Out	In use
C0.MA Have basic BIM knowledge and skills								
Knowledge								
C0.K1. BIM basic concepts, terminology, principles, strategies and its value proposition								
C0.K2. Benefits and uses of BIM compared to traditional methods for improving energy efficiency of new or existing buildings								
C0.K3. Project information development cycle: information specification, development, exchange and maintenance throughout all the building life cycle								
C0.K4. Reasons for open and interoperable solutions to ensure collaboration among professionals of different disciplines								
C0.K5. Methodology to identify, plan, develop and evaluate organization's BIM implementation capabilities and BIM uses								
C0.K6. Relevance of maintenance to maintain the foreseen energy performance								
Skill								
C0.S1. Read a BIM Execution Plan (BEP)								
C0.S2. Read a Information Delivery Manual								
C0.S3. Identify information requirements for his own role								
C0.S4. Identify the format to read information and transfer information within the supply chain								
C0.S5. Identify the EIR (Employer Information Requirements)								
C0.S6. Identify and/or verify the stages of PIM (Project Information Management)								
C1.MA Understand BIM tools								
Knowledge								
C1.K1. Principle of economic subjects for the cost estimation and evaluation of energy refurbishment								
Skill								
C1.S1. Specialised skills to incorporate information in a BIM Model, evaluating openBIM software								
C1.S2. Stay up to date on BIM trends, current developments and new directions of BIM technologies								
C1.S3. Decrease the life cycle cost of the building using methods described in ISO 15686-5								
C1.S4. Evaluate and compare different plans and related ROI (Return of Investments) using methods described in ISO 15686-5								

Source: Deliverable D15.A – D3.2.A Requirements for Learning Outcomes for Target Groups

In summary, the BIM Qualification Models include the energy performance in the entire buildings sector, in order to tackle the problem of energy competences gap. The BIM Qualification Models consist of a BIM Training Scheme and a BIM Qualification and/or Certification Scheme comprehensive of energy skills. During the project the BIM Training scheme has been elaborated and validated through pilot training sessions with more than 3000 people in seven European countries.[3]

2.3.4. Project main outputs

- Report on existing BIM professional profiles
- Report on Roles of Target Groups in the Building Life Cycle and their role in NZEB implementation
- First report on CEN existing standards
- Report on CEN existing standards and standardization landscape
- Maps on NZEB and BIM competences for target groups
- Report for the standardization of training scheme
- Information Materials for Public Administration
- Information materials for technicians
- Information materials for owners
- Information materials for professionals

[3] https://cordis.europa.eu/project/id/754016/reporting/fr

2.4. BIMEET

2.4.1. Concept and approach

BIMEET aimed to promote Building Information Modelling (BIM) training to enhance energy efficiency of buildings[4]. The project focused on creation and implementation of qualification and training schemes for building professionals and blue collar workers across different asset types and across different roles in the industry. The project put the focus on the learner when designing the learning outcomes, by a method that enabled both individual and local adaptation.

The BIMEET consortium applied an approach of engaging providers in the development and delivery of the material and standards in order to accelerate competency and adoption, but also to align the level and calibration of existing workforce and future industry professionals

BIMEET carried out a comprehensive and vast analysis of past and ongoing European 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.

The strategic objective of the BIMEET project was to harmonize energy related BIM qualification and skills frameworks available across Europe with a view of reaching a global consensus through the project engaged BIM for energy efficiency expert panel.

Additionally, the project ambition was to identify and link skills, qualifications, and accreditation into a united BIM for energy efficiency framework, including the complete construction sector supply chain, which would be widely recognizable and applicable – i.e., to establish a harmonized EU – wide framework of learning outcomes in BIM and NZEB and to design it in a LLL adaptable model.

One of the main specifics of BIMEET approach was the successful combination of academic research results, applied innovation through European projects and concrete expectations of the sector.

[4] https://bimzeed.eu/wp-content/uploads/2019/05/O2.1-Literature-review-on-BIM-and-nZEB-needs-in-the-construction-industry.pdf

The results have been applied for creation of a labelling scheme based on BIMEET LO framework (based on BIM4VET Erasmus+ funded project), following these 6 phases:

1) Definition of the label
2) The label assessment commission
3) The training labelling process
4) The constituent elements of the application
5) Training assessment criteria for awarding the label
6) The test on training courses

The main outputs of the project are a skills matrix related to BIM and energy efficiency, harmonized to EQF standard, and a training platform which integrates BIM and Energy training offer. The platform's main purpose is to allow training institutions access to information about the market needs in order to improve the training offer. The feedback from the users about the usage of the platform was quite positive.

2.4.2. Background analysis used for concept development

The consortium developed and deployed a specific methodology to identify roles, skills and training needs in the field of BIM for energy efficiency. They used a repository of Twitter records to capture emerging skills and roles and developed a training portal that aggregates content from different BIM- related data sources. By using this tool, users can keep track of new trends and integrate them into future training content.

The project consortium carried out vast research (through literature review, case studies gathering and interviews) for defining requirements for BIM and energy efficiency as well as identification of gaps in the availability of training. This approach enabled establishment of initial finding and conclusions, used further for development of a unique learning framework.

The project team also carried out a benchmarking of existing EU-wide BIM trainings across the building value chain, which included energy efficiency linkages.

In the further steps, the project delivered a comprehensive scheme of skills associated with BIM and EE roles and responsibilities, as well as an extensive listing of training-related learning outcomes, selected from the analysed relevant BIM & energy regulations and guidelines.

The consortium aimed toward development of an EU- recognizable skills scheme and therefore considered adaptation to align with national schemes in the partner countries.

One of the project findings was recognition of the perspectives of the e – learning and advantages thereof when applied to leverage fields of energy efficiency and sustainability. In line with the attitude towards leveraging capacity of digital technologies in construction, the project recognizes the emergence of new roles and required skills, as well as fast – changing dynamic nature of the skills required by the future construction industry,. The developed skills framework, as well as methods and tools of delivery, relied on these findings.

To develop the concept of BIM-based energy efficiency training, in EU-wide standardized qualification framework for achieving the consortium carried out several types of analyses:

- Analysis of previous and current national and European initiatives and projects with a focus on collecting evidence-based measurable scenarios and use cases that demonstrate the importance BIM in achieving energy efficiency in buildings across the whole value chain;
- Benchmark analysis of BIM trainings across the building value chain in Europe, emphasising energy efficiency linkages, as well as qualification targets, delivery channels, skills, accreditation mechanisms;
- Workshops with BIMEET expert panel, including key BIM-based energy efficiency actors and professionals across Europe;
- Field research – interviews with 15 key industry representatives;
- Harvesting Twitter with algorithms.

The BIMEET project applied qualitative and mixed-method research, to define the roles and required skills in the area of BIM & energy efficiency, based on use-cases, interviews, scientific publications and social media analysis and scalable heuristic social media analysis. For the analysis, the NVIVO qualitative data analysis

computer software was applied, due to its ability to enable word frequency determination with an associated percentage. Figure 1 below presents the BIMEET requirements methodology.

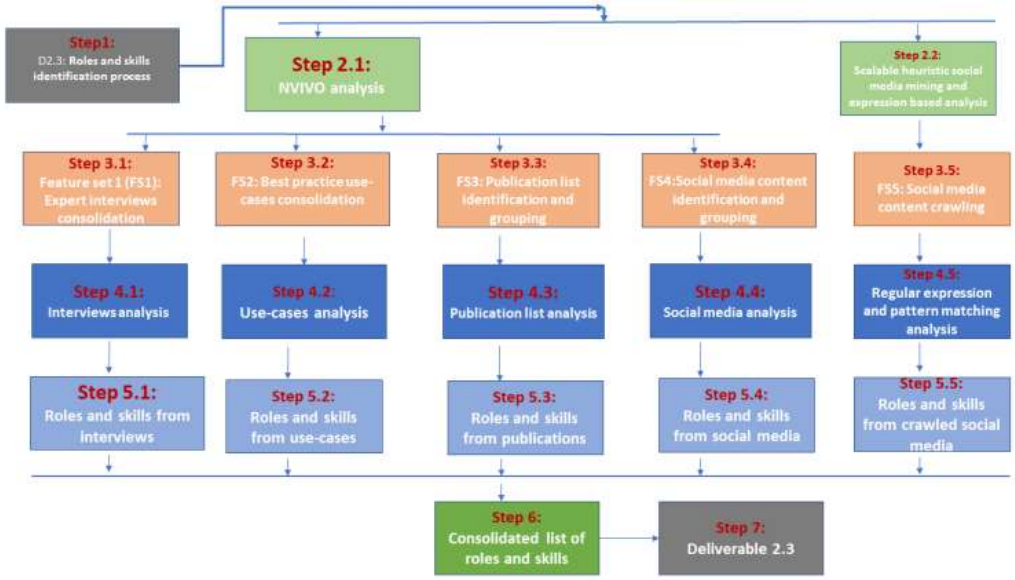


Figure 9: BIMEET requirements methodology

(Source:http://www.bimeet.eu/files/D2_3%20BIMEET%20Required%20roles%20and%20skills.pdf)

As part of the research 38 best practice use-cases from the field of BIM for energy efficiency were analysed through the project platform. The aim of this method was to identify roles and skills by aggregating content from the use-cases, by conducting word count and frequency analysis, word cloud analysis and word tree analysis.

Interviews

Interviews were conducted with 15 BIM industry experts from Europe, which have determined skills and roles in the field of BIM and energy efficiency. The interviews were uploaded to the qualitative data analysis computer software NVIVO where successive evaluations have been applied, which included word frequency, word count, word cloud methods etc.

Scientific literature

A multidisciplinary analysis of the training, education, energy systems, management, international standards, legislation, and key economic and political events related to BIM, was conducted. These analyses led to identification of 80 key publications relevant for the BIMEET roles and skills, using a scientific literature repository. Afterward word cloud analysis using NVIVO was applied.

Social media analysis

For the social media analysis tweets from key actors in the field of BIM for energy and training, have been analysed. The key actors were defined based on forensics algorithms for IP detection and organisation identification, @BIMEET twitter followers and partners of popular BIM training institutions Key inputs which were applied in the analysis were: hashtag, username, and keyword and 50.000 tweets were utilised. Methods such as word frequency, word count, word cloud methods etc. were applied. The novelty of this approach led to the identification of new skills and for BIM for energy.

Scalable Heuristic Social Media Analysis

The Scalable Heuristic Social Media Analysis used forensics algorithms to determine which BIM and energy companies, organization and users are visiting the www.energy-bim.com platform. This led to the creation of a social media database of nearly 40 million tweets which were subject of a text analysis and expression mining.

Results from background analysis

- Skills matrix proposing 6 - 8 specified groups of learning outcomes, which clarify and supplement the required qualifications for each of the selected main category role.
- Map identified skills, qualifications, and accreditation into a BIM for energy efficiency;
- Modified BIM4VET platform in order to build a to robust computer-based online and open-access environment for BIMEET;
- Set a Framework and business model to ensure sustainability of the BIMEET training agenda.
- Development of S-K-C (skills – knowledge – competence) and Learning outcomes

2.4.3. Skills and qualifications framework developed by the project

One of the most important achievements of the project is a matrix of learning outcomes for BIM and energy efficiency, segmented into several disciplines and competency levels

The BIMEET skills and qualification framework is based on: 1) the identification of roles and responsibilities in the construction processes and 2) the formulation of learning outcomes (LOs).

The formulation of LOs was based on a systematic and unique review of BIM guidelines and regulations and their application for improvement of sustainability of construction methods, techniques and assets.

For definition of a construction project stages, RIBA Plan of work was used. 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 of buildings and the factors that have direct and indirect impacts.

The project created EU wide learning frameworks for 6 roles related to BIM and energy efficiency in the frame of EQF and applying Blooms taxonomy as a tool when developing the learning outcomes.

The method for the development of harmonized EU-wide learning outcomes is shown in Figure 2. In the first step the BIM Energy Efficiency Roles/Responsibilities (R, R2) were identified. Skills (S), Knowledge (K), Competences (C) and Learning Outcomes (LO) were defined for each role in design and building and maintenance process. Afterwards, all outcomes produced within the BIMEET project, as well as other EU-projects were taken in consideration. Results (R2, SKC and R (Roles) were collected and stored in Super Matrix. The EU-wide Learning Outcome Matrix was created with the involvement of all the outputs from the Super Matrix, and validated within the consortium expertise and the help of the expert panel.

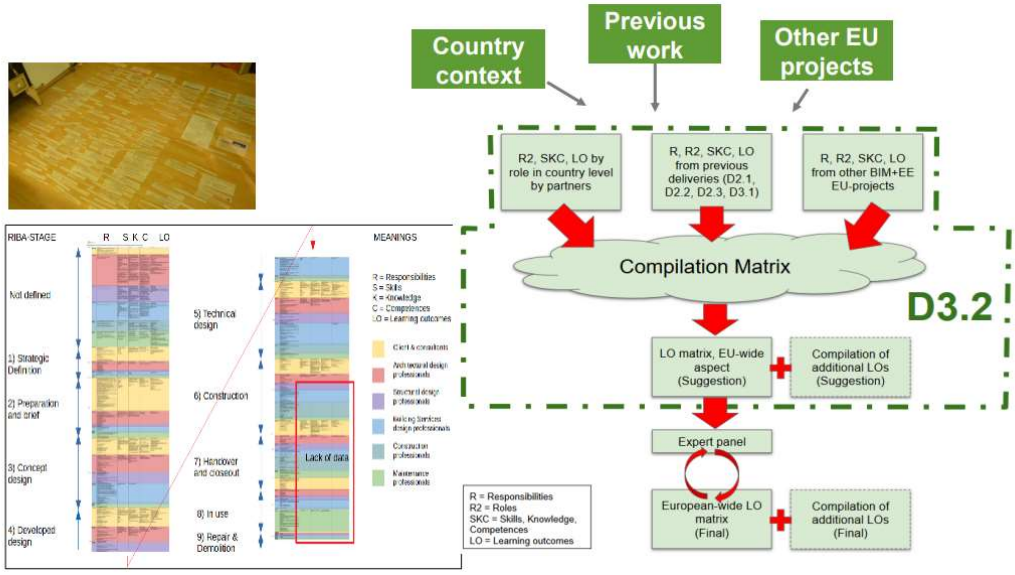


Figure 10: Structure of the learning outcomes by BIMEET
(Source:http://www.bimeet.eu/files/D3_2%20BIMEET%20Definition%20of%20LOs%20in%20the%20EU%20level.pdf)

In order to set the European learning outcomes in BIM and energy-efficient building, six main categories were identified [5]:

- **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

The background analysis and research resulted in 6 - 8 specified groups of learning outcomes for the each of the six main categories [8], [9]. Furthermore, each of the groups consists of 4 - 14 learning outcomes that explain and complement the required qualifications.

[5] http://www.bimeet.eu/files/D3_2%20BIMEET%20Definition%20of%20LOs%20in%20the%20EU%20level.pdf

Table 8: Groups of learning outcomes for each main category, by BIMEET

Client & Clients advisors	**Building services design roles**
LO1 - Fundamentals of BIM and principles of its uses with respect to building life-cycle	LO1 - Fundamentals of BIM and principles of its uses with respect to building life-cycle
LO2 - Fundamentals of sustainable and energy-efficient buildings and building performance	LO2 - Fundamentals of sustainable and energy-efficient buildings and building performance
LO3 - Preparation of information management documentation and setting strategic targets for the project	LO3 - Leading of design process, supporting the client and other stakeholders in decision making
LO4 - Early-stage target setting for energy, sustainability and building performance	LO4 - Implementation of energy performance, building performance and sustainability targets into design process.
LO5 - BIM-based collaboration methods in project management and processes	LO5 - Production of BIM models with accurate and required information content for the different uses and phases of a building project.
LO6 - Quality management procedures for achieving set targets	LO6 - Collaboration, communication and visualization with help of BIM
LO7 - Skills for relevant software and interfaces between software.	LO7 - Implementation of target and quality management procedures in the building project.
	LO8 - Skills for relevant software and interfaces between software.
Architectural design roles	**Construction work roles**
LO1 - Fundamentals of BIM and principles of its uses with respect to building life-cycle	LO1 - Fundamentals of BIM and principles of its uses with respect to building life-cycle

LO2 - Fundamentals of sustainable and energy-efficient buildings and building performance	LO2 - Fundamentals of sustainable and energy-efficient buildings and building performance
LO3 - Leading of design process, supporting the client and other stakeholders in decision making	LO3 - BIM-based construction processes, supporting client and other stakeholders in decision making
LO4 - Implementation of energy performance, building performance and sustainability targets into design process.	LO4 - Implementation of energy performance, building performance and sustainability targets into construction process
LO5 - Production of BIM models with accurate and required information content for the different uses and phases of a building project.	LO5 - Utilizing models and information content for accurate execution of building
LO6 - Collaboration, communication and visualization with help of BIM	LO6 - Collaboration, communication and visualization with help of BIM.
LO7 - Implementation of target and quality management procedures in the building project.	LO7 - BIM in quality management, commissioning and handover procedures
LO8 - Skills for relevant software and interfaces between software.	LO8 - Skills for relevant software and interfaces between software.
Structural design roles	**Maintenance work roles**
LO1 - Fundamentals of BIM and principles of its uses with respect to building life-cycle	LO1 - Fundamentals of BIM and principles of its uses with respect to building life-cycle
LO2 - Fundamentals of sustainable and energy-efficient buildings and building performance	LO2 - Fundamentals of sustainable and energy-efficient buildings and building performance

LO3 - Leading of design process, supporting the client and other stakeholders in decision making	LO3 - Supporting the client and other stakeholders in decision making to achieve energy and building performance targets in operation and maintenance
LO4 - Implementation of energy performance, building performance and sustainability targets into design process.	LO4 - BIM for facilities and utilities management, operation and maintenance
LO5 - Production of BIM models with accurate and required information content for the different uses and phases of a building project.	LO5 - Implementing energy performance, building performance and sustainability targets into operation and maintenance
LO6 - Collaboration, communication and visualization with help of BIM	LO6 - Skills for relevant software and interfaces between software.
LO7 - Implementation of target and quality management procedures in the building project.	
LO8 - Skills for relevant software and interfaces between software.	

