



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

D6.9 – Monitoring of energy-related impact of BIMEET

WP 6

Leader: VTT

Task 6.9

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Abbreviations

AEC	Architecture, Engineering and Construction
ALO	Achieved Learning Outcomes
BEM	Building Energy Model
BIM	Building Information Modelling
CA	Consortium Agreement
DoA	Description of the Action
EE	Energy Efficiency
EPBD	Energy Performance Buildings Directive
EPC	Energy Performance Certificate
EQF	European Qualification Framework
GA	Grant Agreement
HOTS	High Level Thinking Skills
ICT	Information and Communication Technologies
ILO	Intended Learning Outcomes
KSC	Knowledge – Skills – Competencies
LAU	Local Administrative Unit
LO	Learning Outcomes
LOTS	Low Level Thinking Skills
Mx	Milestone date designating the start of a given task
My	Milestone date designating the end of a given document delivery deadline
NUTS	Nomenclature for Territorial Units for Statistics
PC	Project Coordinator
PSC	Project Steering Committee
QA	Quality Assurance
RIBA	Royal Institute of British Architects
RTO	Research and Technology Organisation
TAM	Technology Acceptance Model
TF-IDF	Term Frequency - Inverse Document Frequency
ToC	Table of Content
TUI	Tangible User Interface
UAS	Universities of Applied Sciences
WP	Work Package
WPL	Work Package Leader

1 Executive Summary

The report D6.9 introduces the estimated impact of BIMEET project. Monitoring of energy related impact of the activities and results is executed with help of two performance indicators introduced in the Description of Work (DoW) of BIMEET project: (1) Saving of primary energy through energy renovations and (2) increasing use of renewable energy sources in energy renovation projects.

The energy related impact is monitored based on impact estimation strategy and the calculation formula introduced in BIMEET DoW, taking participants of BIM-EE- trainings as starting point. By learning new skills and competence on BIM- and EE- processes with related tools, the professionals can take advantage of benefits of integrated building information management in a building or renovation project.

Estimation and forecasting of BIMEET eLearning and the planned BIM-EE- trainings during the year 2020 are included as further impact of executed project activities. Also approaches to impact assessment strategy are discussed such as (1) reliability of the unbroken impact chain between the participants of the trainings and impact performance indicators, and (2) general boundary conditions.

Other possible impact performance indicators and the effect of dissemination, knowledge portal, and exploitation are discussed. Significance of the structured, role-based, matrix of learning objectives (LOs) for BIM-EE- competences is highlighted. Finally, a scenario is introduced, using BIM-EE- portal and labeled trainings (matched with LO's) as future follow-up impact tracking system, showing the importance of good competence and skills of professionals in relation to energy efficiency and renewable energy systems and measures in buildings.

2 Introduction

2.1 BIMEET is focusing on skills and expertise in EE-BIM practices

The Description of work (Dow) of BIMEET project expresses well the purpose of BIMEET project, highlighting (1) the importance of addressing multi-objective sustainability (including energy) requirements in the construction industry and (2) boosting the adaptation of Building Information Modelling (BIM), which can bring the most transformative power to value chains of building project and lifetime of facilities.

The new processes and workflow of digitalized construction industry needs new skills and knowledge from all disciplines and other experts involved in the integrated information processes. Trainings of EE BIM are key assets in building up the needed knowledge, skills and competence of engineering stakeholders to actively contribute towards positive impacts for global socio-environmental issues the construction industry bear.

Quoted from the Dow:

In the EU, energy for the building sector represents more than 40% of Europe's energy and CO₂ emissions (European Commission, 2005). The European Commission has defined a clear 2020 target to reduce by 20% the energy consumption and the CO₂ emissions and increase by 20% the share of renewable energies. These objectives have been translated into stringent regulations and policies at the European and National levels. For instance, the recast of the Energy Performance of Buildings Directive (2010/31/EU) imposes stringent energy efficiency requirements for new and retrofitted buildings.

The construction industry hence presents a major opportunity to reduce energy demand, improve process efficiency and reduce carbon emissions; but it is also traditionally highly fragmented and often portrayed as involving a culture of "adversarial relationships", "risk avoidance", exacerbated by a "linear workflow", which often leads to low efficiency, delays and construction waste. The process of designing, re-purposing, constructing and operating a building or facility involves not only the traditional disciplines, but also many new professions in areas such as energy and environment. There is also an increasing alignment of interest between those who design and construct a facility and those who subsequently occupy and manage it, and that demands dedicated skills, knowledge and competencies to address multi-objective sustainability (including energy) requirements.

In this context, BIM is seen as the new technological advancement and new processes in the construction industry that paves the way to more effective multi-disciplinary collaborations with a total lifecycle and supply chain integration perspective. BIM is the process of generating and managing data and information about built environment during its entire life cycle from concept design to decommissioning. BIM has brought the most transformative power into AEC/FM domain (Architecture, Engineering and Construction/Facility Management) during the last decade in terms of its fundamental life cycle and supply chain integration and digital collaboration. BIM holds the critical key to revolutionize the construction industry, which is forecasted to reach over \$11 trillion global yearly spending by 2020 (IHS Economics). BIM and its versatile potential is helping the sustainability agenda as the digitalisation of product and process information provides a unique opportunity to optimise energy efficiency related decisions across the entire lifecycle and supply chain for the built environment projects.

The European Commission's modern industrial policy recognizes the strategic importance of the construction industry, as witnessed by the Public Private Partnership Energy Efficient Buildings launched under the Recovery Plan in FP7 and now supported in H2020. The construction industry in Europe has a wide range of training and education providers with an equally diverse set of training courses that focuses on generating BIM skilled professionals. It

is essential to improve the breadth, depth, quantity and quality of educated and trained professionals in the built environment that can support an effective BIM agenda across Europe. In fact, a number of training and education offerings concentrated on quite a narrow band of the industry; main courses focus on design and construction and not on briefing or planning and the impact of BIM to improving the operations of assets. Moreover, energy efficiency aspects focusing all the stakeholders involved in a built environment project lifecycle are rarely a focus in such trainings.

BIMEET aims to broaden the BIM training agenda to support the European Union's building energy efficiency agenda. This requires broad awareness and expertise in BIM practice across different asset types and across different roles in the industry.

2.1.1 Build up Skills - initiative

The BUILD UP Skills Initiative contributes to the objectives of two flagship initiatives of the Commission's 'Europe 2020' strategy — 'Resource efficient Europe' and 'An Agenda for new skills and jobs'. The Initiative of Build Up Skills is well described in their webpages (Build Up Skills 1):

BUILD UP Skills is a strategic initiative which started under the Intelligent Energy Europe (IEE) programme to boost continuing or further education and training of craftsmen and other on-site construction workers and systems installers in the building sector.

