Grant Agreement No: *753994*

Project acronym: BIMEET

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

Funding scheme: CSA

Starting date of project: 1st September 2017

Duration: 24 months

BIMEET

D2.1 – BIM for energy efficiency requirements capture

Due date of deliverable: M4
Actual submission date: 15.03.2018

WP 2 **Leader: Cardiff University**
Task 2.1 **Leader: Cardiff University**

Deliverable Status	
DL	Delivered
Dissemination Level	
PU	Public

1 Executive Summary

The report D2.1 covers the phase of requirements capture of the BIMEET project. Whereas BIMEET project aims at offering specialised training and educational programs to support with BIM implementation agenda for energy efficiency in Europe, the current report is addressing the requirements elicitation phase. This phase involves training requirements collection and associated analysis in order to inform the training elaboration phase with regards to skills, competencies and required qualifications.

The report provides in-depth analysis and gaps identification in relation to skills and competencies involved in BIM training for energy efficiency prior to integration with following training models and strategies. Consultations and interviews have been used as a method to collect requirements and a portfolio of use-case has been created to understand existing BIM practices and determine existing limitations and gaps in BIM training.

9 Conclusions

In this report we address the requirements elicitation phase for determining gaps and new strategies in delivering BIM training for energy efficiency. We have used a participative and incremental approach and involves the BIMEET expert panel with a view to reach key stakeholder communities with a view to help identify and then screen / analyse past and ongoing projects related to energy efficiency involving aspects of BIM.
Our analysis and studies aimed at 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. We have recorded a number of 38 best practices use-cases from the field of BIM for energy efficiency and conducted in depth-analysis to understand which are the gaps in BIM training and possible areas of improvement. These use-cases are published and maintained on the BIMEET Platform (www.energy-bim.com) and accessible to potential users across Europe. The resulting evidence has been structured by stage and discipline, highlighting stakeholder targets ranging from blue collar workers to decision makers.
As part of this report, the main objective was to identify the gap between the demand of skills and the learning for BIM application in energy efficiency. We have used a consultation driven methodology and use-cases aggregation techniques supported by a semantic searching engine to facilitate submission of BIM queries with sets of associated ontological concepts for recording “live” BIM knowledge and to search for best practices. The consultation process has helped both in defining skills related to BIM technology and associated application for energy efficiency in buildings and, in identifying the BIM training requirements across the value chain (from blue collar workers to middle/senior level workers).

Therefore, in this report we have addressed two major objectives:

1. Identify critical gaps in terms of BIM skills and related training offer based on an assessment of the current situation and,
2. Deliver a set of requirements as derived from the consultations, interviews and use-cases analysis.

Our approach has started from the consultations process that identified, analysed, and assessed construction sector stakeholders’ requirements for BIM training to ensure engagement with energy management in construction. This research revealed a set of perceived barriers to engagement at individual, organisational, and wider industry levels. Based on the research results it was found that an online training repository that provides integrated access to BIM resources (knowledge, expertise, best practice, and software tools and applications) in the form of interactive, dynamic, and user-oriented services may address these barriers.
From the analysis of the consultation results, and the associated literature review, the initial specification of such BIM training and education for energy environment, including the general service requirements, skills to address and organisational policies have been ascertained and described.
We have also identified the need to establish an open BIM community of end-users with access to resources and facilitating training and education programs in order to overcome some of the restrictions to sharing and BIM information exchange which is a major problem in the field.

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BIMEET

D2.2 – Benchmark of existing training offers

Due date of deliverable: 31/03/2018
Actual submission date: 31/08/2018

WP 2 **Leader: Cardiff University**
Task 2.2 **Leader: BRE**

Deliverable Status	
DL	Delivered
Dissemination Level	
CO	**Confidential** Only for members of the consortium (including the Commission Services)

1 Executive Summary

This report involves benchmarking existing EU-wide Building Information Modelling (BIM) training across the building value chain (incl. lifecycle and supply chain). This phase of the project involves highlighting energy efficiency linkages; identifying qualification targets and accreditation mechanisms, whilst highlighting training gaps and enhancement potential.