Source:http://www.bimeet.eu/files/D3_2%20BIMEET%20Definition%20of%20LOs%20in%20the%20EU%20level.pdf

An example of sub – modules for a major group of LOs (the target group of Clients and Client Advisors was selected for this example), is presented in the table below. Notably, skills maturity level for different roles, varies.

Table 9: Learning outcomes framework for Client and Client advisors, by BIMEET Framework

No	bimeet Learning outcome	EQF Level			
Client & Client advisors Client & Project manager (C), BIM manager (BM), BIM coordinator (BC), briefing consultant (Bc)		C C	BM BM	BC BC	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

2.4.4. Project main outputs

The project main outputs are 1) a skills matrix related to BIM and energy efficiency, harmonized in compliance with EQF standard, and 2) a training platform contributing to disseminate the results.

The project outputs and results also include:[6]

- BIM for energy efficiency requirements capture
- Portfolio of 70 use-case studies
- Benchmark analysis of existing training offers
- Energy Efficiency required roles and skills
- Definition of learning outcomes in the European level
- Validation report for BIM for energy efficiency
- Validation and documentation of BIMEET labelling
- BIMEET platform/ Energy BIM Platform
- Validation report for BIMEET platform Testing
- Introduction of BIM enabled EPC assessments – Online course
- 19 piloting training courses with 293 participants;
- eLearning courses: self - studies and webinars with 754 participants

[6] http://www.bimeet.eu/vision.html

2.5. BIMplement

2.5.1. Concept and approach

The main objective of BIMplement project was to improve the quality in the construction and renovation process of nearly Zero Energy Buildings (nZEB) using BIM as a universal information carrier and facilitator of the learning process within projects and between projects.

BIMplement set up large scale training, Continuous Professional Development and flexible qualification methodology integrating technical, cross-craft and BIM related skills and competences. BIMplement trained more than 1,400 professionals (blue-collar and white-collar workers) and the methodology was tested in 49 construction or renovation projects in France, the Netherlands, Spain, Lithuania, and Poland.
It delivered besides a lot of insights gathered in the pilot field labs several results that can be valuable input for the ARISE project.

BIMplement focused on an enhanced systematic approach for the quality control of the entire process of construction of NZEB, to reduce the gap between designed and actual performances of buildings.

BIMplement developed a range of tools that fit the objective of developing a fully qualified and equipped workforce, capable to implement, execute and perform all the necessary labour actions.

Main aim was to achieve an improved quality for NZEB construction and renovation by setting up a large scale, training, CPD and qualification schemes, addressing the entire process phases in a cross-crafts and cross level multidisciplinary approach, strengthened with hands-on and BIM-enhanced workplace learning tools by following objectives:
BIMplement has developed a transferable method based on the experience of previous BUS and H2020 Construction Skills projects and on experimentations in territories with craftsmen and small enterprises.

The project focused specifically on ventilation and airtightness.

BIMplement's most critical endeavour was to raise awareness and convince stakeholders of the importance not only of using BIM, but also of conducting on-site training for manual workers.

The main objective was to improve the quality in the construction and renovation process of nearly Zero Energy Buildings (nZEB) using BIM as a universal information carrier and facilitator of the learning process within projects and between projects.

The overall methodology of BIMplement was based on the direct implementation of the results of the related BUS and Construction Skills projects in combination with a direct implementation of the methodologies combining quality assurance with large scale qualification schemes. This was brought into practice on local and regional scale, by demonstrating, testing and validating the methodology and effectiveness of qualification schemes in real projects.

2.5.2. Background analyses

Development phase

BIMplement started with the development of a BIM-enhanced Qualification Framework/methodology, executed on two dimensions:

- From the BUS and Construction Skills projects (such as BUS-NL, FR, LT and ES and H2020 PROF/TRAC) the approach for an EU Qualification Framework for performing nZEB professional activities will be adapted for:
  - Workers: filling the framework.
  - Professionals: validation of the PROF/TRAC Qualification Framework and if needed extending or adapting this.
- Adding the cross-trade aspects OR interdisciplinary Skills
- Adding the BIM-process when performing nZEB professional activities. This includes the mapping of which extra skills and competences are needed to optimise the results in nZEB-

construction and renovation projects, linked to the professional activities and the workers and professionals involved.

An overall matrix was developed in which the five phases in the construction process were discretized (programme, design, elaboration, realisation, operation & maintenance), and the professions and specialism involved including the levels. This matrix was filled in with the skills and competences needed for each profession/specialism and the related training schemes to acquire the necessary competences. The EQF methodology and guidelines for National Qualification Frameworks were taken into account.

Implementation phase

The methodology and related qualification schemes were implemented on a generic level for the subjects Ventilation and Air tightness. This matrix was further elaborated for:

- the professions / specialisms and EQF levels involved in each phase;
- the required skills, competences and descriptors for the addressed technologies and technology components;
- that are needed to enhance and ensure the quality of ventilation systems and air tightness. Next, this matrix will be linked to the available trainings.
- BIM will be used as a universal carrier for all the information that is needed for the quality enhancement and related trainings. Moreover, in a next step, the matrix can be linked with 'real' projects, documented in BIM.

Pilots, demonstration and validation phase

The pilots were used for verification of the matrix and the qualification schemes and to give feedback to the previous steps. The pilots were also used to test the value of BIM-enhanced tools to empower the different kinds of learning loops.

Exploitation and replication phase

- As the action is limited to training and qualification of professions involved in ventilation technologies and air tightness it is important to initiate and organize further exploitation and replication of the project to increase the number of skilled building professionals and craftsmen across the building value chain. The exploitation plan facilitates:
- the upscaling of the methodology to other /new topics
- sustaining the used content within existing tools
- upscaling the action to other countries by a free and open methodology, implementation services and a shared open development platform.

2.5.3. Skills and qualifications framework developed by the project

The BIMplement Qualification Framework consists of a flexible methodology that allows definition of professional activities, related skills, required competences in order to achieve a desired quality in the field of nZEB. It is set up as a set of re-usable classifications. These classifications can be used in BIM-projects to describe items in a standardized, unified way and to link them to existing classifications that describe involved technologies, project-stages and involved actors.

The BIMplement qualification framework is set up as a multi-layered qualification matrix. It is composed of tasks that have to be performed to be effective. It consists of a layer with basic tasks and one or more layers of context specific layers. For example, nZEB related tasks, BIM-related tasks. If needed more layers can be added, for example for Indoor air quality (IAQ) tasks or Circular Building tasks.

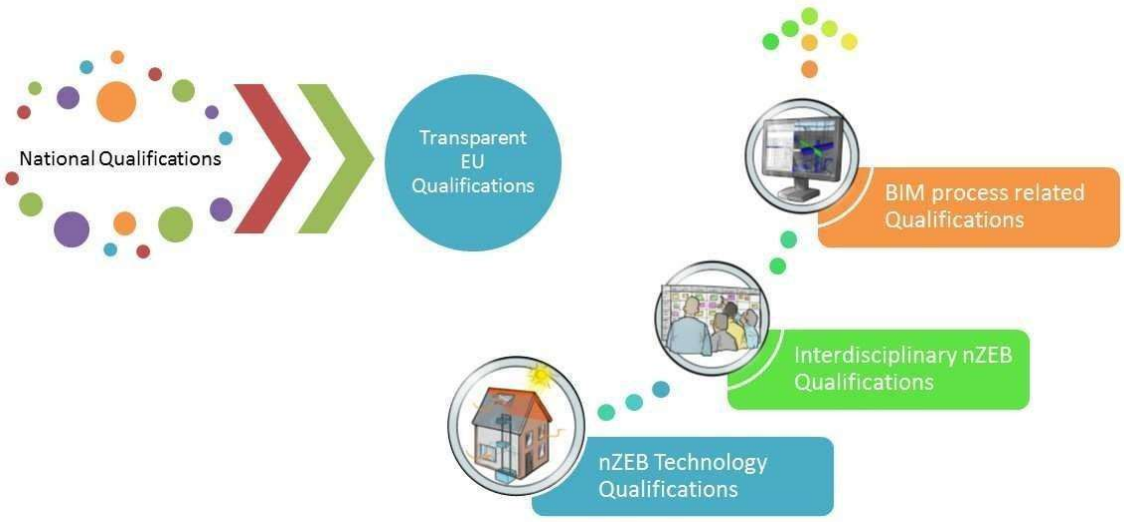
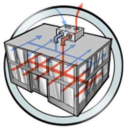


Figure 11: BIMplement concept of qualification framework

The qualification framework outline is based on PROF/TRAC outcomes and served as a quick start for further BIMplement work.

Table 10: Generic qualification framework outline based on PROF/TRAC

nZEB Specialisms				**Professions/occupations involved**								
 Heat pumps	Short description of the specialism			Architect	E-Engineer	M-Engineer	B-Engineer	Process manager	Bricklayer	Carpenter	E-installer	M-installer
Type of	**Process-Phase**	**Tasks related**	**Classification**									
Water-water	Programme	Task 1	nZEB	x				x				
		Task 2	Interdisciplinary	x	x	x	x					
		Task 3	BIM									
		Task n										
	Design											
	Elaboration											
	Realisation											

The generic outline has evolved in three iterations.

Iteration I

Worked out a small number of professional activities within the PROF/TRAC Qualification Excel-format, related to the specialism *Ventilation of residential buildings*. The results were extended by exploring the possibility to store the Qualification as a set of Classifications in BIMaxon.

BIMaxon is a tool for creating and linking Classifications to BIM-models. Working with this tool makes it possible to work with existing BIM classifications such as ISO/IEC 81346

The list of involved professions includes both several blue- and white-collar professions

Iteration II

In the second iteration classifications in BIMAXON were applied and some additional BIMplement classifications have been proposed. This was done to find out if we can work out the BIMplement Qualifications as a set of re-usable classifications. With as result a multi- layered qualification. The result is used to reformat and extend the results of the first iteration.

Iteration III

The third iteration was split into two parts. First a proposal for 'professions and occupations names and codes in BIMplement' was written and the results of the second iteration were worked out in more detail. Finally, all the results were aggregated into one final outcome of the exercises done while developing the methodology.

The developed BIMplement Qualification Framework consists of several existing taxonomies that are linked to tasks that needed to be performed to deliver nZEB Quality empowered with the use of BIM. Delivering nZEB is the objective and BIM is a tool/instrument to reach that goal.

From existing taxonomies, the following were used:

1. extended and interpreted ISCO-08 for describing involved persons.
2. the RIBA-stages [https://www.ribaplanofwork.com/] – presented below

Figure 12: RIBA S1 -S7 stages (White collars) S5 – S7 stages (Blue collars)

3. ISO/IEC 81346 for connecting to Functional & Technical systems such as the Ventilation system

The following taxonomies were added

1. BIMplement (Task classes) for subtasks

   BAS Basic task(we do not detail these tasks, they are only mentioned)
   nZT nZEB Task(all tasks concerning application of nZEB technologies)
   BIT BIM task(all tasks to BIM empower the work to be done (more efficient))

   Aspects of quality control are integrated into the task descriptions

2. BIMplement (What To Classes) for didactical task Descriptions
   K1 - a list of what to know

   K2 - a list of what to understand

   K3 - A list of what to be able to do

The results from the performed iterations are integrated into a set of tasks that have to be performed when applying a ventilation system in an nZEB building (while using BIM to deliver more quality in an efficient way).

BIMplement (Task classes) for subtasks

BAS	Basic task (we do not detail these tasks; they are only mentioned)
BIT	BIM task (all tasks to BIM empower the work to be done (more efficient))
Nzt	nZEB Task (all tasks concerning application of nZEB technologies)

Aspects of quality control are integrated into the task descriptions

An extract from the integrated BIMplement QF is give below:
S0 STAGE 0: Strategic Definition (BIMAXON-STAGE)

1. Perform site analysis

a. site meteorological data
b. local risks (air, soil)
i. pollution (air, soil)
ii. radon

2. Find out client's need and requests

a. in terms of NZEB (Quality)
b. in terms of BIM files

3. Determine if decentral balanced ventilation fits into the project definition
   Choice of the type of ventilation to be implemented in order to obtain nZEB building

S1 STAGE 1: Preparation and Brief (BIMAXON-STAGE)

1. Determine ventilation requirements
2. Determine noise requirements for the room in question
3. Determine possible combination with space heating

4. Determine list of stakeholders (clients, architect, design office, control office, constructors
5. Determine list of BIM stakeholders
6. Check available technical data and documentation

a. technical data

b. BIM data, if products & classifications

For evaluation of maturity level, the project adopted previously developed Prof Trac matrix,

Skills needed to perform a high-quality job in a nZEB project using BIM have been added to the qualifications for working on airtightness and ventilation. The EQF methodology, CEDEFOP guidelines, and Bloom's taxonomy have all proven to be quite valuable, particularly when it comes to developing Units of Learning Outcomes.

Project phase	Tasks	Sub-tasks	ULO Nr.
execution fase	**Making holes in wall(s) and/or floor(s)**		
		check/mark position and dimensions of the recess in the wall	12.1
		make the recess or correct the sizes if necessary	12.2
	Install air ducts		
		construct the duct system (supply and discharge)	13.1
		fix ducts in floors against flooding	13.2

ULOs for the NZEB Ventilation

Nr.	Fields of knowledge /Course	Knowledge	Skills	Competentence	Actor
12.2	ho wa	knowledge of making holes in walls/floors	drilling techniques	necessary	Constructor
13.1	installing ducts	knowledge of airtight of connecting ducts	know how to make airtight connections and the difference between the types of ducts	constructing a duct system	Installer
13.2		knowledge of fixing ducts against flooding	know how to fix ducts against flooding	fix ducts in floors against flooding	Constructor
13.3		knowledge of measures during pouring concrete of floorslab	know how to pour the concrete	produce the adjoining screed / finishing passages in walls	Constructor
13.4		knowledge installing supply valves and preset them	influence of valve on airflows in rooms and influence of air speed on comfort	set up and mount supply valves	Installer
13.5		knowledge of making airtight connections in ducts	necassaty of airtight connections	make airtight connections	Installer
13.6		knowledge installing exhaust valves and preset them	influence of valve on airflows in rooms and influence of air speed on comfort	set up and mount valve	Installer
14.1	Mount centrally ventilation unit	knowledge of vibration-free assembly of units	describe the mounting of the ventilation unit	mounting the ventilation unit	Installer
14.2		knowledge of airtight of connecting ducts	know how to make airtight connections and the difference between the types of ducts	connecting the ventilation unit to the duct system	Installer
14.3		knowledge of waste water systems	know how to connect the unit to the waste water system	system	Installer / adjust expert
14.4		knowledge of airtight connecting ducts	know how to make airtight connections and the difference between the types of ducts	assembling silencers between unit and duct system	Installer
14.5		vapor-tight insulation	insulating air ducts and know when and how to do so vapor-tight	isolating channels from the outside to the unit in systems with heat recovery	Installer / isolator
14.6		knowledge of building decree regarding electricity	making a safe and reliable power supply and/or data communication	construct facilities such as electricity and data cables	installer / electrician

Figure 13: BIMpmement's Units of learning outcomes Source: https://www.bimplement-project.eu/wp-content/uploads/2021/02/D2.1-Methodology-for-a-BIM-enhanced-Qualification-Framework-V1.1.pdf

2.5.4. Project main outputs

BIMplement KIT - a pedagogical kit intended for companies in which one or more persons will have been trained through the BIMplement process.

Elaborated quality control and qualification matrix for ventilation and air tightness elaborated in detail for trades and professions involved in ventilation technologies and air tight building.

Tools, training content and qualification schemes for BIM work place trainers

Filled Qualification Framework includes a complete overview of the professional activities and related skills and competences for all professions involved in realizing ventilation systems and air tight building for nZEB projects, throughout all project phases.

Methodology for a BIM-enhanced Qualification Framework concerns an EU Qualification framework that combines nZEB technology related qualifications, interdisciplinary and cross-trade qualifications and BIM process related qualifications.

The BIMplement maturity scan

The BIMplement "maturity scan" is a tool that provides a general overview of the level of skills of all stakeholders involved in a project, in terms of BIM, but also nZEB, airtightness and ventilation. This tool will be used by the training centres and site trainers:

- to assess the initial level of skills of all stakeholders,
- to identify the group(s) of stakeholders that needs to be upskilled,
- and possibly, to display the final level of skills acquired after the training sessions.

The BIMplement training toolkit 12 one-hour training modules

The proposed principle is to design 12-one-hour training sessions, that can be given to site operators by an employee of the company previously trained on the BIM process and the use of viewers, both on the BIM process and use of viewers, and on the use of the Kit BIMplement pedagogical method.

The ultimate goal is to enable participants in this 12-session cycle to acquire the necessary knowledge for the company to participate in a BIM process:

- understand the impact of a "BIM process" on the worksite and the role of site staff
- learn how to handle freeware viewers and to view the project BIM model
- learn how to find useful information
- learn to communicate via notes and documents attached to the model
- understand the use of a 4D schedule

The 12 modules are the following *(a detailed version is available in the BIMplement D4.5)*

1. Present the project and show its progress with the BIM model
2. Learn how to use a viewer and its basic tools
3. Use a Viewer to find simple information
4. Use the Viewer to Find More Complex Information
5. Self-test of acquired knowledge and skills
6. Communicate with the Viewer tools
7. Locate, read and attach documents to the BIM model
8. Use attached documents to improve on-site implementation
9. Adapt the models to the needs of the site and the operators
10. Use model quantification tools
11. Understand the use of a 4D schedule
12. Training evaluation and feedback

Implementation of the BIMplement Kit

The proposal, in this basic model is intended, for one company wishing to up-skill his own employees. However, it would be very advantageous to carry it out with several companies, especially those very involved in successful airtightness solutions. The idea is then to deal with this training at the global level of a construction project.
Many variants are conceivable, for example:

- Modules 7, 8, 9, 11, 12 are carried out with employees from different companies, allowing a real interoperability between different trades.
- a general contractor providing all the modules for the various team leaders of the subcontractors
- The company's in-house trainer will be able to choose the most appropriate schedule to organize his in-house training, and preferably on the construction site, in order:
  - not to disrupt the progress of the construction site
  - to use the worksite BIM model, which will allow participants to better take ownership of the project and its digital version.