Its final aim is to increase the number of qualified workers across Europe to deliver building renovations which offer high-energy performance as well as new, nearly zero-energy buildings. The initiative addresses skills in relation to energy efficiency and renewable energy systems and measures in buildings.

The BUILD UP Skills Initiative contributes to the objectives of two flagship initiatives of the Commission's 'Europe 2020' strategy — 'Resource efficient Europe' and 'An Agenda for new skills and jobs'.

Pillar I

Build Up Skills projects up to 30 EU countries were funded 2011-2012. funded to work on national roadmaps for qualifying their building workforce for the 2020 challenges. These projects developed national qualification platforms and roadmaps that would serve to successfully train the building workforce in order to meet the targets for 2020 and beyond. This phase is known as Pillar I.

Pillar II

As a follow up, new calls for proposals were launched in 2012, 2013 and 2014. A total of 22 projects have been funded to help implement the roadmaps developed in their countries. This second phase, known as Pillar II, consists of designing and piloting new qualification and training schemes and/or upgrading existing ones, based on the roadmaps developed in Pillar I.

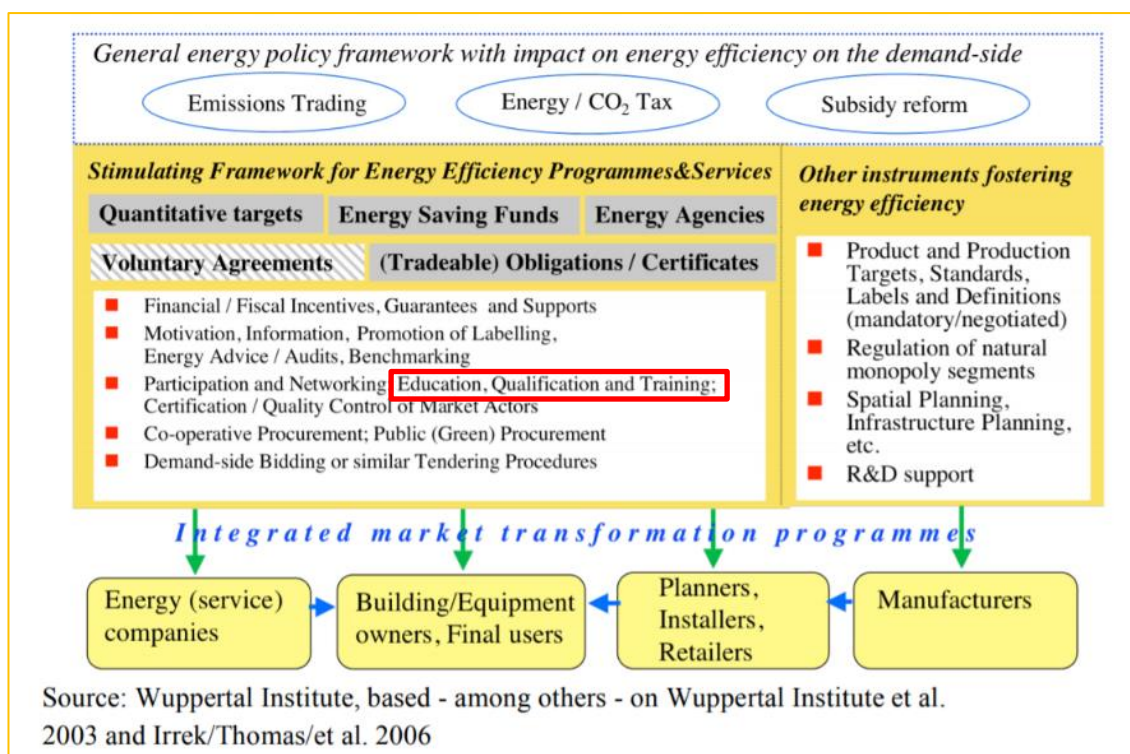


Figure 1: General energy policy framework and Education, Qualification and training highlighted as a tool for simulation Energy efficiency Programmes. Source: Irrek e .al. (2007), figure: Irrek/Thomas et al. (2006) and Wuppertal institute et al. (2003).

The policy-mix in the field of energy efficiency requires a comprehensive approach to bundle different policies and measures into target group- and sector-specific market transformation programmes adequately addressing the different actors in the market chain (energy companies, energy service companies, building and equipment owners, final users, planners, installer, retailers, manufacturers). This is illustrated in Figure 1: These target group-oriented packages of policies and measures are usually specific, depending on the energy efficiency technology or field of application. The package has to be tailored in order to strengthen incentives and overcome barriers for all actors in the market chain regarding energy efficiency (Irrek et al, 2007).

2.1.2 Strategic energy saving targets and assessment

Article 4 of the Energy Efficiency Directive (Directive 2012/27/EU) introduced the requirement for Member States to establish a long-term strategy for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private. JRC Science for Policy Report “Assessment of second long-term renovation strategies under the Energy Efficiency Directive” (Castellazzi et al, 2019) is listing the energy saving targets per European countries. It shows that many countries are setting targets in different ways. Likewise, it is important to set strategic targets for education and trainings, which is done in a roadmap for Build up skills 10 years ago. Following up of the roadmap actions Pilar I and Pilar II is executed as a part on EASME work (Trinomics, 2018). The executive summary of the assessment is added as appendix 1. Below are some of the key focuses:

The original roadmap actions are largely complete, so in theory the roadmaps need to be updated. Updates could focus on supporting uptake as demands grow, as well as on updating course content to keep it up to date.

Elements that could be added are the circular economy implications (lifecycle of buildings), Building Information Models (BIM) and use of IT in construction (and IT literacy generally), Near Zero Energy Buildings (NZEBS), energy efficiency in existing buildings and white collar (professional) sectors. This might need different stakeholders and political commitment at Member State level.

The results show that BUILD UP Skills projects boosted education and training of craftsmen and other on-site construction workers and system installers in the building sector and increased the number of qualified workers across Europe. All projects developed and piloted new qualifications and training schemes and/or upgraded existing ones

3 Strategic Objectives and impact of BIMEET

The aim of BIMEET Project is to

- (a) pave the way to a fundamental step change in delivering systematic, measurable and effective energy efficient buildings **through BIM training with a view to effectively address European energy and carbon reduction targets;***
- (b) promote a well-trained world leading generation of decision makers, practitioners, and blue collars in BIM for energy efficiency;*
- (c) establish a world-leading platform for BIM for energy efficiency training nurtured by an established community of interest.*

The general aims translate into strategic objectives (STO), which are listed in Table 1: BIMEET project and Strategic Objectives (from DoW). The success of the project is evaluated towards its objectives. The impact targets set in Description of Work (DoW) for the project outcomes, are strongly dependent on the overall success of the project.

The impact estimates in this report is especially linked to the success in organising BIMEET training courses during the project, as the key impact measurement is depended on the amount of professionals participated on BIM trainings (BIMEET DoW). However the objective of organising training courses is not highlighted in the project aim or project strategic objectives. During the BIMEET project's time the training courses have been more in the role of evaluating the BIMEET results, especially testing the learning outcomes (LOs).