It highlights the challenges and benefits associated with integrating BIM into energy performance assessment with the aim of streamlining procedures to help ensure delivery of energy efficient buildings which perform more closely to their design intent.

Building on the BIMEET D2.1 deliverable (BIM&EE requirement capture), this report reviews the training offered in the countries represented by the project partners to the supply chain across the construction life cycle. In particular it considers the role of apprenticeships and university courses as a vehicle to develop suitably trained construction professionals in this field. It also assesses the existing BIM training provision and associated certification offered by training organisations to determine whether this can provide the required skills and knowledge.

7 Conclusions

We can gain good insight into the overall provision of BIM and energy efficiency training based on the apprenticeship offerings described in Section 5, the BIM/energy efficiency training summarised in Section 6, the wider findings from the BIMEET expert panel workshop in Brussels and experience gained from the BIM4VET project. Figure 20 overleaf is a 'traffic light' matrix that illustrates the level of training offered across each of the RIBA plan of work stages for the key stakeholders in the construction supply chain. For completeness two matrices are presented: one focussing on BIM training, the other showing integrated BIM and energy efficiency training.

The key points to note are:

- Raising awareness of BIM across the supply chain is reasonable, particularly amongst designers, contractors and clients, but *there could be improvements amongst sub-contractors and facility/asset managers*. With regard to BIM/energy efficiency awareness raising, the provision is limited across the supply chain.
- Similarly, designers and contractors are well-served by BIM training across the concept, design, construction and handover phases. This is usually provided by private training organisations. In this they are supported by certification schemes offered by these bodies, such as those in France and the UK, whereby they can demonstrate their knowledge and competence. Such courses *are often focussed on modelling software*, as in Greece for example, which emphasises the planning and design aspects.
- Students also appear to be well-served, at least those taking bespoke BIM degree courses such as a masters (Level 7) in the UK, or the Level 5 and 6 courses offered by universities in Finland. *Bachelor degrees in traditional construction areas such as architecture, civil engineering, surveying, planning and construction management are increasingly integrating BIM*.
- *Conversely, the extent of integrated BIM and energy efficiency training is either poor or limited in these areas*. Some of the Finnish courses do incorporate aspects of energy and use well-established software tools to undertake energy simulations, overheating assessments etc. Similarly, some of the UK masters degrees include treatment on the delivery and performance of low energy/sustainable buildings, but these are in the minority.
- Software providers are helping to fill this void and are providing courses aimed at modellers and designers helping them to integrate BIM and energy performance tools with the intention to streamline the process and avoid duplication. There is *certainly scope to integrate BIM into national calculation methodologies for energy performance certification, thermal bridge assessment* etc.
- Clients, facility managers and sub-contractors do not appear to have sufficient BIM training across many of the plan of works stages, and such training is largely absent for BIM/energy efficiency. The situation is much the same for students outside of the brief, concept and design stages.
- Overall, the position is developing rapidly with the proposed establishment of courses across the project partners, particularly courses in Luxembourg and France, university courses in the UK etc. but there needs to be a focussed effort in those areas where the main gaps have been identified.

	BIM training	Clients	Facility and asset management	Design consultants (inc. technicians)	Contractors (inc. site managers)	Sub-contractors (inc. blue collar workers)	Students
	Awareness						
RIBA stage	0. Definition						
	1. Brief						
	2. Concept						
	3. Design						
	4. Technical						
	5. Construction						
	6. Handover						
	7. In use						
	Demolition						

Not relevant
Reasonable
Limited
Poor

	Integrated BIM and energy efficiency training	Clients	Facility and asset management	Design consultants (inc. technicians)	Contractors (inc. site managers)	Sub-contractors (inc. blue collar workers)	Students
	Awareness						
RIBA stage	0. Definition						
	1. Brief						
	2. Concept						
	3. Design						
	4. Technical						
	5. Construction						
	6. Handover						
	7. In use						
	Demolition						

Figure 20. Traffic light summary of BIM and energy efficiency training (Top: BIM training, Bottom: BIM and energy efficiency training)