The BIM-PRAXIBAT mobile centre

The PRAXIBAT mobile centre is a mobile container in which it is possible to operate training session directly on the construction site. Two issues are handled with this device: airtightness (because this issue is still not concrete and clear to most workers) and ventilation.
The container is installed on the construction site, usually upon request from the client who makes it compulsory for companies to have their on-site workers to be trained on best practices for airtightness and ventilation implementation.

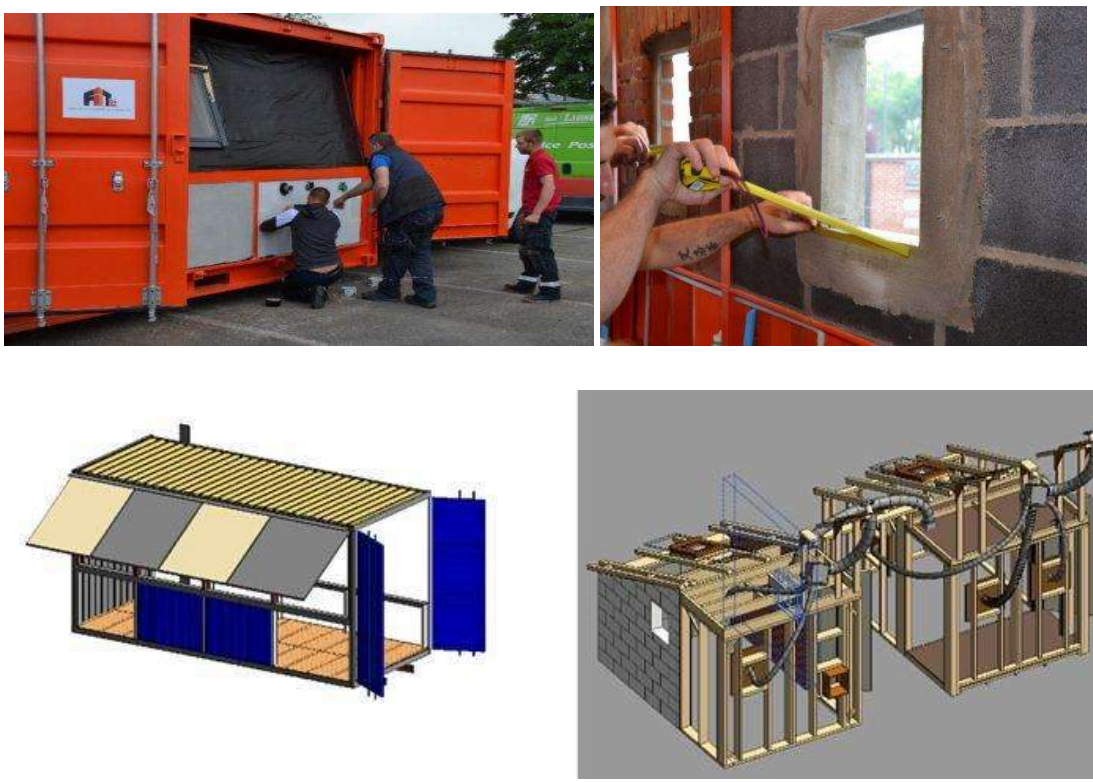


Figure 14: BIMPLEMENT BIM-PRAXIBAT mobile centre

Training sessions

On clients' requests, this container has been installed on 12 construction sites, mainly social housing rehabilitation and public buildings. Altogether, more than 220 blue collar workers, from 65 SME companies took this 1.5 training session centred on the improvement of on-site airtightness practices.

Main results

All clients reported an important improvement of final blower door airtightness tests for the project where training sessions have been implemented. The reported results are improved by 2 or 3 compared to projects with no training.

Training contents

The training contents for the" original" mobile container aim at improving blue-collar workers practices in terms of airtightness implementation. The training sessions are the following:

Table 11: BIMplement training modules – Session 1

Module	Contents of the FIT training session	Duration / Participants
Module 1	Topic : Basic energy efficiency awareness - Understand the importance of airtightness - Explain the thermal regulations and labels	Duration : 4 hours → **room on construction site** Participants : site operators, foremen, site manager
Module 2	Topic : site manager coaching about airtightness - Implement a technical monitoring of the construction of an airtight envelop - Communicate about an nZEB project - Design and improve "airtightness architectural details".	Duration : 7 hours → **room on construction site** Participants : foremen, site manager
Module 3	Topic : practical training for operators - Acquiring good practices on airtightness - Learn the different options technical - Understanding the strong and weak points of the constructive systems	Duration : 7 hours → **container** Participants : site operators, foremen,
Module 4	Topic : assess the work quality - Analyze the airtightness test report - Evaluate the airtightness test results - Learn the appropriate technical solutions to achieve the desired objective	Duration : 4 hours → **room on construction site** Participants : site operators, foremen, site manager

The second version of the mobile centre has been designed from the original container. The aim of this new device is to train on the use of BIM on the work site, for site workers, and includes a focus on airtightness issues.

To that end, the BIM model of the container has been enriched with all useful documents (as explained in D4.5 and pilot-airtightness) to explain solutions and implementation methods.

Such a "BIMed" container can be used to train on the "use of BIM models on construction sites" when the project BIM model is not accessible or if there is no BIM model. The training programme is:

Table 12: BIMplement training modules – Session 2

Module	Contents of the FIT-&-BIMplement training sessions	Duration Participants
Module 1	Topic : presentation of the BIM process concept - BIM process mapping - Understand the importance of a BIM model - Visualize the performance link between a site model and energy issues	Duration : 4 hours → **room on construction site** Participants : site operators, foremen, site manager
Module 2	Topic : basics about nZEB and airtightness performance - Implement a technical monitoring of the construction of an airtight envelop - Communicate about an nZEB project - Design and improve "airtight architectural details".	Duration : 7 hours → **room on construction site** Participants : foremen, site manager
Module 3	Topic : airtightness complementary approaches (BIM & practice) - Acquire and validate good practices - Learn how to use on site a BIM model with a tablet / smartphone for one's batch and how to archive evidence of good implementation	Duration : 7 hours → **container** Participants : site operators, foremen,
Module 4	Topic : assess the work quality - Learn how to use a collaborative platform - Assess the appropriation of business models and of associated evidence of good implementation - Assess the improvement of air tightness and ventilation level - Learn the appropriate technical solutions to achieve the desired objective	Duration : 4 hours → **room on construction site** Participants : site operators, foremen, site manager

2.6. NEWCOM

2.6.1. Concept and approach

The project NEWCOM developed and applied an innovative skills sand qualifications scheme in parallel with promoting their visibility and comparability in a special database. This approach allowed the project to create specific training components for each country and collaborate with local stakeholders in both processes.

The need for the EU-wide project NEWCOM emerged from the BUILD UP Skills Initiative, and it aimed to provide solutions to improve and maintain energy efficiency in the building sector. [7]

The project focus was on the quality of work in the construction phase, considering that the buildings being built or renovated now, are the building stock of the future. The project identified that omissions in the construction phase could be responsible for performance failure of the buildings, with the main reasons being lack of adequate level of skills of workers engaged in construction activities and quality control. The project team also identified a limited availability of further education in the construction sector in many countries in Europe, especially with the focus on mutual recognition. cross craft understanding, lifelong service approaches, continuous controlling and monitoring or BIM-tools which are very important for the construction and maintenance of nZEBs. NEWCOM focused on the development of missing qualification and certification schemes for blue collar workers and building professionals who inspect and control building envelope properties affecting their energy performance, with a specific focus on mutual recognition of roles and skills.

In order to support the quality of sustainable buildings, the project NEWCOM developed several nZEB related training schemes. To ensure maximum flexibility, the trainings were designed in modules so that they can be used both as stand-alone units and as a complement to already established courses.

[7] https://www.newcomtraining.com/fileadmin/2_newcomtraining/downloads/promotions_material/newcom_folder_en_july_2020.pdf

Based on the priority needs of the project partners, NEWCOM's training modules focused on three topics.

1) Flat Roofs and Roof Waterproofing, taking a lifelong service approach, including planning and installation of green roofs and energy efficiency measures.

2) Ventilation Installations, including heat recovery, noise protection, controlled airflow and smart demand systems.

3) Quality Assurance in the planning, construction and operation phase of NZEBs, including aspects on indoor air quality, quality of the thermal building envelope and the energy system, including cost-efficiency measures.

In addition, a competence database was created to help standardise mutual recognition of skills across Europe.

The competence database was based on a methodology developed in cooperation with the Horizon 2020 BIMplement project. After completing a training module, professionals can be tested in accordance with Units of Learning Outcomes which certify the individual's skills. The competence database is linked to the BUILD UP Skills app which is then able to display a professional competency card, viewable by clients or companies.

Although the project developed qualification schemes for sustainable energy skills only (digital skills were included in a separate module), its methodological approach of qualifications based on harmonized ULOs and competence database was found of high relevance for development of the ARISE concept. The NEWCOM competence database can be expanded to nearly every field of work and could be used throughout Europe.

2.6.2. Background analyses

The first step of the project was to detect and assess current training methods and certifications for construction experts in the country's participants, including their implementation. The educational materials that were already available for existing trainings, have also been collected.

The methodology was in the form of desk research, interviews and workshops with construction specialists and stakeholders in all participating countries.

As part of the second step, the project participants created mutually acknowledged educational programs for building professionals, using the findings from the first step and previous BUILD UP Skills projects of participating countries. The related stakeholders from the education and government sectors, and the contractors, have been included in the curriculum development, in order to guarantee the creation of effective trainings and methods for mutual recognition. Additionally, trainings for trainers were applied in order to assess the new training courses.
In the third step, the new training courses have been incorporated in a specifically developed database of general and harmonized descriptors, in order to support a further prospect of mutual recognition. As a mean of registering of the personal recognition of building professionals, the project participants used the existing BUILD UP Skills app. Consequently, the NEWCOM project created a European database for mutual competence recognition of building professionals, which links the description of the competences acquired by attending a relevant course with an expert. The methodology behind the database was based on a previously developed methodology as part of the Horizon 2020 BIMplement project.

Research findings from background analysis:

Similarly, as other projects (e.g., BIMzeED), NEWCOM concluded that further education about energy efficiency is surprisingly scarce in many European countries, and existing courses often don't cover topics like cross-craft understanding, life cycle service or continuous energy control and monitoring.

The only successful model of certification in all of the four partner countries was the mandatory certifications for safety-relevant work, with the accent on the certifications provided by recognized educational institutions, such as construction academies. The construction academies certified training courses are well established on the market and are recognised by the building companies. Additional certification by an external certification body didn't add

any market and real value, because the certification organizations or the persons commissioned by them with the certification sometimes lack the necessary building competences. The final conclusion for the further development of the project was that the entirely new development of qualifications in the form of personal certification had small market potential and that the better option was the development of modules and qualifications as a supplement to already established courses.

After the analytical stage, in which identification and evaluation of existing certification schemes and implementation methods for blue collar workers and building inspectors had been carried out, the consortium made development of missing certification schemes for blue collar workers and for building inspectors. Thereafter, the project team implemented activities for further development and harmonisation of qualification descriptors and units of learning outcomes of new training for mutual recognition.

The project partners developed sets of Learning Units descriptors for each targeted profession, in the fields of: flat roofs, ventilation and building inspection.

2.6.3. Skills and qualifications framework developed by the project

Development of the Units of Learning Outcomes (ULO's) and the ULO database started with the following goals[8]:

I. Well written ULOs: improving quality of ULOs; by using a unified methodology & guideline
II. Transparency of ULOs: availability in public domain
III. Unified format: building ULOs using database of agreed descriptors

The qualifications are split in two parts, the tasks and subtasks in relation to the building process and a set of normalized ULO's. Normalised means in this context that each ULO is unique and

[8] Newcom Deliverable 2.2

occurring once. While finalizing the ULO's, the project adapted their definitions used for the ULO elements to the latest EU directions given in the European Qualifications Framework for lifelong learning (2017/C 189/03, on 22 May 2017).

A unit of learning outcomes (also called "unit" or "module") is a component of a qualification consisting of a coherent set of knowledge, skills and competence that can be assessed and validated.

Optimized process of creating ULO's for NEWCOM was established through several iterations;

Step 1: make a list of tasks to be performed & by whom. Describe them as a plain task

Step 2: define the relevant 'sub-tasks to be performed' & by whom

Step 3: give each subtask a taxonomy code Basic task of nZEB task

(The basic tasks are the standard tasks, even if a worker is not involved in building nZEB. The nZEB tasks are specific nZEB Quality related tasks)

Step 4: Provide didactical details for the nZEB tasks and subtasks

Dimension 3c	Dimension 3d	Dimension 3e
Knowledge involved	Skills involved	Competence involved (Responsibility and autonomy)

Step 5: Connect the tasks and subtask to involved occupations by doing this, cross-craft interactions become clear

Optional **Step 6:** Connect the tasks and subtasks to specific technical components This link can be used later on to connect the ULO's to BIM-models.

The full list of harmonized descriptors for defining required skills,

knowledge and competences contains over 210 ULO descriptions (an extract is given in the table below)

Harmonized competence descriptions - Clear description of training content on basis of ULOs:

- To enable the international comparability of trainings the content of training modules has to be created on the basis of units of learning outcomes.
- The database offers a flexible methodology that allows the definition of professional activities, related skills, and required competences in the field of the construction of nZEBs.
- It is composed out of tasks and related subtasks that have to be performed on a certain time in a process and by (a) certain person(s) with a certain skillset.

On the base of this methodology the NEWCOM project developed specific ULOs for the description of competences going together with the new developed training schemes.

Table 13: Extract – example of Harmonized descriptors for defining required skills, knowledge and competences, by NEWCOM

ULO NR.	COMPETENCE	SKILLS	KNOWLEDGE
1	Add a proper maintenance schedule to the manual	Able to compose a manual	Acceptable noise levels
2	Add adjustment state to the manual	Able to differentiate between the suitability of different condensate drains	Acoustic/noise protection requirements and applicable solutions
3	Adjust supply fan properly	Able to handle dangerous substances	Advantages and disadvantages of different locations for the control unit
4	Adjust the exhaust fan properly	Able to install all specified ancillary components such as sound attenuators in accordance with the manufacturer's specifications	Advantages and disadvantages of exhaust or recirculation hoods in combination with ventilation
5	Answer questions on the influence of ventilation systems on the energy efficiency of the building	Able to insulate air ducts vapour-tight when needed	Advantages and opportunities of BIM
6	Apply energy-efficient roofing measures when	Able to mount the ventilation unit vibration free according to	Air quality parameters (CO2, VOC, PM2.5, odour) and their

	possible and suitable	the manufacturer's instructions	relationships
7	Apply fire safety measures and check valves in the wall(s)/floor	Add adjustment states to the manual	Air- and vapour tight sealing of penetrations in thermal envelope

2.6.4. Project main outputs

- Development of new training schemes with clear competence descriptions on the base of units of learning outcomes (ULOs) for
  - Flat roofing and waterproofing
  - Comfort ventilation
  - Quality assurance (planning/construction/operation)
- Development of the NEWCOM competence database for the Europe-wide comparability of acquired skills
- Educational multilingual platform (www.newcomtraining.eu).
- NEWCOM professional card
- Report on strategies to improve market uptake of cross craft schemes on national and EU-level
- Summary report on national certification strategies for blue collar workers

2.6.4.1. NEWCOM Training modules for NZEBs

The focus of the NEWCOM project was to develop a set of training modules that can be combined into national specific and holistic training schemes. Every module has its own assessment questions and is accessible at different educational institutions if necessary. Based on the task-oriented approach, possible training modules were developed. These modules address both theoretical and practical elements as stated in the unit of learning outcomes.

Following the developed training modules for flat roofing, ventilation installation and quality assurance are described. All of these new training modules have been developed including reference ULOs to

be able to implement them in the NEWCOM competence database in the next step [19], [20].

Flat roofing and waterproofing – acquisition of competences with respect to a “lifelong service approach” such as correct planning and installing of green roofs and renewable energy systems on the roof, avoiding of humidity in the structure of the roof, implementing of energy efficiency measures on the roof as well as further nZEB features.

Comfort ventilation installation – acquisition of competences regarding correct planning and installing of ventilation systems with heat recovery, noise protection and controlled air flow distribution as well as smart demand-controlled systems.

Quality assurance – acquisition of competences in terms of managing of cross-craft interfaces, ensuring of indoor air quality, quality of thermal building envelope and energy system, optimizing of the building as to energy use and ecology, and evaluating of the cost-optimal measures in view of the life cycle of the building

Table 14: Training modules developed by NEWCOM:[9]

Flat roof construction and building waterproofing	Assistance in diagnosing the existing roof
	Layers of nZEB renovation & fixing technology & building physics
	Slope correction and new outlet design and implementation
	Proactive design and installation of joints at height areas
	Health and safety
	Securing the fail-safe implementation of solar systems
	Intelligent failure detection systems for roofs with covered waterproofing
	Cross-craft activities, maintenance and repair
	Extensive green roof
Installation of ventilation systems	Basic principles and checking requirements
	Check of the location in relation with the design
	Assembly and installation
	Starting operation and balancing of the ventilation system
	Maintenance
Quality assurance and quality control	Basic of building physics
	Building materials
	Building components
	Quality inspection of the building envelope
	Illumination
	Heating technology
	Ventilation technologies
	Control systems
	Air conditioning technologies
	Electrical power generation
	Thermal activation of building components
	Energy balances - demand forecasts, energy certificates and certification programmes
	Renovation concept
	General tasks for building inspection
	Monitoring process
	Building Information Modelling (BIM) systems
	Building operation

[9] *The way to needed & transparent nZEB competences for professionals Result-oriented final report (D1.4)*

2.6.4.2. NEWCOM competence database

The NEWCOM competence database provides a basis for mutual recognition of skills of professionals throughout Europe. It links the description of the competences gained by attending a relevant course with the expert. Furthermore, a professional card can be issued on the basis of the acquired skills. The NEWCOM competence database can be expanded to almost any field of work and used throughout Europe.