The Final report of BIMEET project clarifies more the achievements for each listed objective: f (a) key measurable results achieved, and (b) the (potential) impact generated, and (c) consortium plans for sustaining these. Some of the BIMEET project objectives will be sustained and further developed through the newly awarded INSTRUCT project.

Table 1: BIMEET project and Strategic Objectives (from DoW)

STO1: Screen and synthesize past and ongoing European, as well as national, initiatives and projects with a focus on assembling evidence-based quantitative/ measurable scenarios and use cases that demonstrate the role of BIM in achieving energy efficiency in buildings across the whole value chain.
STO2: Benchmark existing Europe-wide BIM trainings across the building value chain (including lifecycle and supply chain), highlighting energy efficiency linkages, as well as qualification targets, delivery channels, skills, accreditation mechanisms, while highlighting training gaps and enhancement potential.
<p><i>This will include:</i></p> <ul style="list-style-type: none"> <i>(a) better determination of future capability needs;</i> <i>(b) clear routes of entry and clear career progression pathways;</i> <i>(c) clear, standard means of recognizing competence;</i> <i>(d) exploring the scope to make apprenticeships more flexible;</i> <i>(e) an industry review of the current skills and capability delivery mechanisms;</i> <i>(f) review of approaches to career planning, training and development with a commitment to rationalise.</i>
STO3: Harmonize energy related BIM qualification and skills frameworks available across Europe (Objective 1) with a view of reaching a global consensus through our BIM for energy efficiency expert panel.
<i>The focus is on setting up a mutual recognition scheme of qualifications and certifications among different Member States supported by an effective strategy to ensure that qualification and training schemes are sustained after the end of the project.</i>
STO4: Map identified skills, qualifications, and accreditation into a BIM for energy efficiency overlay with a total lifecycle and supply chain (including blue collar) perspective.

<i>There are country specific delivery and process variations that will be considered to ensure successful take-up of the BIMEET training program at a national level.</i>
STO5: Adapt the BIM4VET platform (delivered in the context of a related ERASMUS+ ongoing project) to provide a robust computer-based online and open-access environment for BIMEET.
<p>The BIM4VET platform is already providing:</p> <ul style="list-style-type: none"> (a) BIM stakeholder competence matrix, (b) classification of BIM training curriculums in Europe, (c) BIM qualification maturity assessment method, and (d) recommender system for BIM training selection. <p>The resulting BIMEET platform will be available on-line on an open-access mode, nurtured by an established community of interest underpinned by an adapted business model.</p>
STO6: Establish a governance, policy, and regulatory framework as well as adapted business models to ensure the long-term sustainability of the proposed BIMEET training agenda.
<p><i>The consortium will be supported by a 200+ members of the BIMEET community of interest and a panel of experts (around 20 members).</i></p> <p><i>The consortium members will adopt an incremental and participative approach engaging effectively all the above stakeholders.</i></p>
STO7: Disseminate within and beyond Europe the resulting BIMEET platform and training program.

3.1 Competence of stakeholders in BIM-EE adaptation

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 knowledge, skills and competences for different roles in design, building and maintenance process. Further, it is important to define the learning outcomes to support the planning and offering of training courses that fulfil the identified requirements.

In digital transition and BIM adaptation, the importance of people and their competence in BIM process providing added value is understood. Training people must be is a key activity in BIM adaptation. In practice this means an effort for building up competence, education, training as well as mastering BIM tools. Software providers are offering courses on using the many functions in their tools, basically teaching the needed skills to master the tools. Some of the courses cover general BIM use case trainings and deeper knowledge of calculation, analysing, simulation data models for instance in case of energy performance and environmental analyses (CO₂, LCC and LCA).

Figure 2 shows a result of a study: A Critical Look at Integrating People, Process and Information Systems within the Construction Sector (Dave et al, 2016). To focus on people and competences is defined to be the most important strategy in collaboration project - like integrated information management projects are.

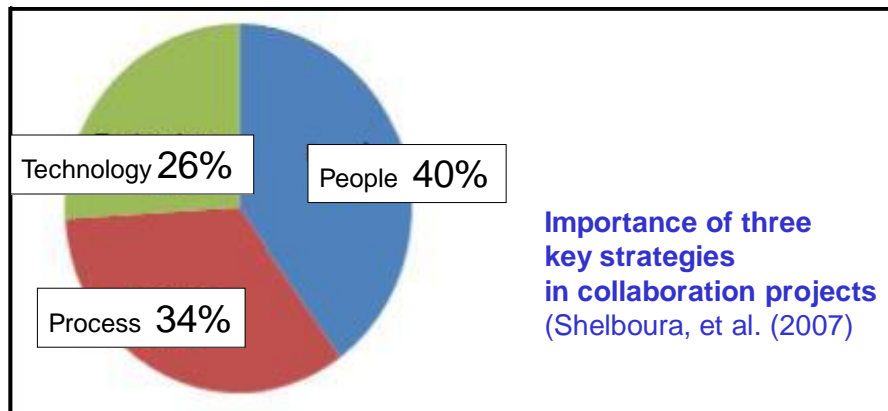


Figure 2: Three key strategies in collaboration projects based on Critical Look at Integrating People, Process and Information Systems within the Construction Sector. Source: Dave et al (2016) and earlier study of Shelbourn et al. (2007).

BIM use case is a single activity in data-flow using BIM authoring tools (with open BIM standards) for certain tasks in the work-flow of the projects. In BIMEET, the focus is towards the case of energy performance management of building enabled with BIM. Figure 3 shows the many already available potential BIM use cases in the total process of energy performance management during a building's life cycle like energy simulations, environmental analysis, component optimization, comparison between expected and realized energy consumption, comfort analysis and so on.