- One of the areas to address is apprenticeships. As noted above, efforts to improve them are being made, including:

    - improving the image of apprenticeships
    - re-structuring apprenticeships to make them more inclusive, improve entry routes and clarify career pathways
    - providing additional guidance and funding
    - engaging with employers
    - improving the quality of apprenticeships and providing transferable skills

But a key point is to introduce energy efficiency as a cross-cutting theme and to improve the integration of BIM into apprenticeships as this will help to fill the training gaps amongst, for example, facility managers, sub-contractors (including blue collar workers and technicians) etc. who are responsible for the design, installation and maintenance of fabric measures, building services etc.
Finland is introducing BIM into its vocational courses and France has already made considerable strides in this direction and is integrating BIM into its *Brevet de technicien supérieur* (BTS) Fluids, Energies, Home Automation (FED).

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BIMEET

D2.3 – BIM for energy efficiency required roles and skills

Due date of deliverable: 31/05/2018
Actual submission date: 31/08/2018

WP 2 **Leader: Cardiff University**
Task 2.3 **Leader: Cardiff University**

Deliverable Status	
DL	Delivered
Dissemination Level	
PU	Public

Executive Summary

The report D2.3 covers the phase of requirements capture of the BIMEET project and identification of roles and skills. Whereas BIMEET project aims at offering specialised training and educational programs to support with BIM implementation agenda for energy efficiency in Europe, the current report is addressing the definition of roles and skills based on the requirements elicitation (see Deliverable D2.1). This phase involves training requirements collection and associated analysis in order to inform the future training elaboration phase with regards to skills, competencies and required qualifications.

The report provides in-depth analysis and identification of roles and skills involved in BIM training for energy efficiency prior to integration with following training models and strategies. Social media analysis have been used alongside standards, use-cases, interviews and scientific publications as a method to collect roles and skills in order to inform future BIM practices and promote improved BIM training and education.

5 Conclusion

This report conducts intensive analysis for identification of skills and roles for the process of BIM for energy efficiency. From the evaluation of process, we have implemented four analysis scenarios identifying use-cases analysis, interviews analysis, scientific publication and international standards analysis as well as twitter analysis.

Our approach has started from the consultations process (see BIMEET D2.1 and D2.2) that identified, analysed, and assessed construction sector stakeholders' requirements for BIM training to ensure engagement with energy management in construction. From this consultations and use-cases we have applied NVIVO qualitative and quantitative analysis to determine skills and roles of BIM for energy efficiency. The aims of this report is to determine skills and roles which will inform the training process which can greatly educate a community of users in the field of BIM and promote energy efficient practices among companies and users.

The findings show that the evaluation that has been employed for skills and roles identification has helped to understand better the training requirements and gaps for the BIM training process and has the ability also to support the implementation process which has an impact on energy practices and BIM implementation program in Europe. The evaluation of the stage referred to as "social media analysis" showed that the resulted list of roles and skills is novel and can bring new insights into the process of BIM training and education. The new technological capabilities proposed by social media gave a unique opportunity to re-engineer and improve the existing methodology and to extend on the existing state of knowledge for BIM in energy efficiency. In addition to the acknowledged role of social media, the analyses have suggested that some organisational characteristics had to change in order to facilitate change and support the implementation of the new BIM processes leading to the conclusion that, besides relying on a specific technology, BIM is a dynamic process that cannot be captured with traditional analysis methods. The analyses have also shown that this stage was crucial due to the number of supporting concepts which play a major role in the BIM process characterisation and a holistic methodology is required for the assessment of BIM with associated competencies and training programmes.

Finally, the analysis also demonstrated that an organisation in the field of BIM for energy and construction needs to pay attention on organisational and human skills involved in BIM process and adapt a "continuous improvement" approach to change. From the related work, it was determined that the role of these BIM roles and skills concepts is very often neglected in the existing BIM studies. For example, all the studies reported the urgent need of training in order to use efficiently the existing BIM skills and competencies and utilise the full potential of the new system in order to increase productivity and improve quality. Also, the analysis of the research results showed that there is a potential danger of resistance to change which might constrain the overall change process. As a result, the analysis we have conducted has shown a need to involve the end-users more closely in the decision-making process as well as in the implementation process.