The core element of the database is the harmonized description of competences of training schemes it contains. This is done through the units of learning outcome database, which is a very relevant part of the NEWCOM competence database. Only by implementing this feature is it possible to compare the content and acquired competences of training schemes.

The NEWCOM developed training modules can be linked with the competence database. Professionals can be tested and recognized on the basis of developed and agreed ULOs (units of learning outcomes) in correlation with these new training schemes. After a successful verification of their competences, professionals have the possibility to register in the NEWCOM competence database implemented through the BUILD UP Skills advisor app to show their competences in a validated format (professional card) and to be found by customers or companies.

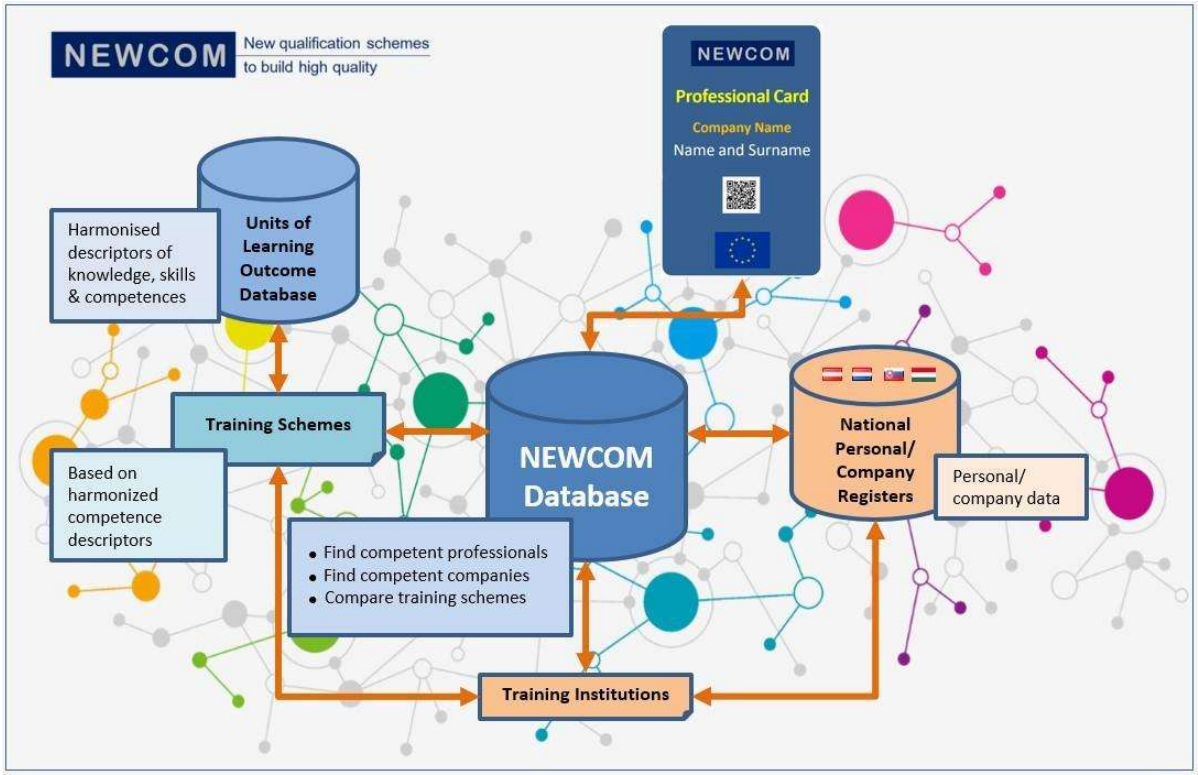


Figure 15: The environment of the NEWCOM database

2.7. Building Smart qualifications for BIM and BIM for Energy efficiency

2.7.1 Concept and approach

BuildingSmart does not deliver trainings but provides a global learning framework and certification of achieved skills, by taking an online exam, based on a multiple-choice selection [18]
The assessment to achieve the certification consists of a Question Database of a minimum 150 questions created for each learning module. The Question Database is used in the Qualification Platform to randomly select questions for each candidate test. There is a minimum of 4, and ideally, 10 questions developed per a learning outcome, to achieve the minimum 150 questions per module.

BuildingSmart provides two levels of Professional Certification in BIM – Foundation and Practitioner:

1) Level 1, Foundation, is the first release of the Program that focusses on knowledge-based learning

2) Level 2, Practitioner, is a more comprehensive approach that addresses applied learning and practical expertise within individuals. Currently in development,

Level 1- Professional Certification – Foundation is delivered in multiple curricula. Each curriculum is defined by the following three resources:

1) The Learning Outcome Framework (LOF), which defines the course learning objectives.

2) The Body of Knowledge (BoK), a resource that describes the content (references) of each learning objective.

3) The Question Database, to populate the Qualification Platform for Student exams.

Qualification

Students wishing to receive bSI qualifications must complete a bSI approved course from a registered Provider. Once the training is complete, the student is eligible to sit an exam and become bSI qualified. Testing and qualification is managed via an online Qualification Platform. This is a straightforward multiple-

choice exam that can be completed within 30 minutes. Directly after completely the exam, the student will be notified of their result. If they have passed, they will receive a digital certificate with their name, Provider, unique ID, date etc. which can be printed or shared digitally.

2.7.2. Background analysis – n /a

2.7.3 Skills and qualifications framework

For Professional Certification – Foundation, Building Smart International has a framework of Learning Outcomes classified in 5 learning modules for BIM.

General specifications for the modules 1- 5: It is suggested that the time required to sufficiently cover all content within the LOF is not less than 6 hours. This is designed to be implemented into training courses with a duration of 1-2 days.

Module 1: Understand what BIM is, why it is needed, and recognise its specific terminology

1.1 Define the drivers that have led to BIM;
1.2 Define BIM;
1.3 Identify & define key BIM terminology;
1.4 Define BIM maturity levels;
1.5 Define what constitutes an Information Model.

Module 2: Recognize the advantages of BIM compared to traditional project delivery

2.1 Know why collaborative and new ways of working are required;
2.2 Identify the effects of poor information management on projects;
2.3 Identify the standards developed to mitigate poor information;
2.4 Identify the benefits of BIM to construction professionals;
2.5 Identify the benefits of BIM adoption to clients and facility management.

Module 3: Understand the project information development cycle (and its key terms);

3.1 Know why employers need to clearly define their requirements (EIR);
3.2 Know why the supply chain needs to agree a plan to execute BIM on the project (BEP);
3.3 Know why consistent exchanges of information are required;
3.4 Identify the key elements and benefits of using a collaborative exchange platform (CDE);
3.5 Know why clearly defined information management responsibilities are required;
3.6 Know why assessing potential supply chain members before appointment is required.

Module 4: Recognize the need for open and interoperable solutions

4.1 Define who buildingSMART are;
4.2 Define open BIM and its benefits compared to using proprietary products and systems;
4.3 Know what IFC is and its benefits;
4.4 Know what MVDs are their benefits;
4.5 Know what IDMs are their benefits;
4.6 Know what the bSDD is and its benefits;
4.7 Know what BCF is and its benefits.

Module 5: Identify an organisation's capability in working with BIM

5.1 Understand the potential benefits for a company in adopting BIM;
5.2 Understand the factors that define an organization's level of BIM Maturity;
5.3 Know why BIM adoption needs to align to organizational goals;
5.4 Identify the benefits and challenges to BIM adoption;
5.5 Know what the data security implications are for adopting BIM.

IBIMI – Building Smart Italy have recently developed a set of 5 learning modules with accompanying learning outcomes, for BIM and energy performance of buildings, covering the whole lifecycle of a building, classified in 5 stages – plan &

analysis, preliminary design, technical design, construction, operation). The learning objectives do not specify target learning audience - specific professions and roles, but are focused on providing knowledge and skills for use of BIM tools to provide energy performance of buildings in stages of buildings' design, construction and use. Therefore, this framework unites both observed fields (NZEBs and BIM) in a very efficient way – improving skills maturity progressively, by upgrading the knowledge of advantages of digital communication and information exchange and management, and impacts thereof on efficiency of both the asset and the process.

Specification of IBIMI modules and accompanied learning objectives and learning outcomes is given in the tables below.

Table 15: Learning outcomes framework by IBIMI

Mod. 6.1 Understand which information for existing conditions is necessary to specify, produce, exchange, maintain and/or refurbish

Tasks / learning objectives	**Learning outcomes**
Select/develop the use case for energy analysis	1.1 To be aware of the advantages of using BIM for defining the existing conditions for developing new and/or refurbished buildings
Select the relevant information related to the technologies to be used for improving energy performance	1.2 Identify and list the technologies to be used for existing conditions when developing BIM models for new and/or refurbished building
Gather the information related to different technologies and materials among which to choose the best technical solution	1.3 Understand the strategies to reduce energy consumption and sources of renewable energy, both in the choice of materials and in the design of construction solutions, to guarantee a low energy consumption
To acquire the EIR related to the improvement of the energy performance and legal requirements	1.4 Identify the benefits of including energy performance requests in the Exchange Information Requirements (EIR)

To acquire any information and constrain to meet legal requirements	1.5 To identify local and national legislation before performing the energy analysis

Mod. 6.2 Understand which information is necessary to specify, produce, exchange, and maintain during the preliminary design stage

Tasks / learning objectives	**Learning outcomes**
Select and manage information related to the different use cases at preliminary design stage using open standard formats	2.1 Identify the purpose and advantages of using BIM for improving energy performance of a building during its lifecycle, compared to traditional methods
Contribute and develop the BIM Execution Plan for the specific use cases	2.2 Identify the benefits of including energy issues when developing a BIM Execution Plan (BEP)
Select relevant use cases demonstrating good energy performance levels at the preliminary design stage	2.3 Identify use cases for energy efficient preliminary design stage
Select the relevant information of each technology to be considered in the energy simulation to optimize the operational costs	2.4 Identify the key technologies that could be considered in a BIM simulation, to evaluate cost / benefit analysis on preliminary design of a Nearly Zero Energy Building (NZEB)
Identify the key actors and the information needed to perform the energy analysis	2.5 Identify the main actors of the building process to produce, exchange and maintain information of the BIM model and their roles and responsibilities for energy efficiency

Mod. 6.3 Understand which information is necessary to specify, produce, exchange, and maintain during the technical design stage

Tasks / learning objectives	**Learning outcomes**

Select and manage information related to the different use cases of technical design using the relevant standards	3.1 Identify use cases for energy efficient technical design of buildings
Be capable of selecting the right parameters to introduce in a code checking software	3.2 Identify code checking possibilities to verify energy requirements
To define the Level of Information Need (LOIN) necessary to describe the BIM object used for energy performance evaluation and related standards	3.3 Identify the information needed for NZEB requirements (Geometry and information property set) and exchange formats
Select the right tools to meet sustainability requirements for the life cycle of a building	3.4 Identify different solutions (including CDE) to meet NZEB and other sustainability requirements during the building lifecycle
To ensure reliable information for energy efficiency evaluation	3.5 Identify the measures to assure high quality of energy efficient design of buildings

Mod 6.4 Understand which information is necessary to specify, produce, exchange and maintain during the construction stage

Tasks / learning objectives	**Learning outcomes**
Select and manage information related to the different use cases during the construction stage using relevant standards	4.1 Identify the objectives to ensure high energy performance during the construction process
To ensure the correct information for each use case	4.2 Identify use cases for energy efficient construction of NZEB buildings
To be able to identify roles and responsibilities for managing the information during the construction phase	4.3 Identify requirements for the information management at the construction phase for meeting energy efficiency performance; CDE roles and responsibilities

To ensure that the information for each technology is sufficient to evaluate sustainability during the construction	4.4 Identify different technologies to meet Nearly Zero Energy Building and other sustainability requirements during the construction stage
To ensure the completeness and correctness of the information released during handover	4.5 Identify and define the best handover strategy to ensure correct management of the building
To be able to collect and manage the information of the asset for the handover	4.6 Identify and manage standards, procedures and technologies for "As-built" data collection (Geometry, Information and Documentation)

Mod. 6.5 Energy management at the operational stage-principles, tools and methods for smart energy management, underpinned by BIM

Tasks / learning objectives	**Learning outcomes**
Select and manage information related to operations and maintenance using the correct standards	5.1 Identify use cases for energy efficient management of Nearly Zero Energy Buildings at the operational stage;
To be able to verify the existence of the information required for the asset management	5.2 Identify the information requirements and standards for open BIM information exchange for the facility management
To be able to identify the information necessary to maintain the best performance of the installed technologies	5.3 Identify the technologies for the maintenance stage to ensure the foreseen energy performance
To be able to select the critical information to ensure the correct management of the installed technologies	5.4 Identify and assess the risks of using incorrect information that are essential for facility management and maintenance
To manage the correct procedures for the final disposal of equipment, materials and components at the end of the lifecycle	5.5 Be aware of the use of correct information for the disposal of any component to transfer to landfill or for reuse

3. Comparative analysis of the studied models of skills

3.1 Main research objectives, methodical approach and structure of the analysis

This chapter describes methodology and results of the first of the two stages of research of skills framework: models.

Subject of the research were seven frameworks of skills and competences in construction sector, developed by the H2020 funded projects BIMcert, Net-UBIEP, BIMEET, BIMplement, NEWCOM, the Erasmus+ funded project BIMzeED, and the international brand BuildingSmart.

The main objectives of the first stage of research were:

1) to analyse and compare qualitative features of the frameworks,
2) to identify similarities and differences and therefrom the way of setting basis for design of the ARISE concept of transactions of skills,
3) to provide input for the second stage of analysis – skills mapping and maturity comparison (Chapter 4).

The methodological approach consists of multi – criteria analysis and comparison of frameworks, without selecting a particular reference point.

As the first step , eight criteria of relevance were selected,:

- Conceptual model of the framework,
- Included professional profiles,
- Considered phases of a building life cycle,
- Implemented system of grading skills maturity,
- Method of integration and consistency of digital and sustainable energy skills,
- Number and content of developed learning modules,
- Recognition / Certification of skills,
- Method of delivery.

- The criteria were selected tin order to provide an overview of qualitative features that were needed as a basis for comparison of commonalities and differences of the analysed frameworks, and therefrom to carry out assessment of the potential for transactability of competences.

  The composition of the analysis consists of a sequential evaluation of all considered frameworks, regarding each of the adopted criteria, pointing out conformities and specifics.

3.2. Skills framework concept

All the analysed projects carried out vast research (desk analyses, surveys, expert panels, Delphi method, industry needs analysis, overview of educational programs, communication with stakeholders on both supply and demand side, etc.) that resulted in:

- identified gaps in academic and VET education, for NZEB and BIM skills (with a higher level of maturity in energy efficiency skills, due to implementation of the relevant EU directives),
- recognized lack of European – wide qualification frameworks (separately) for BIM and NZEB); the two frameworks exist in many countries, but without links between them,
- specified absence of a unified and harmonized common framework of skills and qualifications for digital and sustainable energy skills in construction,
- notified urgency of development of a unified framework, to enable the construction sector to meet the requirements set by European energy and climate resilience policy targets,

Based on the background analyses, the projects designed and developed their learning frameworks, in accordance with:

- the projects' declared mission, objectives and ambition,
- own experience of the project partners and identified needs in their countries, as well alignment with national frameworks,
- external (out of the project consortia) expertise – focus groups and / or panels of associated partners and expert groups.

The most important similarities found among the frameworks are:

- Tendency for union of skills and competences in the two fields that are important for the construction sector of the future: sustainable energy and digital skills,
- Basically a similar approach in forming the skill frameworks as matrices of competences, applicable for professional profiles in a specific phase, process or activity in a construction project life cycle,
- Frameworks designed this way correlate a profession / expert profile in a construction process or its stage, to the typical work activities, operations and duties, by defining the kind and level of skills (competences) required to carry out professional duties effectively, competently, autonomously and with sufficient level of quality, with particular focus on the knowledge and skills that have impact on the energy performance of buildings,
- Digital skills are applied to enhance the effect of sustainable energy skills and, on the other hand, to improve the reliability, effectiveness and collaboration (engagement of professional roles) throughout the construction project.

The most important differences found among the frameworks were:

- Scope, objective and level of maturity of some of the analysed skills,
- Method of integration of sustainable energy and digital skills,
- Methodological approach in correlation of a professional profile to the work process stages (as described in Chapters 3.3 and 3.4)

Some of the projects focused more into details in describing competencies required from the same profession, but in various stages of a building life cycle (e.g., *Net-UBIEP*).

IBIMI (bSI – Italy) schemes, on the other hand, do not specify professional roles, but focus on exchange and management of information in building process stages.

Several projects (e.g., *Net-UBiep, BIMplement, NEWCOM*), observed competences as compositions of relevant knowledge and skills.

BIMzeED applied a similar approach and argued the need of a balanced theoretical knowledge and practical skills in all developed modules, shaping the format of delivery in support of such an attitude.