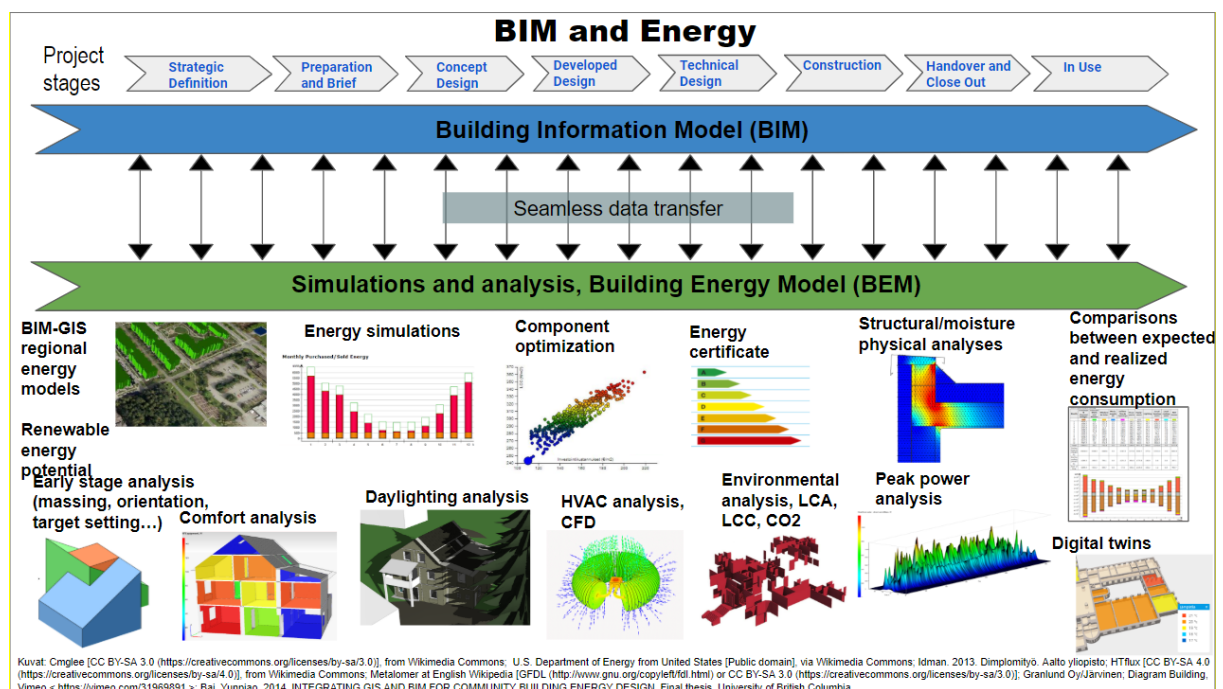


Figure 3: BIM use cases with building Energy model (BEM) using the initial data from domain BIMs, during different project and lifetime phases. Source: (CC-BY 4.0) Eksergia.fi – Open Web School of Energy Efficient Buildings.

Transition to BIM based working includes various aspects much more than implementing the use cases. BIM Diamond is a framework developed at VTT, Finland that is based on the four elements – business, actors, processes and technologies – important for adoption of BIM in general or in case of any BIM use case, like model uses for energy performance (Figure 4).

The diagram illustrates the BIM Diamond model, showing the relationships between four main components: Business, Processes, Actors (human), and Technologies (ICT / BIM). The relationships are defined by the following flows:

- Business to Processes:** Execution (light blue arrow), Targets, directions (dark blue arrow).
- Processes to Business:** Information needs (light blue arrow).
- Business to Actors (human):** Innovations, quality (light blue arrow), Incentives (dark blue arrow).
- Actors (human) to Business:** Efficiency (light blue arrow).
- Actors (human) to Technologies (ICT / BIM):** Usability needs (light blue arrow), Tools, manuals (green arrow).
- Technologies (ICT / BIM) to Actors (human):** Information, knowledge (green arrow).
- Technologies (ICT / BIM) to Processes:** Use cases (light blue arrow), Support (green arrow).
- Processes to Technologies (ICT / BIM):** Guidelines, skill requirements (light blue arrow).

Below the diagram, there is a row of 12 small icons representing various BIM-related concepts, including 3D models, a crane, a magnifying glass, and a bar chart.

National BIM Requirements, COBIM 2012

BIM Diamond, Copyright VTT

3.2 Executed and future planned training courses and use of eLearning material

Table 2 shows the summary of participants in executed trainings courses (18 courses in 4 countries). Total participants reached is 293 students and professionals. The planned training courses will reach 690 and BIMEET eLearning around 2920 students and professionals by the end of year 2020. Total participants and audiences include around 3900 students and professionals.

Table 2: Summary of participants in executed trainings courses, and planned trainings courses estimated audiences for BIMEET eLearning by end of year 2020.

	Students	Professionals	All
Executed training courses during BIMEET project (face-to-face)	139	154	293
Planned training courses 2020	560	120	680
TOTAL training	699	274	973
Estimated minimum audience for eLearning courses	300 (estimated minimum)	900 (estimated minimum)	1200 (estimated minimum)
Estimated average audience for eLearning courses in 2020	2230	690	2920
TOTAL participants and audience	2929	964	3893

3.3 Boundary conditions

The aspects recognised and listed below are noticed boundary conditions, to be considered in assessment and monitoring the impact of BIMEET project outcomes. They can either become barriers or enablers for a positive impact.

3.3.1 BIM adoption and maturity in different countries

The education and training on BIM follows the general BIM adoption rate and digitalisation level of construction processes. The general BIM maturity is at diverse stages in different EU countries. This is the case between partner countries of BIMEET; Finland, UK, Luxembourg, France and Greece all find themselves in different stages. The national BIM requirements/guidelines can be used as bases to estimate the stage.

Also actual development and commercial availability of BIM tools for energy performance information (Energy simulation tools) and BIM tool development to environmental performance information (BIM and LCA-tools and EPD calculations) follows the overall BIM adoption maturity of the country.

In Figure 5 the BIM maturity is shown as levels (from level 0...level 3) which describes the stages and the paradigm shift with re-engineering needed in the processes. BIM design process produces much more information in earlier phases of a building project - enabling informed decision making on performances, cost and functional capacities at the very beginning phases that is deemed very important or an overall positive impact of the project.

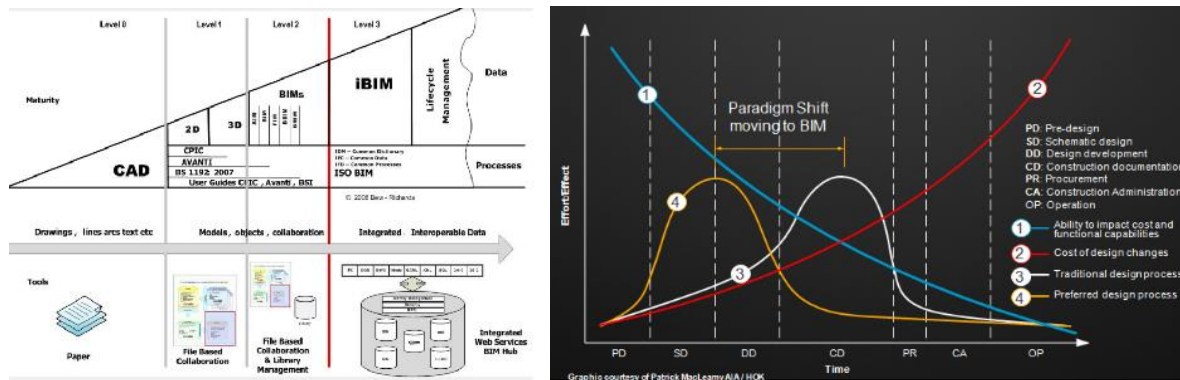


Figure 5: BIM adaptation as levels (from level 0 to level 3) and Paradigm shift moving to BIM. Sources of figures: Right: 2008/13 Bew-Richards. Left: Patrick MacLeamy AIA/HOK.