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Duration: 24 months

BIMEET

D3.1 – Definition of responsibilities and roles for BIM & Energy Efficiency

Due date of deliverable: 31/08/2018
Actual submission date: 31/08/2018

WP 3 **Leader: INES Formation**
Task 1.1 **Leader: INES Formation**

Deliverable Status	
DL	Delivered
Dissemination Level	
PU	Public

Executive Summary

The roles and skills listed in WP2 are analysed according to the European Qualification Framework, and a list is established considering the screening and benchmarking of training institutions performed in T2.2.
The actors' profiles and responsibilities related to BIM and energy efficiency in building are identified from case study analysis, software benchmarking and the review of BIM guidelines.
Then, a framework is proposed according to the EQF recommendations. *Knowledge*, *Skills* and *Competencies* are being associated to each *responsibility* in relation with BIM and energy efficiency. Knowledge is the basic and general information stakeholders should have to accomplish a responsibility. Skill is the technical and detailed information each actor should know in his domain, i.e. in other words: the know-how. Competency is the aptitude to accomplish a responsibility.
This framework enables distinguishing different levels for each responsibility, i.e senior and technician, and helps to define the level of EQF. In this context, Bloom's taxonomy is also used to better define competencies and define learning outcomes in a further work.

5 Conclusion

This report presents the methodology adopted to define stakeholders' responsibilities and associated knowledge and skills according to the EQF recommendations. This is done through the eight phases of RIBA Plan of Work.

A first study was elaborated around the results of WP2: roles and skills of different stakeholders A list of responsibilities related to BIM and Energy Efficiency was then concluded and defined for four main groups of roles: clients, contractors/ sub-contractors, design consultant and facility management.
A second study was elaborated around BIM to BEM workflows. Partners have defined some workflows using different 3D design and thermal tools. IFC and gbXML are the common formats of exporting and importing models. Main results of thermal simulations were exposed in this report. Definition of these workflows helped us to complete the list of responsibilities.
Further an extensive review of COBIM enabled to extract the most common responsibilities related to BIM & EE.

This responsibilities' matrix enables a better understanding of the involvement of the different stakeholders in the life cycle of buildings. For example, Clients are involved essentially during the phase preparation and brief phase. Contractors intervene rather on the technical design and construction phase. Design consultant have their main responsibilities during concept, developed and technical design. Regarding facility management, senior and technicians are involved essentially when the building is in use.

According to the EQF recommendations, knowledge and skills ssociated to each responsibility are defined. Knowledge is the basic and general information we should have to accomplish a responsibility. Skill is the technical and detailed information each actor should know in his domain, in other words, the know-how. Competency will be discussed later with the learning outcomes in order to define the EQF level corresponding to the training.

We note that new skills appear with the BIM & EE process and required for almost all roles, such as communication. In fact, to better evaluate the energy efficiency of the building, actors should communicate around their models and energy scenarios. Reporting skills are essential, too, such as they permit to understand the decisions made generally along the process, and especially to enable architects who don't have necessarly energy knowledge for example, to understand the results of energy simulations.

Based on these results and the different responsibilities and associated skills defined in this report, learning outcomes will be defined in the European level and will be adapted therefore in the national overlay.

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BIMEET

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

Due date of deliverable: M14
Submission date: 31.10.2018 (first draft)
Submission date: 31.01.2019 (final version)

WP 3 **Leader: INES**
Task 3.2 **Leader: METRO**

Dissemination Level		
CO	Confidential	CO

Executive Summary

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

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

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

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

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

- Focus is always kept on the learner: what is (s)he expected to know or understand.
- Learning outcomes need to be defined and written in a way where there is room for individual and local adaptation.
- Too detailed statements should be avoided. Also overly complex statements prevent learners, teachers and assessors from relating to the statements.
- Learning outcomes cannot replace related knowledge, skills and competence statements.
- Learning outcome should start with an action verb, followed by the object of the verb as well as a statement specifying the depth of learning to be demonstrated, and complete with an indication of the context. Table 3 illustrates the system.
- Generally not more than one action verb for each learning outcome. Figure 4 was used as one of the references for using appropriate action verbs.