Chapter 2 provides a description of the basic features of the projects, wherefrom specifics of the analysed concepts can be summarized as:

- *BIMcert* produced a complex curriculum, divided into three strides, with a number of modules classified therein. The project promoted micro modules, based on particular learning outcomes of the complex curriculum learning modules that can be combined in multiple – upskilling patterns, tailored to individual or organizational needs and preferences, and adjusted to prior knowledge.
- *BIMzeED* produced a modern, future – oriented, flexible, multi – target learning framework, applicable for academic as well as vocational education, again as a combination of learning units in suggested learning plans.
- *NETUBIEP* introduced a 3D – matrix of skills that incorporated and harmonized competences observed in three aspects: 1) professional profile, 2) stages in a building's life cycle and 3) roles in information exchange and management process by use of BIM.
- *BIMEET* introduced a complex matrix of skills and competences, that included main groups (main levels) of LOs correlated to buildings' life cycle stages (according to RIBA work plan) and assigned levels of skills maturity in compliance with EQF, that vary (one of the specifics of this scheme), depending on the professional profile, roles and responsibilities in the observed stage. Furthermore, each main group of LOs encompasses 6-10 sub – outcomes (sublayers) that explain in more details type and level of knowledge and skills achieved and have their own level of maturity assigned.
- *BIMplement* invented a multi –layered matrix that included graded knowledge, skills and competences, composed of generic and specific capacity to complete disaggregated and classified tasks in the fields of

BIM and NZEB.

- *NEWCOM* continued the work started in *BIMimplement,* but focusing on several specific competences in air tightness and ventilation, producing as one of the major outputs – competence database, as a pre – phase of wide recognition of skills.

3.3. Covered scope – target groups and professional profiles

Most of the projects started from the roles of AEC professionals (type of professional profiles and their responsibilities and typical work operations and duties that they carry out in a construction process), which needed to be subject of role – related and expertise – specific upskilling process, to achieve objectives and maturity levels defined by the project developed qualification scheme.

Identified and specified responsibilities and therefore the required competences for professional profiles differ among the analysed schemes, mostly due to:

- different focus, goals and approach of the projects.
- different background research and analysis that have led to conclusions of the needed content, level of maturity and format of training delivery and recognition.

For instance,, while some of them (*BIMcert, bSI*) considered BIM not only a leveraging tool for energy performance, but as an equally important discipline that should be studied independently prior to its union with sustainable energy skills, there were other projects exclusively focused on quality control and assurance in the construction stage (to reduce or avoid the performance gap), and on the construction site workers, moreover on particular expert fields therein (*BIMplement, NEWCOM*); apart from that, projects as *Net-UBIEP* recognized the importance of professional hierarchy in BIM in NZEB processes, to competently carry out assigned duties.
Apart from the roles, responsibilities and competencies of professional profiles included in the AEC sector, some of the projects (*BIMcert, BIMzeED*), designed flexible schemes that are adaptable for HE, VET and SMEs development in the fields of NZEBs and BIM.
Notable, *BIMzeED* explored, analysed and identified, not only gaps in

current construction sector profiles, but also new professions that will be needed due to technology progress and increase of demands for sustainability of construction processes [6], as quoted in the Chapter 2.2. This is a very important guidance for profiling schemes, in terms of finding the optimal method for equipping AEC workers with skills that will enable them to follow promptly the progress of technology, advanced materials and manufacturing, construction and installation methods, as well as emerging and constantly improved RES technologies and NZEB solutions being applied in buildings. Additionally, skills for following the progress of digital technologies, e.g., for information delivered by manufacturers, will be required as a pre – requisite for adoption of emerging energy skills for sustainable construction.

BIMEET project identified six groups of professional profiles (Clients, Architectural design roles, Structural design roles, Building services design roles, Construction work roles, maintenance work roles), each further including 4 profiles accompanied to the particular stage of the process.

BIMPLEMENT used ISCO-08 (International Standard Classification of Occupations) classification structure of professional profiles. The project classified professions in: Civil, Mechanical and Electrical Engineering, Architecture, Financing and Procurement, Facility Management, BIM, Technicians and Craftsmen.

NEWCOM used a national qualification framework (of the partner countries), for professional profiles of site workers specialized for air tightness, ventilation and flat roofs installation.

BIMcert navigates the professional profiles towards its third stride of the curriculum (identifying professions such as: Facility Managers, Clients, Contractors, Manufacturers, Quantity Surveyors), while the strides 1 and 2 are not exclusively intended for one professional profile, but designed as multi – targets learning units, and applicable for several profiles. The module Digital skills in construction was developed specially for construction site workers, as one of the target groups that were in the project's focus mostly.

BIMzeED developed most of the learning units to be applicable for several professional profiles (including construction and architecture students), while only several are exclusively intended for particular professions (e.g., LU2: BIM and NZEB for Workers). The professional roles were identified in consultation with the project external expert group and they include the following disciplines and roles: Project manager, Consultant, Designer, Construction manager, Specialist in green building, Technicians Craft workers Apprentices, Quantity surveyors.

3.4. Considered phases of a building / construction project life cycle

In further steps, some of the projects identified phases in a building's life cycle, in order to determine roles, duties and occupations of professional profiles within a stage of a construction project. This approach was based on findings of projects previous research or experience, that same professions (e.g., Designer) have different duties that therefore require different competences, in different stages in a construction process (for example, this is one of the specifics of *NETUBIEP*). Their skills and competences frameworks are designed as two – dimensional matrices, correlating occupation / profession and construction process stages. One of the specifics in this aspect is the *NETUBIEP*'s 3D matrix of competences, defining three dimensions of a competence: professional profile in a construction process, role in a building life cycle, and role in the information management - BIM process.

For the definition of a building (a construction project) life cycle stages, basically three sources were used in the projects:

- RIBA Plan of Work (*BIMlement, BIMEET, NEWCOM*),
- PROF/TRAC matrix (*BIMzeED Netubiep*),
- Own experience and survey results (*BIMcert, bSI)*

Generally, most of the projects identified the following stages of a construction project / a building life cycle:

- Plan
- Design
- Construction
- Operation
- End of life / Renovation

Some of the projects (e.g., *BIMcert*), developed learning modules that are generic and applicable for all stages of a construction project (e.g., *BIM Fundamentals, Introductions to Low Energy Buildings Construction*).

3.5. Project scale systems of skills maturity levels

All analysed frameworks of skills and competences used a selected or project - designed grading system to define the expected level of knowledge and skills required for the observed profile, i.e., the required level of maturity Some of the frameworks rely on EQF system of 8 levels (*BIMzeED*, *BIMEET*), while the others developed their own scale, of usually 5 to 6 levels, starting from 0 or 1 as the lowest and finishing at 5 as the

highest level of achieving skill or knowledge. Some of the projects (*Netubiep, BIMplement),* adopted Prof – Trac grading system of 6 levels of maturity of skills.
When profiling the maturity grading system, *BIMcert* also took in consideration the requirements of the selected accreditation scheme (OCN)

Based on the analysis of the projects' learning frameworks, it can be noticed that most of the analysed projects developed modules of learning outcomes in line with CEDEFOP (European Centre for the Development of Vocational Training) recommendations and applied Bloom's Taxonomy thereby. This was used as a levelling mechanism for comparison of projects' LOs in the levelling matrix (Chapter 4 of this Report).

3.6. Integrity and consistency of digital and sustainable energy skills

The method of integration of BIM and NZEB skills into a common framework is specific for each of the projects and is a result mostly of the background analyses that have led to conclusions for the most effective methods of incorporation.

The analysed projects (except *NEWCOM*, which treated only sustainable energy skills, but also considered a method for future inclusion of BIM skills), observed BIM as a technology for leveraging sustainable energy skills. The projects applied this general approach of use of BIM tools to improve energy performance, in order to achieve integration of BIM and sustainable energy skills, in a way found as the most effective to enable professionals a seamless transition from the traditional (current) to a digitalized method of work.
Most of the projects started with identification of required competences in sustainable energy skills, and then incorporated BIM tools for achieving the specific energy skills.
BIMcert applied a unique approach in this aspect, treating BIM as a technology that provides many benefits for the construction processes and actors, and therefore is studied as a separate discipline, while studying of BIM tools for sustainable energy skills starts at a certain level of achieving competence in BIM skills – an approach titled in the project as *Use of BIM tools for improved energy efficiency of buildings*.

Despite the general similarity of their basic approach, the skill frameworks developed by the analysed projects differ, in:

1) content, scope and description of particular skills, for NZEBs and BIM,

2) assessed level of maturity of skills for some professional profiles.

The differences are due to prospection of roles and responsibilities of professional profiles and the required competences that arise therefrom, mostly due to practice, regulations and industry needs, on national level in the countries included in projects.

While some projects start the learning guides with generic skills and gradually improve towards more specific skills related to the professional profiles (e.g., *BIMcert's* three- stride scheme), the other projects offer, at the very beginning, learning outcomes intended for various subgroups of professional profiles, introducing different levels of skills maturity for different roles (e.g., *BIMEET, BIMzeED*).

Several projects (*Net UBIEP, BIMplement, BIMzeED*) achieved integration of the both frameworks (for BIM and NZEBs), by combining / upgrading the Prof-Trac scheme of sustainable energy skills with BIM skills, using thereby own or their external experts' attitude (Net- UBIEP, BIMplement), or building Smart International scheme (*BIMzeED*).

BIMplement defined the required competence as a composition of related generic and specific skills in BIM and NZEB and put them in the context of a building process stages.

Some of the projects contain separate modules for sustainable energy and BIM skills, joined in some point of the learning pathway (*BIMcert, BIMplemen*t, as well as *bSI* framework), while the others have modules that all include BIM as a tool for EE skills (*BIMzeED, BIMeet),* from the very beginning of the upskilling process.

Building Smart Italy - IBIMI developed learning modules that encompassed skills for use of BIM tools for exchange and management of information related to energy efficiency of buildings, classified in 6 stages of a building's life cycle, not dependent on the role or professional profile.

Thus, consistency of the both frameworks (BIM and NZEB) in the analysed schemes is different, mostly due to the different approaches applied for

integration of the two frameworks, as well as because of origin of specified and implemented competences (previously developed taxonomies, own experience and expertise and / or surveyed needs).

An impactful aspect for profiling consistency of sustainable and digital skills, in the way it was conducted in the projects, were projects' objectives and target groups in main focus. Namely, in the projects having blue collar workers among priority groups, digital skills are explained as a leveraging tool for sustainable energy skills. Even among these projects, differences can be found: *BIMplement* and *NEWCOM* applied digital skills in support of energy skills frameworks, while *BIMcert* observed digital skills per se, and designed training modules that equipped site workers with digital skills of using BIM models to find, understand, process, forward, comment and use information related to their job place and includes sustainable energy work operation / activity. This approach was found justified, considering the intensive technology progress that demanded having flexible skills for handling various equipment, materials and methods.

In most of the projects that considered all professional profiles equally, consistency was achieved gradually, by connecting the two frameworks at some point of maturity (determined by the projects' individual prospection). *BIMcert* went further in such an approach, designing micro modules to be combined in either of the two observed competence frameworks, or in a novel (BIM&EE) one.

3.7. Developed learning modules – number and content

To support the developed qualifications and training schemes, the projects prepared training materials and put part of them in trials, to test the efficiency of learning and assessment materials as well as of delivery models and tools. The tests served not only for improvement of materials and methods, but also very important, to inform, raise awareness and increase capacity of professionals and target groups across Europe.

The number of modules developed by the projects is presented in the table overview in Appendix 7.1.

3.8. Method of delivery

Most of the projects recognized the benefits of the concept of micro learning modules, based on specific learning outcomes. That enables better supplementary capabilities of projects' modules, since the maturity level can be achieved by a sequence of combined micro units.

All projects recognized the benefits and perspectives of e – learning, or beyond blended mode, as introduced by *BIMcert*.

Most of them made combinations of theoretical and practical knowledge and designed the method of delivery appropriately for this approach.

Specific for *BIMcert* delivery methods, is the guided self – learning, that encourages learners to progress learning upon guidance and initial lessons given by instructors / trainers, which was found very appropriate and effective for employed professionals, as time and cost beneficial for them.

The projects that had construction site workers in focus (*BIMplement, NEWCOM*), found the on – site delivery, on real life projects / examples, the most efficient method of training delivery for this target group of construction site workers (craftsmen, foremen, site managers).

3.9. Recognition / Certification

All projects emphasized the need for wide recognition of skills and competences and therefore made efforts, in early stages of their frameworks design, to achieve alignment with national and international systems of recognition (national and international frameworks of qualifications and accreditation schemes). To provide an easier recognition and transferability of qualifications, projects piloted various design of: individual learning accounts (*BIMplement*), digital passports of skills (*BIMcert*), and a digital competence data base (*NEWCOM*).

Recognition of qualification schemes of most of the projects, within their duration, was achieved on a project, national and international (among partner countries) level and in some of the project's accreditation was provided by external bodies (*Net-UBIEP,- bSi; BIMcert – OCN*). Some of the

projects (*BIMcert, BIMzeED*) also considered additional transferability of their frameworks to the international system of CPD.
Further improvement towards international recognition was achieved by some of the projects by promoting micro modules (BIMcert), an innovative approach that enables better flexibility and compliance with a wide range of recognition and accreditation schemes.

3.10. Conclusions

Overview of the basic features and outputs of the analysed projects is presented in Table 3 in the Appendix 7.1.

There are a lot of conformities, along with specifics, of the analysed frameworks and this fact provides:

- a firm justification of the ARISE concept of feasibility of learning transactions among different training schemes,
- a basis for the second stage -the quantitative analysis, of the maturity of comparable skills (Chapter 4),
- fundamentals for alignment with national frameworks and systems for registering and accumulation of records of progress in competences (CPD, ECVET).

The most important similarity is the recognized need and efforts made to establish an integrated framework of digital and sustainable energy skills in the construction sector and to ensure its consolidation through correlation with familiar and accepted taxonomies and qualification frameworks.

4. Levelling and alignment matrix for representative samples of competences

4.1. Main research objectives, methodical approach and structure of the analysis

In continuation with the comparative multi - aspect analysis (Chapter 3), the further stage of comparison of skill frameworks and maturity models was carried out. Levelling and alignment matrices of learning outcomes were developed, in compliance with the UNESCO and CEDEFOP Methodology [27] with four objectives:

1) to explore comparability of competences for selected samples of professions, at cross – schemes and international level,

2) to confirm portability of learning outcomes developed under various programs, as a basis of ARISE concept of recognition and transactability of learning achievements,

3) to enable transnational cooperation of different learning frameworks, based on comparison of learning outcomes and acquired competences., and

4) to provide the foundation for the blockchain transaction structure.

According to the [24]: "*A systematic use of learning outcomes in frameworks and qualifications allows for the introduction of levels supporting comparison and transfer of qualifications; outcomes increase the overall transparency of qualifications, making it possible for individual learners as well as future employers to judge their quality and relevance; and it points towards a 'common language' allowing for a dialogue between education and training institutions and external stakeholders on skills needs and the relevant responses to these..*"

The methodology of the comparison in this, second stage, based on levelling and alignment matrices of learning outcomes, allows a systemic overview of conformities and differences between content and level of competences developed by the analysed schemes and also reflects the specifics of the approaches of the particular schemes towards the maturity of skills.

The learning outcomes, taken over from the curricula and learning modules of the analysed programs, were evaluated in terms of proficiency of skills they provide,

using thereby the Bloom's taxonomy applied in the description of learning outcomes., as a levelling and translating tool.

The same seven skill frameworks were analysed by the method of alignment of learning outcomes: *BIMcert, BIMzeED, BIMEET, Net-UBIEP, BIMplement, Building Smart International* and *NEWCOM*.