BIM and common understanding

EFCA's booklet on BIM and ISO 19650 (EFCA) from a project management perspective describes the importance of common understanding.

BIM has led to new work processes and new ways of interacting in projects. All information processes of a building project are included (see Figure 6). This again has led to new definitions and terminology for which we need to establish a common understanding. To ensure that all employees know and understand how a BIM mind-set influences all project processes, it is important to educate the whole organisation and the stakeholders that have both direct and indirect linkages with built environment projects. The trainings must be related to the function each employee has, or the role they possess, both in the company and in projects. Key issues include:

- to calculate a tender and deliver a bid it is necessary to understand the legal and economic implications of what is being requested and which deliverables are to be included;
- to manage a BIM project, it is necessary to understand the new ways of interaction and deliverables for each stakeholder and how to use BIM technology to manage time, quality, cost and risk;
- to prepare for BIM project execution it is important to appoint a BIM manager for the project to match project setup to the contract requirements and to clarify if anything is not specified;
- a designer needs to learn how to implement more of the information into the model, instead of in separate documents, and to use the model throughout the process. The designers also need to understand that the model is the main deliverable and therefore must be in the main focus of QA.

Once a national or international body of knowledge is established, BIM certification should certainly be a priority for dedicated BIM personnel and any individuals who will have direct control over the BIM implementation process.

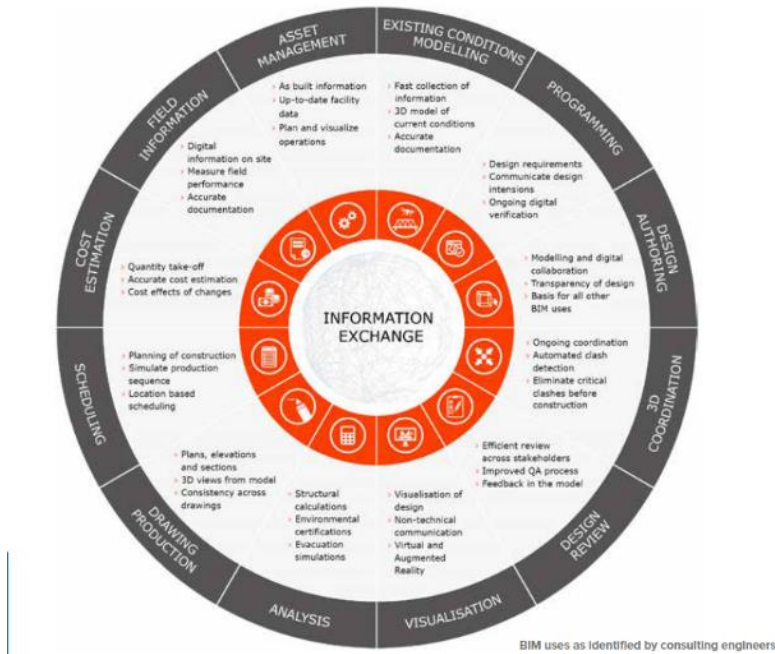


Figure 6: BIM uses cover all processes where information is needed. Source: Picture by courtesy of COWI

3.3.2 Developing green building marketplace

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

- a. *Multi-disciplinary integrative capacity of BIM: BIM provides a unique opportunity to integrate data, information and underpinning processes across lifecycle and supply chains. This will promote informed and energy efficient design interventions.*

Boundary conditions for this target are BIM adaptation and maturity, use of openBIM tools and integrated processes.

- b. *Informed sustainability design: BIM contributes to sustainable lifecycle decisions and processes as it leverages on the capability of the complete construction value chain thus optimizing design decisions on complex issues such as energy efficiency.*

This area of BIM adaptation is dependent on clients' requirements for sustainable building, for low carbon and nZEB, performance based processes in place - and the relevant good competence of the professional. Tools are existing.

- c. *Increase of BIM use for retrofit: there is an increasing trend for use of BIM in large as well as smaller projects with a sought benefit of maximizing energy efficiency and sustainable outcomes.*

Boundary conditions for this target is demanding the use of BIM in retrofit projects and ambitious requirements setting.

- d. *Using BIM for building performance monitoring: there is an increasing evidence of the value BIM tools during the operations and maintenance phase of a project, with the view of reducing the endemic gap between predicated and actual energy consumption in buildings.*

BIM use cases and tools /platforms are under development for supporting many maintenance and facility management tasks. Monitoring energy from buildings is already well developed area and tools exists

- e. *Training support & communication tool: As BIM embraces building products and processes, it constitutes a useful support for training, and to communicate the best practices for energy efficient and high-quality construction, in particular to on site staff.*

Boundary conditions for this target are adaptation of BIM use-cases and maturity, use of openBIM tools and integrated processes and for instance BIM uses in big room sessions in building site.

3.3.3 Educational system and degrees for professional roles

Professional roles in real estate and construction is diverse and the stakeholders range from different educational background like AECO professionals working in design domain, construction domain and in maintenance as well as professionals from various other domains like economy and business, laws and regulations. Within the BIM domain for AECO professionals, BIM manager/ BIM coordinator, BIM modeller are roles still forming, and they will reflect strongly to national ways how design and construction education, roles and responsibilities have been organised as well as defined. The varying roles and its linkages of Finnish education system for engineering profession required for different phases of design, construction and maintenance are shown in Figure 7. Different competence scale are identified through Learning Outcomes (LO) matrix in earlier deliverables within BIMEET project based on the roles and responsibilities of a professional involved in different phases.

BIM coordinator role and the duties are well identified in Finnish context (CoBIM 2012, series 11) for successful BIM adaptation in projects. Other roles like BIM manager is deemed important to drive organizational BIM strategies and goals; domain integrated BIM competence for AECO professionals are promoted within the AECO education or as continuing education courses and trainings. An early analyse of competencies of BIM specialists (Barrison & Santos, 2011) found that although there are different focuses, both the job market and specialists are generally in agreement about which competencies a BIM Manager should have, to perform well. The identified roles of BIM manger/coordinator/modelers, BIM competent professionals and specialists are vital at both organizational and project level to achieve the set targets through use of digital construction tools and processes. Thus the traditional engineering education systems should incorporate these new competence requirements for the future workforce as well as provision of different trainings/courses should be developed and provided for the existing professionals to address the strong demand of BIM competent workforce for engineering projects.

Also some designers say they do not need any specific BIM coordinator, as modelling process has become the one and only routine way of working for them. In these cases the BIM process have been well adapted and integrated to working processes of the organisations.