The objective of this work was to define the first draft of the learning outcomes for training courses that would provide the required skills and knowledge for the selected roles in design,

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

building and maintenance processes in order to effectively utilize building information modelling for energy-efficient buildings.

The first draft for the definition of the learning outcomes was based on country specific definitions for the required KSC for the main roles. The basic method for defining the country-specific requirements was based on the following procedure:

- defining the main roles in design, building and maintenance processes
- identification of the main process phases
- identification of tasks related to energy performance management and BIM for the different roles based on the main phases
- defining the required KSC for the roles to manage these tasks in different phases
- summarizing the results for role-specific requirements
- concluding the required learning outcomes on the basis of the summarized required knowledge, skills and competence.

During this procedure, national guides for plans of works for different roles and national guides for common BIM requirements were made use of in defining phases, tasks and roles. For example in Finland, guides for plan-of-work have been formulated for architectural design, structural design, HVAC/MEP design, and management of building projects.

In addition, the earlier results from previous stages of BIMEET and common European projects that have studied advanced BIM processes for energy-efficient design and building were made use of when formulating the needed knowledge and skills during the performance-based and BIM-based design and building process. These include the recent HOLISTEEC project that developed methods and tools for BIM-based energy efficient design [4] [5]. In the formulation of the learning outcomes, this report also studied the on-going relevant projects and their conclusions about learning needs.

Construction industry and building projects has several roles and stakeholders. Because of existing differences in design, building and maintenance processes, the main roles are also called and defined in somewhat different ways in different European countries. To define the European learning outcomes related to BIM and energy-efficient building, six main categories were selected:

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

[4] Jung N, Häkkinen T, Rekola M. Extending the capabilities of BIM to support performance based design. ITcon Vol. 23 (2018), pg. 16. https://itcon.org/papers/2018_02-ITcon-Jung.pdf

[5] Ferrando C, Delponte E, Difranco M, Häkkinen T, Rekola M, Abdalla G, Casaldaliga P, Pujols WC, Lopez A, Shih SG. Holistic and optimized life-cycle integrated support for energy-efficient building design and construction: HOLISTEEC methodology. 10th European Conference on Product & Process Modelling - ECPPM 2014. Vienna, Austria. 17-19th September 2014

The report presents the country-specific results and the summaries proposed for European definitions of learning outcomes for the main roles in design, construction and maintenance related to BIM and energy-efficient building.

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

8 Conclusions

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

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

Construction industry and building projects has several roles and stake holders. Because of existing differences in design, building and maintenance processes, the main roles are also called and defined in somewhat different ways in different European countries. To define the European learning outcomes related to BIM and energy-efficient building, six categories were selected:

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

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

In all cases, the defined learning outcomes also include lists of different types of tools, the use of which belongs to the required skills of different roles. The types of BIM compatible tools vary including for example owners' requirement setting tools to designers' BIM authoring software and simulations tools and installers BIM viewers.

In the case of designers and engineers, the understanding and use of BIM authoring software and the use of (BIM compatible) different kinds of calculation, simulation and assessment tools is naturally fundamental. In addition, essential learning outcomes include understanding about what information and what kind of data is needed in different stages by different actors. Especially in the case case of designers and engineers, the understanding of data requirements of different design domains and different tasks and especially understanding in extracting information from BIM to BEM for simulations and import results to BIM. To ensure the energy-efficient operation of the building, understanding about information requirements of the construction and maintenance phases is also important.

In many cases, the understanding and ability to apply collaborative working methods are also important as it supports interdisciplinary working practices resulting in best solutions with regard to energy performance and indoor environment.

The outcome of this deliverable will be improved and extended with the help of the expert panel and the communities of interest before its validation as the EU wide learning outcomes that will be used to refer and/or develop National learning outcomes for EU countires. Different levels of courses/trainings will be planned and executed based on the learning outcomes.