4.2. Method of development of matrices

The method of development of matrices consisted of the following steps (as shown on the figure 16 below);

1. Selection of a representative sample of a professional profile, included in the analysed projects / schemes, whose qualifications will be compared across the schemes,
2. Identification of learning pathways - learning modules and their sequence, developed by different schemes and applicable for leading the selected professional profile to the required competence,
3. Specification of learning outcomes (taken over from the developed frameworks)
4. Identification of skills maturity levels, by using a) project scales, b) Bloom's taxonomy.
5. Construction of an alignment matrix, including comparison of individual learning outcomes developed by different schemes, as well as their maturity levels,

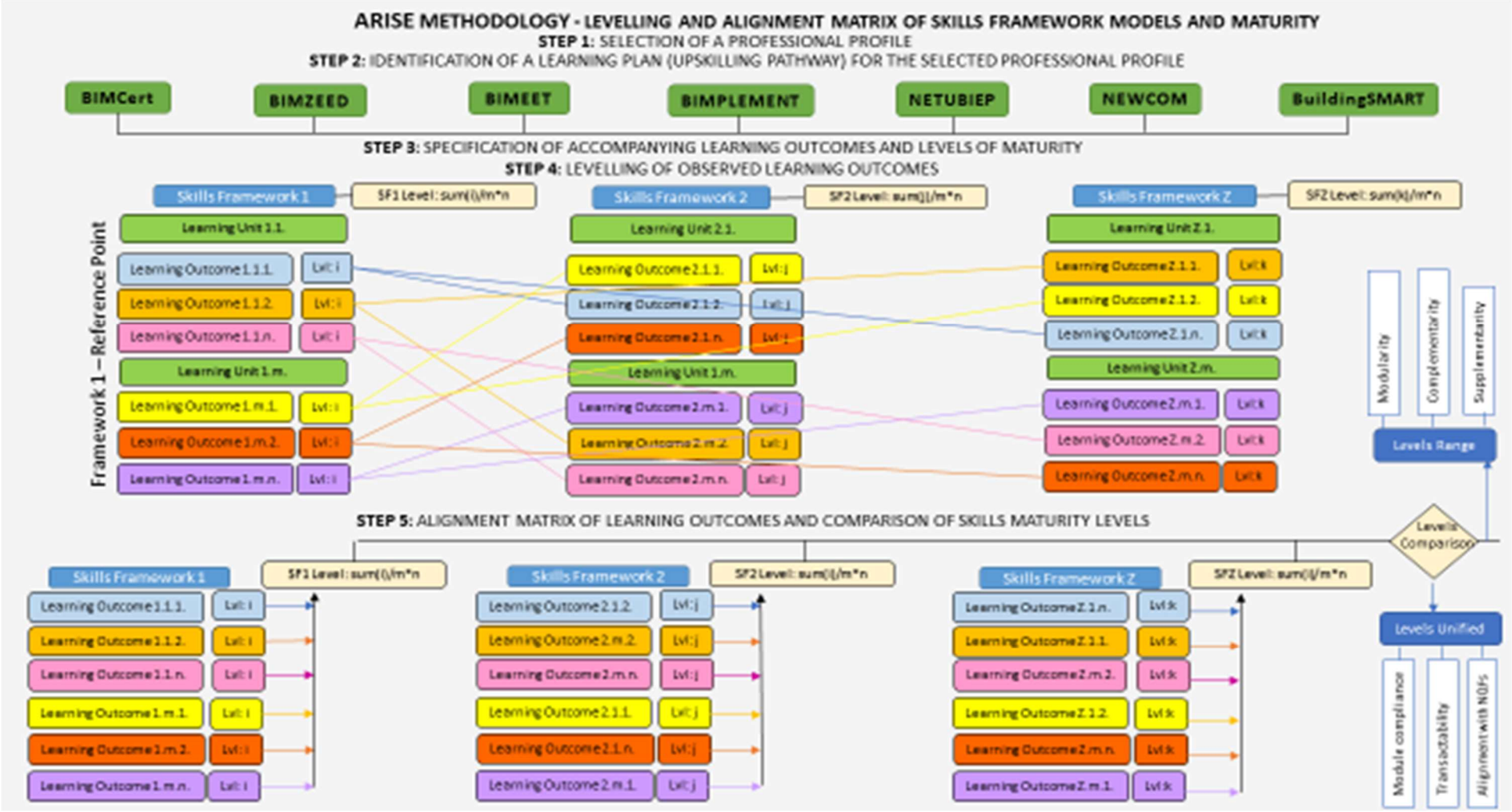


Figure 16: Flowchart of method of development of levelling and alignment matrices

Several challenges were found during the development process:

- Selection of comparable professional profiles and disciplines, since they have different title and contextualization in various schemes,
- Harmonisation of the observed competences across the analysed schemes - levelling professional roles, and closely related to that, their required competences, identified by various projects / schemes,
- Identification of the learning pathways tailored for the selected professiones,
- Deciding on the phases of construction projects – for the purposes of levelling, it was decided that professions selected for comparison should be observed in their roles in the complete life cycle of a building; selection and inclusion of learning outcomes was made in line with this decision.
- Put the content of skills and their level of proficiency into a comparative format (alignment matrix)

BIMcert		BIMZEED		BIMEET		NetUbiep		Bimplement		BUILDING SMART		NEWCOM	
Learning Units	Level	Learning Units	Level	Learning Units	Level	Learning Units (BIM Model Evaluator)	Level	Learning Units	Level	Learning Units	Level	Learning Units	Level
1, Introduction in BIM fundamentals	2	LU1.Collaborative BIM to achieve nZEB	7*	Group 1 (LO1) Fundamentals of BIM and principles of its uses with respect to building life-cycle	4*	Introductory module - basic BIM knowledge and skills		List in specifications, ask for a 3D or BIM model to be able to follow the evolution of the project from sketch to call for bid, do not impose BIM	2	1. Module 1: Understand what BIM is, why it is needed, and recognise its specific terminology	2	BIMSystems	2
2. BIM Principles	2	LU8. BIM model standardization for nZEB design	6*	Group 2 (LO2) Fundamentals of sustainable and energy-efficient buildings and building performance	3*	Module 1 - BIM Dissemination / Diffuse BIM		Understand the importance of BIM data related to the objects in the models. Start to select properties for the main objects, and writing of simple BIM specification	2	Module 2: Recognize the advantages of BIM compared to traditional project delivery	2		
3. BIM for Clients	2	*according to the Project scale		Group 3 (LO3) Preparation of information management documentation and setting strategic targets for the project	6*	Module 2 - Information Management Applications				Module 3: Understand the project information development cycle (and its key terms);	2	Building operation	2
4. Introduction to Low Energy Building Construction	2			Group 4 (LO4) Early stage target setting for energy, sustainability and building performance	6*	Module 3 - Procurement Management				Module 4: Recognize the need for open and interoperable solutions	2	Quality assurance and quality control (15 learning units)	2
				Group 5 (LO5) BIM-based collaboration methods in project management and processes	3*	Module 4 - Using BIM Technologies				Module 5: Identify an organisation's capability in working with BIM	2		
				Group 6 (LO6) Quality management procedures for achieving set targets	6*	Module 5 - BIM Model Analysis				Mod. 6.1 Understand which information for existing conditions is necessary to specify, produce, exchange, maintain and/or refurbish	2		
				Group 7 (LO7) Skills for relevant software and interfaces between software	4*					Mod. 6.2 Understand which information is necessary to specify, produce, exchange, and maintain during the preliminary design stage	2		
				*according to the Project scale						Mod. 6.3 Understand which information is necessary to specify, produce, exchange, and maintain during the technical design stage	2		
										Mod 6.4 Understand which information is necessary to specify, produce, exchange and maintain during the construction stage	2		
										Mod. 6.5 Energy management at the operational stage-principles, tools and methods for smart energy management, underpinned by BIM	2		

Figure 17: Setting of learning plans in the observed schemes (example of professional role of Client)

BIMcert		BIMZEED		BIMEET		NetUbiep		Bimplement		BUILDING SMART		NEWCOM	
Learning Units	Level	Learning Units	Level	Learning Units (Architectural design roles; Architectural design	Level*	Learning Units (Professionals)	Level	Learning Units	Level	Learning Units	Level	Learning Unit: Quality assurance and quality control	Level
1, Introduction in BIM fundamentals		LU1.Collaborative BIM to achieve nZEB	EQF 4-7	LO1: Learner is able to explain the fundamentals of BIM and the underlying principles of uses with respect to building life-cycle	6	UL01: Identify advantages of using BIM, evaluation related technologies, standards and trends.	2		2	Module 1: Understand what BIM is, why it is needed, and recognise its specific terminology	2	Module 1: Basic of building physics	
2. BIM Principles		LU3: NZEB Realization and Commisssioning: Building Envelope and Air Tightness	EQF 6	LO2:Learner is able to explain the fundamentals of sustainable and energy-efficient buildings and building performance.	6	UL02: Evaluate economic / quantity take off of the life cycle cost of the building, 5D cost estimation	4			Module 2: Recognize the advantages of BIM compared to traditional project delivery	2	Module 2: Building materials	
3. 3D BIM Modelling		LU4: NZEB Realization and Commisssioning: Building Services and Smart Technologies	EQF 6	LO3:Learner is able to lead design process and support the client and other stakeholders in decision making.	6	UL03: Make a 4D phases planning, integrating life cycle concepts in different project phases in order to set-up organized management systems.	3			Module 3: Understand the project information development cycle (and its key terms);	2	Module 3: Building components	
43D BIM (Parametric) Objects		LU5: NZEB Realization and Commisssioning: Quality Assurance	EQF 4-7	LO4: Learner is able to implement energy performance, building performance and sustainability targets into design process	6	UL04: Identify requirements for the management of data in the CDE, ensuring the respect of the information requirements and of Information Delivery Manual.	2			Module 4: Recognize the need for open and interoperable solutions	2	Module 4: Quality inspection of the building envelope	
5. Digital Collaboration in Construction		LU6: BIM Model uses during construction	EQF 6	LO5:Learner is able to produce BIM models with accurate and required information content for different uses and phases of a building project. maintenance.	6	UL05:Produce and manage digital data for the design of nZEB and consider 7D performance indicators for the analysis of data.	3			Mod. 6.1 Understand which information for existing conditions is necessary to specify, produce, exchange, maintain and/or refurbish	2	Module 5: Illumination	
6. Information Management for Digital Construction		LU7: BIM Model Uses for Specification and Quantification	EQF 6	LO6: Learner is able to collaborate and use collaborative approaches to support communication and visualization.	6	UL06: Select energy efficiency solutions (and their suppliers) integrating different RES systems into buildings without clash detection.	4			Mod. 6.2 Understand which information is necessary to specify, produce, exchange, and maintain during the preliminary design stage		Module 6: Heating technology	
7. Quantification using BIM Tools		LU8: BIM Model Standardization for nZEB Design	EQF 6	LO7: Learner is able to explain and give examples about implementing target and quality management procedures in the building project.	5	UL07: Conduct risk management and disaster planning troubleshooting problems related to BIM.	3			Mod. 6.3 Understand which information is necessary to specify, produce, exchange, and maintain during the technical design stage	2	Module 7: Ventilation technologies	
8. Data Interoperability for Digital Construction		LU9: Building Energy Modeling (BEM) Design and Export	EQF 7	LO8: Learner is able to use different relevant software and interfaces between relevant software.	5	UL08: Produce a maintenance plan and a maintenance manual for the building plants in order to transfer management information to owners.	3					Module 8: Control systems	
9. Introduction to Low Energy Building Construction		LU10: Energy Simulation with BIM Tools	EQF 7	*project identified		UL09: Evaluate the completeness of the handover strategy and verify the correspondence between the "as built" and the final BIM model of the building.	4					Module 9: Air conditioning technologies	
10. Advanced BIM and energy efficiency		LU12: BIM in Facility Management Software	EQF 6- 7			UL10: Use Reverse Engineering methods for the definition of models of existing buildings for their refurbishment.	3					Module 10: Electrical power generation	
11. BIM for Retrofit and Refurbishment						UL11: Make technical supervision and verify the respect to pre-defined BIM standards, technical requirements and legislation (with code checking).	3					Module 11: Thermal activation of building components	
						UL12: Produce a correct decommission of the building and provide to recycle any part in the respect of local, national and international laws	3					Module 12: Energy balances - demand forecasts, energy certificates and certification programmes	
												Module 13: Building Information Modelling (BIM) systems	
												Module 14: Building operation	

Figure 18: Setting of learning plans in the observed schemes (example of professional role of Designer (Architect)

BIMcert		BIMZEED		BIMEET		NetUbiep		Bimplement		BUILDING SMART		NEWCOM	
Learning Units	Level	Learning Units	Level	Learning Units (Maintenance work roles - Property Manager)	Level	Learning Units (BIM Model Evaluator)	Level	Learning Units	Level	Learning Units	Level	Learning Units	Level
1, Introduction in BIM fundamentals		LU1.Collaborative BIM to achieve nZEB	EQF 6-7	LO1: Learner is able to explain the fundamentals of BIM and the underlying principles of uses with respect to building maintenance.	3*	Introductory module - basic BIM knowledge and skills		2. Learn how to use a viewer and its basic tools	2	Module 1: Understand what BIM is, why it is needed, and recognise its specific terminology	2	Module 1: BIM systems	2
2. BIM Principles		LU5: NZEB Realization and Commissioning: Quality Assurance	EQF4-7	LO2:Learner is able to explain the fundamentals of sustainable and energy-efficient buildings and building performance.		Module 1 - BIM Dissemination / Diffuse BIM		3. Use a Viewer to find simple information	2	Module 2: Recognize the advantages of BIM compared to traditional project delivery	2	Module 2: Building operation	2
3. Introduction to Low Energy Building Construction		LU10: Energy Simulation with BIM Tools	EQF7	LO3:Learner is able to manage BIM based construction processes and support the client and other stakeholders in decision making.	3*	Module 2 - Information Management Applications		4. Use the Viewer to Find More Complex Information		Module 3: Understand the project information development cycle (and its key terms);	2		
4 BIM for Facilities Mnagement		LU11: Near Zero Energy Building Facilities Management	EQF 5-6	LO4: Learner is able to use BIM for facilities and utilities management, operation and maintenance.	4*	Module 3 - Procurement Management		6. Communicate with the Viewer tools		Module 4: Recognize the need for open and interoperable solutions	2		
		LU12: BIM in Facility Management Software (CMMS)	EQF 6-7	LO5: Learner is able to implement energy performance, building performance and sustainability targets into operation and maintenance.	4*	Module 4 - Using BIM Technologies		7. Locate, read and attach documents to the BIM model		Mod. 6.5 Energy management at the operational stage-principles, tools and methods for smart energy management, underpinned by BIM	2		
				LO6: Learner is able to use different relevant software and interfaces between relevant software.	4*	Module 5 - BIM Model Analysis							

Figure 19: Setting of learning plans in the observed schemes (example of professional role of Facility Manager)

Levelling matrices served to compare, match and mark the learning outcomes that cover similar content, objectives and scope. Visually, levelling matrices present the position of learning (micro) modules in the sequence of acquiring a specific competence – it is also a representation of the frameworks' specific approach in observing progress towards the targeted competence.

BIM cert		BIMZEED		BIMEET		NetUbiep		Bimplement		BUILDING SMART		NEN/COM	Level
Learning Outcomes	Level	Learning Outcomes	Level	Learning Outcomes	Level	BIM USER	Level	Learning Outcomes	Level	Learning Outcomes	Level	Learning Outcomes	2,28
1. Introduction in BIM fundamentals	2,00	1. Collaborative BIM to achieve nZE	2,92	L01: Learner is able to explain the fundamentals of BIM and the underlying principles of uses with respect to building life-cycle.	1,14	CO.U5 Have basic BIM knowledge and skills	2,00	Module 1. Present the project and show its progress with the BIM model	3,00	1. Module 1: Understand what BIM is, why it is needed, and recognise its specific terminology	2,00	Module 1: Building Information modelling System	2,4
1. Summarise your role and the roles of others within the Digital construction sector	2	1. Identify BIM Project Collaboration requirements based on the Project Performance Requirements (BIM Uses), and Project Roles and Responsibilities – Contractual Hierarchy	3	1. Recall essential contents, summarize and give examples of BIM terminology and definitions and standards.	1	CO.K1. BIM basic concepts, terminology, principles, strategies and its value proposition	2	1.1. Using a Viewer to show the visualization of the models (project manager models or execution models) depending on the project, presentation with one of the Viewers that will be used: ▪ Viewer IFC Collaborative platform Navisworks Freedom	3	1.1 Define the drivers that have led to BIM;	2	Know BIM definitions and terms	2
2.Explain the basic principles of BIM and summarise the common terminology associated with BIM	2	2. Develop and define the Statement of Requirements (SOR) or Statement of Work (SOW) describing the BIM deliverables, essential requirements, and specifications	3	2. Recall the basic idea of building information systems	1	CO.K2. Benefits and uses of BIM compared to traditional methods for improving energy efficiency of new or existing buildings	2	1.2. What is the company's involvement in the BIM process	2	1.2Define BIM)	2	Can discuss the benefits and potential of BIM in a project team.	2
3. Summarise and list the overall benefits of BIM, particularly in relation to specific roles in the construction industry and energy management	2	3. Evaluation of tender for the project BIM deliverables, requirements and expectations	5	3. Recall essential contents, summarize and give examples overall BIM process during building life-cycle	1	CO.K3. Project information development cycle information specification, development, exchange and maintenance throughout all the building life cycle	2	1.3. Extracts of the BIM documents from the call for tender (BIM specification analysis)	3	1.3Identify & define key BIM terminology;	2	Know the functionality of major BIM software packages	2
4. Identify the role of BIM in achieving improved sustainable construction and energy efficient performance	2	4. Establish the information framework required to assist communication and collaboration from Design - Construction - Operation for asset handover	3	4. Explain the essential issues related to information management, data transfer and sharing.	2	CO.K4. Reasons for open and interoperable solutions to ensure collaboration among professionals of different disciplines	2	1.4. Importance of airtightness management and/or other critical points	2	1.4Define BIM maturity levels	2	Can link interfaces of software packages with tools for quality assurance.	3
		5. Utilize data from classification systems such as Omni Class, UniFormat etc	3	5. Demonstrate knowledge of national guidelines for building information modelling during construction.	3					1.5 Define what constitutes an Information Model.	2	Can support the implementation of integral planning in building projects.	3
		6. Strategically map the project workflow	3			CO.K6. Relevance of maintenance to maintain the foreseen energy performance	2						

Figure 20: Extract from a levelling matrix (for profile: Construction site workers)

In the next step, alignment matrices were developed, in which the learning outcomes with previously identified commonality, were put in the same horizontal line. This layout (arrangement) enables direct and precise comparison, not only of the scope and profile (content), as well as level of maturity.

To level and compare the learning outcomes from different schemes, Bloom's taxonomy of levels of knowledge was applied, considering that, apart from internal grading systems that some of the projects have developed, this universally accepted taxonomy stayed in force in all of the projects. One of the characteristics of the taxonomy - the active verbs used to describe the learning outcomes – and the correlations describing individual project grading systems (provided in the projects' deliverables), served as a basis for this assumption.