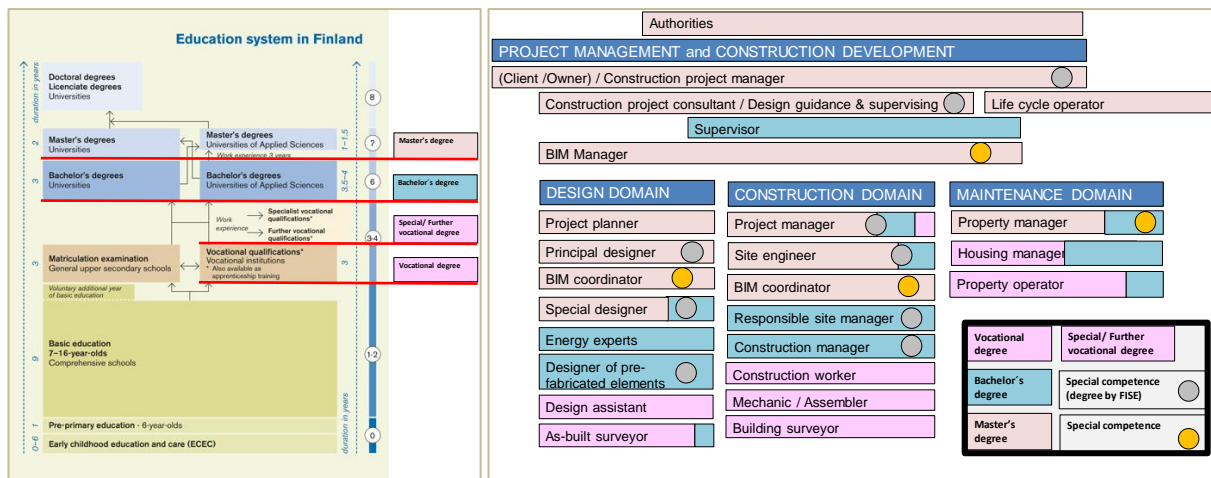


Figure 7: Education system in Finland and the diversity of educational background of professional roles.

3.3.4 The way to organise trainings

Finding time to participate to trainings are today's boundary condition amongst professionals. The training offerings which are based on blended learning are therefore mostly used. Software skills are trained by the software developers and is part of the licence. The new features are often trained in webinars.

Also the webinars and eLearning are forms responding to user needs of "learning when the need is active". If the organisations have a strategic competence development plan, might help a stepwise competence development.

Majority of BIM education tends to focus on BIM software trainings, however training for both graduates and professionals in openBIM concepts, collaborative way of working focusing stakeholder roles and responsibilities in different phases of a project, BIM management and coordination aspect as well as different BIM utilization possibilities are seen increasing (BIM education- Global 2019 Update Report). The course content, maturity of trainings however lack homogeneity as course development, implementation primarily has been through different teaching and training organizations. A review of tertiary BIM education research conducted by Amarnath et. al (2016) identifies six conceptual categories where active BIM educationalist and researchers' focus regarding BIM education:

- (1) Identifying need for BIM in tertiary educational institutions
- (2) Identifying skillsets for BIM education
- (3) Developing BIM educational BIM frameworks
- (4) Developing BIM curricula
- (5) Experimenting with BIM course
- (6) Developing strategies to overcome BIM educational issues

Current trends and provision of online education has grown significantly. While such provisions provide the training providers and educational institutes to incorporate wider audiences, it also provides an equal opportunity for the learners to plan and manage learning schedules based on their availability of their time. Various eLearning modules related with BIM and EE are in developments similar to BIMEET project focus. Current progress of development of unofficial BIMalliance group (BIM Alliance info), primarily formed as a result of 4 different EU projects – BIMCert, BIMplement, Net-UBIEP and BIMEER) collaborates to explore areas of mutual opportunity and to minimize the energy footprint in construction. Different eLearning modules developed in the individual projects have been made available to wider audiences.

4 BIMEET impact assessment

4.1 Viewpoints to impact assessment

The energy related impact is monitored based on impact estimation strategy and the calculation formula introduced in BIMEET DoW, taking participants of BIM-EE trainings as starting point. By learning new skills and competence on BIM and EE processes with related tools, the professionals can take advantage of benefits of integrated building information management in a building or renovation project. It is based on a stronger competence and ability to design and procure better solutions to energy efficiency, due to a more detailed information extracted from BIM based energy simulations and historical energy monitoring data of the building.

Impact is the relation of achieved results versus targeted results for impact. In BIMEET the targeted results for impact is well described and estimated in the Description of Work. This impact is related to a potential decrease of energy consumption of buildings. The monitoring of this impact is presented in section 4.2.

Chain of dependencies

Between the participants of the trainings and impact performance indicators there is a chain of interrelations and the impact in many stages is indirect:

- A1: Impact of BIM based energy performance process in building projects
- A2: Impact of well implemented energy performance process in building projects

- B1: Impact of strong competence of the experts in the energy performance process
- B2: Impact of training for professionals to increase competence
- B3: Impact of education to increase competence (not only skills and knowledge)

- C1: Impact of learning material to support trainings and education

4.1.1 Direct and indirect impacts

Impact can be direct or indirect. Potential decrease of energy consumption with the help of better education and training of professionals and students is an indirect impact. The chain from training course to decreased energy consumptions of building stock is long and therefore vulnerable to breakdowns and negative boundary conditions.

A1: Impact of BIM based energy performance process in building projects and A2: Impact of energy performance process in building projects can be seen as direct impacts as well as B1: Impact of competence of the experts in the energy performance process. Assuming that the energy performance targets are set by the client and the expert can make use of the benefits of EE-BIM process, we can say that the direct impact exists.

However the impact of B3: Impact of education to increase competence, B2 Impact of trainings to increase competence and C1 Impact of learning material to support trainings and education are building up the foundation to competences of professionals for acting in energy performance process, therefore their impact is in-direct in nature. Nevertheless their impact is crucial to the final goal and must be stressed more.

4.1.2 Desired impact reached without training or education activities

The desired impact (energy efficient building) may also happen through awareness and without extra education or trainings. The professionals from different disciplines already working with BIM can implement more BIM based energy simulation tools (+ processes) to the workflow to the projects as clients requirements for performance targets and BIM use case are set. Energy Performance Contracting (and similar procurement concept), with country specific Climate Action policies are supporting this development. Direct positive impact can be reached especially if the clients are setting high performance targets for their projects.

During BIMEET project, information about BIM and EE has been available in BIMEET portal. Many dialogues during dissemination session and workshops have supported awareness raising on the BIM EE tools and processes. The statistics and services of BIMEET portal are reported in D6.5. Both these activities are supporting the quick adaptation of performance based design and BIM energy simulations and LCA calculations in building projects.

4.2 Monitoring of the impact of the training courses

4.2.1 Results

Project level performance indicators for monitoring the impact of BIMEET project are: energy savings and renewable energy production.