BIMcert		BIMZEED		BIMEET		NetUbiep		BImplement		BUILDING SMART		NEWCOM	
Learning Outcomes	Level	Learning Outcomes	Level	Learning Outcomes	Level	BIM USER	Level	Learning Outcomes	Level	Learning Outcomes	Level	Learning Outcomes	Level
1. Introduction in BIM fundamentals	**2,00**	**1. Collaborative BIM to achieve nZE**	**2,50**	**Combination of Learning Units**	**2,00**	**C0.US Have basic BIM knowledge and skills**	**2,00**	Module 1. Present the project and show its progress with the BIM model	**2,33**	**1. Module 1: Understand what BIM is, why it is needed, and recognise its specific terminology**	**2,25**	**1. Module :Building Information Modeling (BIM) systems**	**2,00**
1. Summarise your role and the roles of others within the Digital construction sector	2	**1. Identify BIM Project Collaboration requirements based on the Project Performance Requirements (BIM Uses), and Project Roles and Responsibilities – Contractual Hierarchy**	3	1.3. Recall essential contents, summarize and give examples overall BIM process during building life-cycle	2	C0.K4. Reasons for open and interoperable solutions to ensure collaboration among professionals of different disciplines; C0.S2. Read a Information Delivery Manual;	2	1.2. What is the company's involvement in the BIM process	2	2.1 Know why collaborative and new ways of working are required; 1.5 Define what constitutes an Information Model.	2	BIM Systems	2
2.Explain the basic principles of BIM and summarise the common terminology associated with BIM	2	**2. Develop and define the Statement of Requirements (SOR) or Statement of Work (SOW) describing the BIM deliverables, essential requirements, and specifications**	3	1.1 Recall essential contents, summarize and give examples of BIM terminology and definitions and standards.	2	C0.K1. BIM basic concepts, terminology, principles, strategies and its value proposition	2	1.3. Extracts of the BIM documents from the call for tender (BIM specification analysis)	3	1.2 Define BIM;1.3 Identify key BIM terminology. 1.4. Define BIM maturity levels, Define what constitutes BIM model	2		
3. Summarise and list the overall benefits of BIM, particularly in relation to specific roles in the construction industry and energy management	2	**8. Recognise and illustrate effective communication within projects aimed to achieve nZEB**	2	3.1 Explain the objectives, benefits and describe the overall workflow of using BIM for construction project management.	2	**C0.K3. Project information development cycle: information specification, development, exchange and maintenance throughout all the building life cycle; C0.S3. Identify information requirements for his own role;**	2			2.4 Identify the benefits of BIM to construction professionals;2.2 Identify the effects of poor information management on projects; 2.3 Identify the standards developed to mitig2.5 Identify the benefits of BIM adoption to clients and facility management.ate poor information;2.5 Identify the benefits of BIM adoption to clients and facility management.	3		
4. Identify the role of BIM in achieving improved sustainable construction and energy efficient performance	2	**9. Identify interdisciplinary teamwork towards common goals**	2	4.1 Explain the overall BIM based construction processes to achieve best results in energy-efficient design and construction	2	C0.K2. Benefits and uses of BIM compared to traditional methods for improving energy efficiency of new or existing buildings; C0.S5. Identify the EIR (Employer Information Requirements)	2	1.4. importance of airtightness management and/or other critical points	2	6. 1. 1.To be aware of the advantages of using BIM for defining the existing conditions for developing new and/or refurbished buildings	2		
2. BIM Principles	**2,00**	**LU5: NZEB Realization and Commissioning: Quality Assurance**	2,94 ден	**Combination of LUs**	**2,67**	**Combination of LUs**	**2,00**	**Combination of LUs**	**2,75**	**Combination of LUs**	**2,00**	**1. Module:Building Information Modeling (BIM) systems**	**2,00**
1. Explain the context and essentials of BIM	2	5.1. Establish the coordination framework required from Design - Construction - Operation by using data inputs and model structure to organize modelling elements efficiently.	3	5. Learner is able to explain and use BIM based collaboration methods for project management and processes	2	C0.K3. Project information development cycle: information specification, development, exchange and maintenance throughout all the building life cycle; C0.K5. Methodology to identify, plan, develop and evaluate organization's BIM implementation capabilities and BIM uses	2			2.1 Know why collaborative and new ways of working are required; 3.1 Know why employers need to clearly define their requirements (EIR);3.2 Know why the supply chain needs to agree a plan to execute BIM on the project (BEP); 3.3 Know why consistent; 3.4 exchanges of information are required; Identify the key elements and benefits of using a collaborative exchange platform (CDE);3.5 Know why clearly defined information management responsibilities are required;; 3.6 Know why assessing potential supply chain members before appointment is required.	2		2
2. Detail the application and standards of BIM	2	5.2 Quality checking procedures for construction standards and compliance including safety with the model.	3	6. Learner is able to explain, implement and supervise quality management procedures in building project to achieve set targets	3	C0.S1.- C0S6 Read a BIM Execution Plan (BEP); Read a Information Delivery Manual;; Identify information requirements for his own role; Identify the format to read information and transfer information within the supply chain; Identify the EIR; Identify and/or verify the stages of PIM	2	Understand the importance of BIM data related to the objects in the models. Start to select properties for the main objects, and writing of simple BIM specification	2	2.3 Identify the standards developed to mitigate poor information;	2		2
2. Summarise the technological requirements for BIM implementation and security	2	5.3. Explain how act influence of heating and cooling generation on energy performance	2	7. Learner is able to use different relevant software and interfaces between relevant software	3	C2.K1. Principle of data mining, data base and back up; C2.K3. Principle of data security and administrative law in the archiving of data in a CDE (Common Data Environment)	2			4.2 Define open BIM and its benefits compared to using proprietary products and systems;	2		2

Figure 21: Extract of the alignment matrix (for profile: Facility Manager)

The matrices actually show how competences related to a specific AEC professional profile have been designed by the analysed projects (*Figure 16 and 17)* which the learning outcomes and level of skills achievement were (*Figure 18*) and how they can be matched (*Figure* 19).

4.3. Professional profiles selected for analysis by levelling matrix

The analysis encompassed three professional profiles:

- Clients (Public administration and private investors),
- Designers (Architects),
- Construction site workers,
- Facility managers

The selection was made considering the following facts:

- their important roles in a construction project life cycle,
- closing the circle of a building life cycle (plan, design, construction, operation)

- responsibility of the selected professions in the future energy efficient construction and operation of buildings (by selecting these professions, focus was put on quality assurance and quality control of energy performance, thus on reduction of performance gap)
- identified need for upskilling of the selected professions (evident in the projects' background analyses and studies), more than for professions included in preparation of design and technical documents.
- Two of the selected profiles are market drivers representing the pulling force for increase of market demand; the third one is one of the main professions (blue collar workers) with highest demand for skills of the future
- All the analysed projects (training programs) considered the skills and competences required for the selected professional profiles

To set a basis for a relevant comparison of the content and proficiency of the selected professional profiles, the context was determined in which they are applied and operable within the analysed frameworks; summarized (from several of the analysed projects) description of their main roles was used thereby.

4.4 Establishing a reference point for comparison of learning outcomes-based competences

Considering that learning outcomes are presented and described in different ways across the analysed schemes, the comparison and establishment of similarities requires previous selection of a reference point [23].

As a reference, *BIMcert* scheme was used, for several reasons:

- it includes separate BIM and EE modules, and unites them at a point of maturity of the both frameworks, which is appropriate for initial knowledge of a wide range of professional; profiles and their targeted upskilling and qualifications,

- it can therefore be easily aligned with national frameworks of skills in BIM and NZEB, while promoting the new, federated framework,

- it is a comprehensive scheme aiming at amalgamation of the occupational profiles across the AEC sector

- it has a consistent structure of digital and EE skills, with a capacity to be linked to national frameworks

- it was based on a survey on industry needs, covering countries form the highest to the lowest BIM maturity; The survey was used to discover match/mismatch between qualifications and labour market requirements.

- It features elements of hierarchy, by gradually navigating the learner, from initial towards advanced level of digital and sustainable energy skills (refer to Chapter 2,2, *Figure 1: Scheme of Strides of BIMcert program*)

- specifically for this scheme, description of the LOs have a broader context, which enables their simple comparison and alignment with the other analysed schemes and accommodation of several relevant LOs develop in a more discretized format, by some of the other schemes,- because of the reason above, they can be easily detailed and split into micro units, to be adaptable for upskilling a number of professional profiles and applicable for their specific roles in a construction process.

It is also in compliance with the recommendations of the CEDEFOP Study (2019) for selection of reference point [23], according to which, the preferred reference point should be focused on real life professional tasks, have the lowest number of learning outcomes items, while its Competence Matrix, should allow indicating different performance levels.

4.5 Method of comparison of the content and level of proficiency of competences

A detailed comparison of the content, objectives and profile of each learning outcome to the reference scheme was applied, to identify commonalities, conformity and to appropriately mark them,

Mapping of the analysed LOs enables identification of the similar meaning, content and purpose (levelling matrix), and also determines commonalities and

differences in terms of performance levels by putting the identified similarities into a comparative format (the alignment matrix)

The method of sequential individual comparison makes the mapping process more time-consuming and requires deeper expertise in working processes in which professions are contextualized. On the other hand, it provides more precise results of matching, considering that some descriptions of LOs are presented in a rather broad manner, whereas others are too much focused on the details.

With an ambition to provide a basis for design of an intelligent mapping tool in further stages, automatic selection and filtering was considered in the working versions of files. However, automated text processing of qualification data could not provide adequate results, because of the diverse structure of the LOs descriptions (preventing automated recognition and reasoning), the variety of terms used for description of skills (that makes difficult and not precise the automated mapping of similar concepts), the fact that occupational profiles have not been compiled according to a uniform construction scheme consistently applied across all analysed frameworks.

The conformity in expected level of performance (maturity) was evaluated through the alignment matrices. For this evaluation, there was an opportunity for an autonomous selection, based on active verbs applied in Bloom's taxonomy.

4.6. Findings based on levelling & alignment matrix analysis

The levelling matrices were designed to show differences and similarities and to support recognition of learning outcomes obtained by different schemes, while the alignment matrices provide an overview of conformity of upskilling sequence and level of maturity achieved thereby, This method of comparison, in general, although with some limitations, can in most cases serve as a starting point for further steps and can be used to support training programs in reflecting on their own choices as well as in identifying parts of qualifications that are common across programs and countries [24].

The following main findings of the second stage of analysis can be specified:

1. The levelling and alignment matrices, based on comparison of LOs of different frameworks, confirm compliance, transferability, and, in some cases, supplementarity of the competences that were analysed:
2. Learning plans were established or selected (where they existed in the frameworks), presuming that the learning pathway starts without prior knowledge in BIM and EE skills. In case of prior knowledge, it will be recognized through a method that will be described within the ARISE QA&QC system. This approach also provided levelling of the analyzed schemes, putting them at the same starting point of upskilling.
3. All the analysed skill frameworks integrate digital and energy efficiency skills in a summarized similar order:
    - Introduction to digital skills
    - Introduction to sustainable energy skills
    - Integration of sustainable energy skills by leveraging thereof with digital skills, in a way specific for the professional duties and tasks of the observed profession (train how to deploy energy skills by use of BIM tools).
4. Most of the analysed schemes assign the same learning outcomes to various qualifications / professional profiles, with internal difference of maturity level, depending on the targeted profile. This is particularly evident for the initial modules in digital and sustainable energy skills (in the schemes by: *BIMcert*, the reference modules are *BIM Fundamentals* and *Introduction to Low Energy Buildings*). To enable an easier comparison in further analyses, it is recommended to introduce, e.g., assessment criteria (refer to *BIMcert approach*), that can evaluate different levels of skills, according to the needs of various professional profiles.
5. Notably, such an approach is in favour of the construction sector professionals, since they can have only several further learning modules if they change work place towards a similar profession.
6. Maturity level of skills of the three analysed professional profiles, span from 2 to 4 (dominantly 2 for the first and the third analysed profile, and 3 and 4 for the second one).

7. Maturity level of the initial digital and energy learning outcomes is mostly 2 (knowledge), and 3 (implementation) for further learning objectives (profession – specific), where the centre of gravity of the competences lies more towards level 3 and (in some cases) 4.
8. For all the analysed professional profiles, a good extent of compliance is evident, in two aspects:
    - Content of the learning outcomes (they can be correlated and matched with the LOs of the reference framework, in extent of 90 – 100 %)
    - Maturity levels: differences, estimated among the seven analysed frameworks, for the observed qualifications, as the max/ min average can be considered as low (20- 30%).
9. Differences between maturity of learning outcomes with similar content (aligned learning outcomes) can be further used to supplement a qualification, grading it at advanced and expert level.
10. Learning outcomes that can't be matched to the reference point can be used for profiling a sub-specialization in the observed professional profile (e.g., procurement officer of Client, maintenance operator in facility management, etc.)'
11. A better match is demonstrated for the profiles of *Clients, Designers* and *Construction site workers*, possibly due to the fact that these professions operate in areas with clearly defined technologies and standards, organization of work and professional practices.
12. The competences of the professional profile *Facility Manager* were found with the lowest level of match among the analysed schemes. This can be explained by the fact that the importance of the role of operators of buildings needs to be more recognized and included in professional schemes.
13. The professional profile with highest complexity and widest scope of learning plans and suite of learning outcomes (80 to 100 LOs per a scheme), in all the analysed schemes is the *Designer*. That is due to the: 1) professional duties and responsibility of this profession, in a) creating the digital environment (building digital twin) for collaboration of all profiles throughout the building life cycle), b) making decisions and solutions related to building performance, having impact on the complete life cycle , as well as 2) various architect and engineering

disciplines classified in the AEC clusters and 3) hierarchy in project development process (e.g. BIM modeller, coordinator, manager, etc.)

14. The high extent of similarity of skills and maturity, for the professional role Designer is due to active implementation of European directives for energy efficiency and compliance with national legislation, which demand certification of designers for energy efficient buildings.
15. Similarities of the concepts of all the analysed schemes, justified by the levelling matrices, point out on their modularity and portability.
16. The differences point out the potential for complementarity and encouragement for further splitting of the learning units (of different schemes), discretization of learning outcomes (possibly by disaggregation into sub-layers), and detailing into tasks, which eventually can lead to federation of the learning modules designed by different projects.
17. Portions for which convergence to a high extent is evident, enable transferability and interchangeability of the (sub)systems of skills, thus alignment thereof in horizontal plane (the same level of the same skills).
18. This is an important step forward towards the international recognition and appreciation of skills and qualifications and a possibility for creation of a comprehensive unified matrix capable of accommodating various upskilling and qualification schemes (for the observed professional profile), which is one of the pillars of the ARISE concept.

5. Conclusions

5.1. Specifics, compliance and complementarity of the analyzed models

The findings of the study, given below, consist of two main parts, those related to the relative features of the frameworks (Chapter 3) and those correlating them by the content and profile of the selected qualifications (Chapter 4).

1 All the analysed schemes recognized the need for improvement of competences in energy efficiency and digital skills, for all professional profiles across AEC sector, compared to the current level (that had been identified through basic analyses carried out by the projects)

2. They all pioneered the union of two frameworks, of digital and sustainability skills. They all agreed that the future of competences in sustainable energy skills in the construction sector should be observed in integration with digital skills.

3. Specifics of the analyzed frameworks can be seen in:

- contextualization of competences of professional profiles (type of work tasks and required level of proficiency for completion of tasks),
- importance of particular skills for a quality and autonomy of execution of professional duties (expressed through the skills content and maturity)
- method of integration of digital and sustainable energy skills,
- skills found as additionally required by some of the schemes (evident in the not – matched LOs),

4. Taking in consideration that frameworks have been developed on the basis of analyses in partner countries and beyond, considering thereby the NQFs and national sector's interests, compliance of the analysed LOs with the national frameworks can be expected, as will be further explored in Deliverables 2,3, 7.1 and 7.2 of the ARISE project.

5.2. Recommendations for development of conceptual design of ARISE framework of skills and competences

1) Competence matrices developed by ARISE shall enable comparability, transactability and deploy supplementary potential of learning outcomes developed by various frameworks.

2) Competences shall include both sets of skills (digital and sustainability), in a consistent way.

3) Each of the sets can be studied individually, whilst their integration shall be made in a point where professional profiles are directed towards their specific work duties.

4) Consistency shall be achieved by leveraging sustainable energy skills by collaboration in digital environment.

5) The role of the same professional profile in a building life cycle do not have to be prioritized, allowing the same profession to acquire knowledge and skills required for participation in all stages.

5.3. Guidelines for following technology progress in the fields of a) sustainable energy, b) digital skills, c) innovative methods of delivery and recognition, d) new professions and jobs

1. As a general recommendation, technology progress shall be followed by including progressively data and information about emerging and adopted technologies in the fields of NZEBs and digitalization, into learning outcomes and training materials.
2. Professionals shall be taught how to insert, find and apply digital data related to advanced materials and technologies, in a BIM model, in particular those related to sustainable materials, construction methods and techniques, energy performance and clean energy generation [28].
3. The main approach shall be to learn how to use digitalization:

- To improve collaboration in a construction process and construction project, and make it a more efficient and effective, towards reduction of costs, time and performance gap,
- To enhance and continuously improve energy performance,

4. Particular attention shall be paid to compliance of software tools for calculation of energy performance with the EU and national directives and technical codes, covering energy indicators and coefficients.
5. Follow up and alignments with the globally adopted competences in sustainability shall be applied.
6. Particular attention shall be turned on a) renovation projects, b) specifics of non – residential buildings, c) specific types – traditional and historical buildings.
7. Professional fields that shall be further considered in the sustainable skills framework are [25], [28]:

- energy monitoring and auditing,
- energy storage,
- smart energy management systems,
- energy recovery and reuse,
- maintenance of energy performance,
- synergy with circular economy of construction materials and efficient use of resources [25],
- incorporation of nature-based solutions,
- micro grids and concept of prosumers,
- climate adaptiveness of buildings.

8. Professional fields that shall be further considered in the digital skills framework include BIM as a connection tool with disruptive digital technologies in the construction sector [29]:

- digital manufacturing, pre fabrication and modular construction
- autonomous (intelligent) construction
- cloud &real time collaboration
- big data and predictive analytics
- augmented reality and visualisation
- 3D printing and additive manufacturing
- 3D scanning and photogrammetry

9. Methods of delivery shall progress towards autonomous e-learning. Transaction mechanisms of recognition of learning shall be put in place to support the novel learning methods [26],[27].
10. The analysis of compliance and complementarity, based on method of comparison of LOs, enables to identify perspectives for continuous development of the ARISE framework, in order to meet the future demands for new competences in the construction sector, with a three – fold response: to labour market demands, technology progress and advanced methods of training delivery and recognition.

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7. Appendices

7.1 Appendix 1 - Summary of comparative analysis of frameworks and maturity models of skills

	Skills framework model	Number of learning modules	Content of Learning Units			Target groups included					Recognition	Method of delivery
			Separate BIM modules	Separate EE modules	BIM & EE modules	Public administration	Designers	Construction contractors	Blue collars	Clients (PA, FM, OM)	Certification / Recognition	
BIMcert	3 Strides of learning units; consisting of micro modules (learning outcomes); combinations (learning plans) to achieve targeted qualification; LOs defined on the basis of survey of industry needs.	30	yes	yes	yes	yes	yes,	yes	yes	yes	OCN, CPD	Blended / digital
BIMzeED	Set of learning units and accompanied learning outcomes defined in line with EQF; recommended learning plans (combination of learning units) for specific users, to	12	no	no	yes	yes	yes	yes	yes	yes	Consortium / project certificate	Blended

	achieve required skills maturity level											
NETUBIEP	3D matrix of skills and competences, based on roles in a building life cycle, combined with roles in a BIM process of information exchange Prof-Trac based skills for EE; BIM skills based on survey and analysis within the consortium; EE skills upgraded with BIM	4	no	no	yes	yes	yes	yes	yes	yes	Building Smart	Blended
BIMEET	Based on identified roles and responsibilities of target groups in a building life cycle and BIM process; several levels of analysis – surveys, panel of experts, country specifics, etc.)	2	no	yes	yes	yes	yes	yes	yes	yes	Project level, ambition for EU recognition	Blended
BIMPLEMENT	Task based (multi-layered (knowledge - skills -competence matrix);; combination of generic, EE an BIM skills,	12	yes	yes	yes	yes	yes	yes	yes	yes	National (project partners) QFs	Digital, Blended On site
NEWCOM	Task based; focus on air tightness, ventilation, and	31	yes	yes	no	yes	yes	yes	yes	yes	National (project partners) QFs	Digital, Blended On site

	quality control; target groups: construction site workers, quality managers designers; introduced competence database											

7.2 Appendix 2 – Alignment matrix of LOs for professional role Client (Public Administration and Private Investors)

BIMcert		BIMZEED		BIMEET		NetUbiep		BImplement		BUILDING SMART			
Learning Outcomes	Level	Learning Outcomes	Level	Learning Outcomes	Level	Learning Outcomes	Level	Learning Outcomes	Level	Learning Outcomes	Level	NEWCOM	Level
3. BIM for Clients	2	Combination of LUs	2,33	Combination of LUs	2,00	Combination of LUs	2,33		2	Combination of LUs	2,00	Building Information Modelling (BIM) Systems	2,67
1. Define the role of the client or their representative, including Facilities Managers, in a BIM process	2	2 Identification and selection of the Project Procurement Model requirements in the form of the Delivery Model (Contract) and Procurement Strategy.	2	Explain owners' strategic target setting processes to guide energy and performance requirement setting in business cases.	2	**C0.K6. Relevance of maintenance to maintain the foreseen energy performance**	2			2.5 Identify the benefits of BIM adoption to clients and facility management.	2	Can discuss the benefits and potential of BIM in a project team.	**2**
2. Define what assets and level of detail are required to enable a client to develop Organisational, Employer's and Asset Information Requirements	2	**2. Develop and define the Statement of Requirements (SOR) or Statement of Work (SOW) describing the BIM deliverables, essential requirements, and specifications**	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.	2	C4.K3. Principle of planning and scheduling for BEP (BIM Execution Plan); C4.K8. Principle of information maturity level representation of the model defining the methodology for BIM maturity level	2			**1.2 Identify and list the technologies to be used for existing conditions when developing BIM models for new and/or refurbished building; 1.4 Identify the benefits of including energy performance requests in the Exchange Information Requirements (EIR); .2 Identify the benefits of including energy issues when developing a BIM Execution Plan (BEP);**	2	**Can link interfaces of software packages with tools for quality assurance.**	**3**
3. Summarise the use of BIM in a variety of client contexts, with particular emphasis on whole lifecycle costing and added value	2	**4. Establish the information framework required to assist communication and collaboration from Design - Construction - Operation for asset handover**	3	3. Learner is able to prepare BIM execution plan and explain essential aspects in setting strategic and project targets	2	C3.K1. Processes, methods and principles of decision-making on procuring services and suppliers; C3.K2. Theories and principles for the selection of products; C3.K3. Legal and technical aspects on green procurement, state and rules for using public funding and international good practices of energy performance; C3.S5. Define building environmental impact as part of the contract; C3.S6. Include measurable Quality Analysis criteria as part of the contract	3	List in specifications, ask for a 3D or BIM model to be able to follow the evolution of the project from sketch to call for bid, but do not impose BIM data	2	2.5 Identify the main actors of the building process to produce, exchange and maintain information of the BIM model and their roles and responsibilities for energy efficiency	2	**Can support the implementation of integral planning in building projects.**	**3**

(Learning objectives correspond to the BIMcert Module: BIM for Clients)

7.3. Appendix 3 – Alignment matrix for a representative sample of LOs for construction site workers

BIMcert		BIMZEED		BIMEET		NetUbiep		BImplement		BUILDING SMART		NEWCOM	
Learning Outcomes	Level	Learning Outcomes	Level	Learning Outcomes	Level	BIM USER	Level	Learning Outcomes	Level	Learning Outcomes	Level	Learning Outcomes	Level
4.BIM for Site Data Mnagement, LO 3. Use Cloud Technologies for Site Data Management	3,00	Combination of LUs 2 and 5	4,25	LO3:Learner is able to manage BIM based construction processes and support the client and other stakeholders in decision making.; LO8: Learner is able to use different relevant software and interfaces between relevant software	2,80	C4.ME Use BIM technology	3,00	Module 4: Using the Viewer to Find More Complex Information. Module 6: Communicationg via viewer. Module 7, Module 9	3,00	Module 4: Recognize the need for open and interoperable solutions	2,00	Module 1: Building Information modelling Ssytrem	
3.1 Use a cloud technology to access information from BIM models.	3	4. Assess systems related to building function and architecture.	4	8.1 Use digital construction management tools and systems; 8.2 Create combination model and use model checking tools for clash detection; 8.3 Use different tools for BIM-based collaborative working.; 8.4 Use tools for information take-offs from the models.8.5 Use tools for 4D and BIM based site management plan.8.6 Use BIM viewers with tablet devices; 8.7 Use project data and file management systems.	3	C4.K2. Principle of integrated design and data transferring, with particular knowledge of IFC (Industry Foundation Classes) structure using international standards	3	Ccomplex data in the digital BIM model (in what space are theses objects attached to?) specific objects and properties	3	4.1 Define who buildingSMART are; 4.2 Define open BIM and its benefits compared to using proprietary products and systems;;	2	Know the functionality of major BIM software packages	2
3.2 Use a cloud technology to collaborate with the team on site e.g. mark ups, clash detection, etc.	3	1. Compare 2D plans / drawings (contractual precedence) to BIM model though a diligence checking. Export 2D plans and other documentation from the BIM model on site. Financial management.	4	6.3 Demonstrate how to work collaboratively with the project stakeholders including the design team, client, users, manufacturers, construction site and building authorities.; 6.4 Explain possibilities	3	C2.S9. Ensure that construction process and product information is transferred into BIM Model / Technical Specifications and provide information on status of works when request; C3.S6. Include	3	Multiple BIM model handling; MEP models (General questioning when drafting a BIMplement training course in relation with ventilation and airtightness);Structures model	3	4.3 Know what IFC is and its benefits; 4.4 Know what MVDs are their benefits;; 4.5 Know what IDMs are their benefits;; 4.6 Know what the bSDD is and its benefits; 4.7 Know what BCF is and its benefits.	2	Can support the implementation of integral planning in building projects.	3
3.3 Use a cloud technology to assign information to the model e.g. checklists to populate QA/QC procedures, Site issues, QR codes, RFIDs, etc.	3	3. Manage data, keep records of implementation, monitor outcome.	3	3.3 Utilize 4D for schedule visualization and communication to provide project team understanding of project milestones, schedule, and construction plans.	3	C4.K3. Principle of planning and scheduling for BEP (BIM Execution Plan); C4.K7. Techniques of automatic code checking and management of software e-permit	3	5.2. Handling in autonomy: Searching for information that requires the use of all the tools used in the 4 previous modules	3				
3.4 Issue reports via cloud technology.	3	2. Communicate with customers on construction progress and effectuation of building performance.	3	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.	2	C4.K8. Principle of information maturity level representation of the model defining the methodology for BIM maturity level	3	6.1 How to exchange with others; 6.2. The different tools that can be used; 6.3. Find tools location; 6.4 Draft notes / comments / labels; 6.5 Send questions; 6.6. Read answers	3				
3.5 Use a cloud technology to collaborate with the design team.	3	11.Monitor project realization and handle deviations. Communicate in contracting phase, understand and respect the role of all actors involved.	3	3.5 Use construction production model for scheduling, management, control, monitoring and commissioning, visualization, planning procurements, planning construction site.	3	C4.S8. Produce a visualization design in order to report back to costumers, users and reviewers	3	Module 7: *Links between BIM models and documents*	3			Can link interfaces of software packages with tools for quality assurance.	3

(Note: Learning objectives correspond to the BIMcert Module: BIM for Site Data Management)

7.4. Appendix 4 – Alignment matrix for a representative sample of LOs for Facility Managers

BIMcert		BIMZEED		BIMEET		NetUbiep		BImplement		BUILDING SMART		NEWCOM	
Learning Outcomes	**Level**	**Learning Outcomes**	**Level**	**Learning Outcomes**	**Level**	**BIM USER**	**Level**	**Learning Outcomes**	**Level**	**Learning Outcomes**	Level	**Learning Outcomes**	Level
3. BIM for Facilities Mnagement	**1,33**	**LU11: Near Zero Energy Building Facilities Management**	**1,85**	**LO4: Learner is able to use BIM for facilities and utilities management, operation and maintenance.**	2,60	**C3.ME Apply procurement management**	2,83	**Modules 7 and 8**	**3,00**		**2,75**	Building Information Modelling (BIM) Systems	0,00
1.1 Identify current inefficiencies within existing Facilities Management (FM) processes.	2	**11.1 Facility or asset performance checking to confirm it is working at optimal expectations and as designed**	4	**4.1 Explain the BIM-based and intelligent FM information workflow for different kinds of care and maintenance tasks**	2	C3.K1. Processes, methods and principles of decision-making on procuring services and suppliers	2						
1.2 Summarise how BIM-FM integration can target these inefficiencies	2			**4.2 Explain the use of the maintenance model in property management and doing short term and long term planning.**	2	C3.K2. Theories and principles for the selection of products	`						
1.4 Understand how BIM for FM can be strategically integrated to achieve an organisation's business goals.	2	12.5. Understand the impact of BIM to Asset and Facilities Management and how this transforms interaction within the project	2			C3.S5. Define building environmental impact as part of the contract	1					Can discuss the benefits and potential of BIM in a project team.	**2**
2.1 Establish the relevance and correlation between Organisational, Employer's and Asset Information Requirements.	3	**2.1** Establish the relevance and correlation between Organisational, Employer's and Asset Information Requirements.	3	**11.6. Establish the coordination framework required from Construction – Operation by using data inputs and model structure to organise modelling elements efficiently**	3							**Can support the implementation of integral planning in building projects.**	**3**
`3.1 Use a BIM for FM software packages to access digital data associated with an asset.	3	11.2. Linking asset data to the model for facility management; 12.1. Linking asset data to the model for facility management; 12.2. Collect, manage and disseminate documentation, graphical models and non-graphical data for the whole facility team in a Common Data Environment (CDE); 12.3. Establish the information framework required to assist communication and collaboration from Construction -Operation for asset management; 12.4. Establish the coordination framework required from Construction – Operation by using data inputs and model structure to organise modelling elements efficiently	3	6.1.Use BIM - based facilities management tools and systems.6.2. Use different tools for BIM-based collaborative working.6.3. Use tools for information extraction from the models; 6.5. Use model based maintenance manual for management of technica linformation, service requests, contracts, documents, various maintenance tasks, maintenance history etc.6.6. Use digital archive systems for documents and models.	3	C5.K3 Principle of integrated design and data transferring, with particular knowledge of IFC (Industry Foundation Classes) structure using international standard; C5.S4. Validate BIM Model	3	Module 7: ***Links between BIM models and document; earn how to locate, read and attach documents to the BIM model (technical document and BIMplement educational material attached inside the BIM model);***	3	5.4 Identify and assess the risks of using incorrect information that are essential for facility management and maintenance	2	**Know the functionality of major BIM software packages**	**2**
3.2 Use a BIM for FM software package to collaborate with the FM Team.	3	11.7. Identify interdisciplinary teamwork towards common goals	3	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	3	C2.S5. Evaluate the completeness of the handover strategy; C2.S6. Verify the correspondence between the "as built" and the final BIM model; C2.S9. Ensure that construction process and product information is transferred into BIM Model / Technical Specifications and provide information on status of works when request; C2.S10. Ensure the update of the BIM Model / Technical Specification when a maintenance is performed;	3	Module 6: Communicating with the Viewer; 6.1 How to exchange with others; 6.2 The different tools that can be used; 6.3 find tools location; 6.4 draft notes / comments / ; 6.5 Send questions; 6.7 Read answers	3	5.2 Identify the information requirements and standards for open BIM information exchange for the facility management	3	**Can link interfaces of software packages with tools for quality assurance.**	**3**

(Note: Learning objectives correspond to the BIMcert Module: BIM for Facility Management)

7.5. Appendix 5 – Alignment matrix for a representative sample of LOs for Designers –Architects

BIMcert		BIMZEED		BIMEET		NetUbiep		BImplement		BUILDING SMART		NEWCOM	
3 Introduction to Low Energy Building Construction	**2,00**	**LU3: NZEB Realization and Commisssioning: building enevelope and Air Tightness; LU4: NZEB Realization and Commissioning: Building Services and Smart Technologies**	**2,33**	**LO2:Learner is able to explain the fundamentals of sustainable and energy-efficient buildings and building performance; LO4: Learner is able to implement energy performance, building performance and sustainability targets into design process**	**2,67**	**BIM Expert - Specialist, C4.ES Use BIM technology, C4.ES Analyse the BIM Model**	**2,00**	**n/a**		**Mod. 6.2 Understand which information is necessary to specify, produce, exchange, and maintain during the preliminary design stage; Mod. 6.3 Understand which information is necessary to specify, produce, exchange, and maintain during the technical design stage**	**2,83**	**Module: Quality Assurance and Quality Control**	**3,00**
1. Summarise the key terms and definitions associated with energy use in buildings	2	Identify the interaction of building location, design, use and outdoor climate.	2	2.1 Explain and give examples of aspects and terminologies of energy and building performance; 2.5. Point out legislation and regulations related to energy performance, thermal comfort and air quality	2	C4.K4.Principles of interplays between all aspects of building design, building use and outdoor climate for dynamic evaluation; Principles and systems of sustainable buildings, including renewable energy production	2			1.5 To identify local and national legislation before performing the energy analysis	3	Module 1: Basic of building physics	3
2. Outline the key principles of energy usage and wastage during the construction and operation of buildings	2	Recognise design methods for passive energy technologies; Select sustainable constructions technologies and materials; Identify sustainable materials and the importance of its appropriate application	2	2.3. Explain the issues that affect energy performance of buildings and demonstrate competence in domain specific solutions.	2	C4.K6. Design techniques for different scenarios for new resilient buildings to future climate changes and for the refurbishment of existing buildings	3			4.2 Identify use cases for energy efficient construction of NZEB buildings; 5.1 Identify use cases for energy efficient management of Nearly Zero Energy Buildings at the operational stage;	3	Module 2: Building materials; Module 3: Building components	3
3. Show how a building's fabric can generate high levels of energy output	2	Recognise the impact of architectural design on sustainability and energy performance;	2	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.	3	C5.K1. Principle of global environmental impact of different building products and technologies (RES use, insulation, HVAC systems and building automation systems)	2			1.3 Understand the strategies to reduce energy consumption and sources of renewable energy, both in the choice of materials and in the design of construction solutions, to guarantee a low energy consumption	2	Module 11: Thermal activation of building components	3
4. Exhibit how a building's heating and ventilation system can consume high levels of energy	2	Explain how act influence of heating and cooling generation on energy performance; Identify specifics and basic parameters of heating and cooling;	2	4.2. Implement passive house design strategies for architectural design.	3	C4.K5. Principles and systems of sustainable buildings, including renewable energy production	2			2.4 Identify the key technologies that could be considered in a BIM simulation, to evaluate cost / benefit analysis on preliminary design of a Nearly Zero Energy Building (NZEB)		Module 6: Heating technology; Module 7: Ventilation technologies; Module 9: Air conditioning technologies	3
5. Outline the key principles of System Thinking	2	Select sustainable construction technologies and materials; Recognise and illustrate effective communication within projects aimed to achieve nZEB; Evaluate the integrated design	3	2.4 Explain relations between life-cycle costs, environmental impacts, energy performance and building performance and the quality of construction work.	2	C5.K3 Principle of integrated design and data transferring, with particular knowledge of IFC (Industry Foundation Classes) structure using international standard	2			2.1 Identify the purpose and advantages of using BIM for improving energy performance of a building during its lifecycle, compared to traditional methods	3	Module 12: Energy balances - demand forecasts, energy certificates and certification programmes;	3
6. Illustrate the use of BIM tools in Low Energy Building Construction	2	Create BIM elements for nZEB design considering parameters such as transmittance and orientation; Design and engineer energy reduction systems to reach nZEB - in respect to building envelope	3	4.7. Produce, simulate and analyze what if scenarios for different energy efficient design alternatives and make feasibility studies	4	C4.S5. Use BIM enabled simulation techniques to reduce the environmental impact	3			2.1 Identify the purpose and advantages of using BIM for improving energy performance of a building during its lifecycle, compared to traditional methods	3	Module 13: Building Information Modelling (BIM) systems	3
											3		

(Note: Learning objectives correspond to the BIMcert Module: Introduction to Low Energy Building Construction))