The calculation formula of the indicators takes the amount of participants to BIMEET trainings as a starting point. Assumption that the new skills and competence on BIM and EE process with related tools highlight the benefits of integrated building information management in a building or renovation project. It is based on a stronger competence and ability to design and procure better solutions to energy efficiency, due to a more detailed information extracted from BIM based energy simulations and historical energy monitoring data of the building.

In the planning phase of BIMEET project the estimated number of participants of trainings organized by BIMEET partners, expert group members of members of community of interest is **1725 (including students and professionals)**

Realized number of participants to trainings organized by BIMEET partners and expert group is 293 (including **154 professionals**). When adding an estimation of participation to the 2 eLearning courses developed in BIMEET, we end up to 1493 (including **1030 professionals**). Table 3: Estimation of the energy-related impact of BIMEET in terms of energy savings and renewable energy production in DoW and Table 4 below provide an estimation of the energy-related impacts, based on the number of estimated participants.

Table 3: Estimation of the energy-related impact of BIMEET in terms of energy savings and renewable energy production in DoW.

Project Performance Indicator	Quantification	Measurement unit
Energy savings triggered by the project within its duration	55	Primary energy savings triggered (GWh/year)
Renewable Energy production triggered by the project within its duration	5.5	Renewable Energy production triggered (GWh/year)

Table 4: Estimation of energy-related impact of BIMEET based in trainings by the end of year 2020. Estimations A and B.

<i>Project Performance indicator</i>	Quantification	Measurement Unit
Energy savings triggered, estimation A	47,5	Primary Energy (GWh/year)
Renewable Energy production triggered, estimation A	5,0	Renewable Energy production (GWh/year)
Energy savings triggered, estimation B.	125,5	Primary Energy (GWh/year)
Renewable Energy production triggered, estimation B.	13,0	Renewable Energy production (GWh/year)

Below, in chapters 3.2.2 - 3.2.4, the impact assessment process is explained in steps following the presumptions and formulas of the calculation introduced in DoW. Estimation A follows the presumptions of that estimation approach. Estimation B takes different presumptions, and offers another result for comparison.

4.2.2 BIMEET impact assessment calculation overview

Explanation of the calculation bases leading to the final quantified output- Part 1:

Concerning the impact of the project within its duration, the potential energy saving is based on the number of experts (or entities) involved in the project who are expected to use the results of this project in training sessions:

- PARTNERS: Five partners of the consortium (House of Training, CSTB, INES, METROPOLIA, CRES) offering **3 training sessions** within the project duration (this is part of WP5)
- EXPERT PANEL MEMBERS: Twenty-five experts from the experts panel working in entities offering training sessions on BIM&EE. It is expected that each of these experts (or entities represented by the experts) will give **2 training sessions** within the project duration
- COMMUNITY OF INTEREST MEMBERS: Fifty training experts from the community of interest (see § 6.2) (from an expected total number of 200 experts), working in entities offering training sessions on BIM&EE. It is expected that each of these experts or entities **will give 1 training session** within the project duration.

*As we can expect, each training session would be **attended by 15 trainees**, mostly practitioners working in companies dealing with the energy retrofit of buildings. The total number of practitioners impacted by the project is $(5*3+25*2+50*1)*15 = 1725$.*

During BIMEET project the training courses were mainly produced by the partners as their goals were mostly testing the project outcomes.

Actors in community of interest did provide courses on EE or on BIM, but these courses were not counted in. One actor from BIMEET expert panel was giving training on BIM -EE subject, and these trainings have been counted in.

Further the estimation of the students and professional taking the open eLearning course has been counted in, as the development of this course is directly based on BIMEETs LOs and quality level set in BIMEET labeling scheme.

Total number of participants: 1493.

4.2.3 BIMEET trainings and eLearning

During the project time BIMEET project partners and expert panel have provided 18 trainings and 2 eLearning courses with materials on the content of BIM and diverse aspects of energy efficiency. The content of the trainings have been defined by learning target/ learning outcomes in the theme of BIM and Energy efficiency.

Table 5 shows the total number of participants in all trainings divided to professionals and students.

BIMEET trainings provided by partners and expert group members are listed in Table 6, Table 7, Table 8, Table 9.

BIMEET project partners have provided 2 eLearning courses with self-learning material. The courses with their LOs and learning goals are presented in D3.4. Table 5 shows a minimum and an average estimation on the participants for eLearning courses until end of year 2020. eLearning course 2 will be distributed openly via Eksergia.fi platform and via INES learning platform. INES Platform: <https://e-learning.ines-solaire.org/course/index.php?categoryid=196>

BIMEET eLearning course 1: Introduction of BIM enabled EPC assessments online course

BIMEET eLearning course 2: BIM for energy efficiency in buildings

An estimated minimum (900 professionals) has been used for the calculation of the Estimation B (see section 4.2.4). The planned courses and audience for BIMEET eLearning is presented later in this report as part of (see sections 4.2.5 and 4.2.6).

Table 5: Total number of participants in BIMEET trainings.

	Students	Professionals	All
House of Training	-	15	15
Metropolia	81	69	150
INES	58	26	84
BIM Design Hub	-	44	44
TOTAL 1	139	154	293
eLearning courses	300 (estimated minimum)	900 (estimated minimum)	1200 (estimated minimum)
TOTAL 2	439	1054	1493

Table 6: List of learning and training sessions organised by Metropolia (Finland).

When	Participants	How many persons?	How many days?
2019	BIM coordinator course participants - professional education	14	3
2020	BIM coordinator course participants - professional education	21	3
2019	BIM basics course online	12	3
2020	BIM basics course online	14	3
2019	BIM manager course	8	1
2018	Students from Master's program at Metropolia _Product modeling course	30	3

2019	Students from Master's program at Metropolia_product modeling course	26	3
2019	Students from Bachelor program at Metropolia_Utilization of BIM in construction	17	2
2020	Students from Bachelor program at Metropolia_Utilization of BIM in construction	8	2

Table 7: List of sessions insured by INES (France) according to the training "Le BIM pour l'efficacité énergétique des bâtiments".

When	Participants	How many persons?	How many days?
February 2018	Trainers of the French national education	18	3
October 2018	Professionals: ARCH, CD, ASS, BM, BC, C	14	1
2018 – 2019 – 2020	Students from ENSAM (Ecole des Arts et Métiers) and USLB (Université Savoie Mont-Blanc)	40	4
2018 – 2020	Professionals: site managers on energy efficiency	12	0,5

Table 8: List of training by BIM Design Hub (Member of the project's Expert Panel in Greece) as part of Autodesk Revit training - Introduction to BIM concepts and implementation.

When	Participants	How many persons?	How many days?
2017	Association of Architects Thessaloniki	20	4
2018	Professionals ARCH,STR engineers + company of MEP engineers	9	2
2019	Professionals ARCH,STR engineers + 2 construction firms	11	2
2020	Professionals ARCH,STR engineers	4	1

Table 9: Training provided by House of Training (Luxembourg).

When	Participants	How many persons?	How many days?
2018	Professionals ARCH,STR engineers, MEP engineers, constructors and researchers on BIM and improved energy efficiency	15	1

4.2.4 Calculation of the impact based on trainings

Explanation of the calculation bases leading to the final quantified output- Part 2:

*It is also possible to estimate a mean equivalent number of renovation projects annually performed by a company (ADEME, 2013) (i.e. 8 equivalent renovation projects). The calculation is mostly based on the French Agency ADEME survey “Chiffres clés du bâtiment – 2013” and then applied for any company from the five countries of the consortium. According to this French survey, 2 500 000 energy related renovations (including window renewal) were achieved in 2013, for a total turnover of 13.5 billion €. As the number of SMEs in France working in the building sector is around 300 000, the mean number of annual energy related renovation projects performed by an SME is around 8, with a mean amount of 5,200 € for each renovation. According to this assumption, we can expect that the BIMEET project will influence the equivalent of 1725*8 renovation projects within its duration.*

Need-based behavior patterns to take an eLearning course

It is likely that professionals will take an eLearning session when they face the need of knowledge in their working flow with present projects. eLearning and webinars are more agile than face-to-face training programs in this sense. We estimate that **minimum 900 professionals and 200 students** will take the BIMEET eLearning course by end of 2020.

If courses are widely launched, the estimation may be higher: 2000 professional and 600 students.

In this report the estimation A is calculated with the minimum estimates.

8 renovation projects / company or more?

Some professionals may be involved in more than 8 projects, which is often the case with designers. We can estimate that half of the professionals are designers and they are involved in 20 renovation projects during one year

Estimation A

Number of all participants in BIMEET trainings (students and professionals) = 1493

Number of renovation projects which are influenced: $1493 \times 8 = 11944$

Estimation B

Number of all participants in BIMEET trainings (professionals) = 1208

Number of renovation projects which are influenced: $1208 \times 20 = 24160$

Estimation B is provided in order to show another result, with a slightly different reasoning, for comparison. It is taken only the amount of professional participating to the trainings, as they are working with building, design and construction and renovation daily and can make the difference in energy and environmental decisions and make a direct impact.

8 renovation project / company or more?

Some professionals may be involved in more than 8 projects, which is often the case with designers. We can estimate that half of the professionals are designers and they are involved in 20 renovation projects during one year

Estimation B is taken following assumptions:

- *based only the amount of professionals*
- *based on the average estimation of professionals participating eLearning (table 8)*

- 608 professionals will work in small scale renovation projects (100 m²) and 600 professionals will mostly work in larger scale renovation projects (2000 m²): apartment housing projects and office renovation project as well as public buildings, as well as renovations of schools. Average size of buildings: 1300m²

Explanation of the calculation bases - Part 3: Primary energy

According to a BPIE survey (BPIE 2014), the mean specific primary energy consumption for residential buildings is estimated at around 200 kWh/m². Assuming a mean surface area of 100 m² for each renovated housing, and that the BIMEET project could help to shift from a renovation type to a better one (as defined by the BPIE survey) with an additional 30 % energy saving, the expected total energy saving is $1725 \times 8 \times 200 \text{ kWh/m}^2 \times 100 \text{ m}^2 \times 0.3 = 83 \text{ GWh}$. According to the BPIE survey, it is estimated that there are 25 billion m² built useful floor area in the EU27. The residential buildings account for 75 % of this building stock, and the non-residential buildings 25 %. Taking into account the likely renovation of non-residential buildings in addition to the renovation of residential buildings, and assuming that the mean additional energy saving for non-residential buildings triggered by the use of BIMEET outcomes is at the same order of magnitude as for residential buildings, the expected total energy saving including non-residential buildings is $83 \times 4/3 = 110 \text{ GWh}$. As the project duration is 2 years, the mean annual energy saving is 55 GWh.

RESULTS: Estimation A

$1493 \times 8 \times 200 \text{ kWh/m}^2 \times 100 \text{ m}^2 \times 0.3 = 71,5 \text{ GWh}$

$71,5 \times 4/3 = 95,3 \text{ GWh}$. $95,3 / 2 = 47,5$. The annual energy saving triggered by the BIMEET project is 47,5 GWh.

RESULTS: Estimation B

$1208 \times 20 \times 200 \text{ kWh/m}^2 \times 1300 \text{ m}^2 \times 0.3 = 188,5 \text{ GWh}$

$188,5 \times 4/3 = 251,3 \text{ GWh}$. $251,3 / 2 = 125,5$. The annual energy saving triggered by the BIMEET project is 125,5 GWh.

Explanation of the calculation bases - Part 4: Renewals

The BIM technology is also relevant for enhancing the integration of renewables in buildings. We can expect that the BIMEET project would help to improve the efficiency of systems or to install more renewable energy systems, leading to 25 % more renewable energy produced in buildings. If we assume that the mean renewable energy production would rise from 50 kWh/m² to 62.5 kWh/m² (25 % more), and that only half of the buildings will integrate renewables, the total additional renewable energy production (for residential buildings) is $1725 \times 8/2 \times 50 \text{ kWh/m}^2 \times 100 \text{ m}^2 \times 0.25 = 8.6 \text{ GWh}$. If we add the non-residential buildings it leads to $8.6 \text{ GWh} \times 4/3 = 11 \text{ GWh}$. The annual renewable energy production triggered by the BIMEET project is 5.5 GWh. These expected impacts can be discussed as some uncertainties remain (for instance the mean equivalent number of renovation projects annually performed by a company). Nevertheless, the methodology didn't integrate the effect of the BIMEET project on the energy efficiency of new buildings (as the potential energy saving for existing buildings is larger than for new and more efficient buildings), thus leading to a potential additional energy saving.

RESULTS: Estimation A

$1493 \times 8/2 \times 50 \text{ kWh/m}^2 \times 100 \text{ m}^2 \times 0.25 = 7,5 \text{ GWh}$. If we add the non-residential buildings it leads to 7,5

$\text{GWh} \times 4/3 = 10 \text{ GWh}$. The annual renewable energy production triggered by the BIMEET project is 5,0 GWh.

RESULTS: Estimation B

$1208 \times 20/2 \times 50 \text{ kWh/m}^2 \times 1300 \text{ m}^2 \times 0.25 = 19,6 \text{ GWh}$. If we add the non-residential buildings it leads to 19,6

$\text{GWh} \times 4/3 = 26,0 \text{ GWh}$. The annual renewable energy production triggered by the BIMEET project is 13,0 GWh.

Explanation of the calculation bases - Part 5: Renovation rate

On the long term and after the project, we can expect an even larger impact of the BIMEET project on energy efficiency. As stated in the Article 4 of the Energy Efficiency Directive 2012/27/EU, each EU countries shall reinforce the strategy for renovating the building stock. According to the BPiE survey, the renovation rate should be multiplied by at least 2. If the renovation rate of the European building stock (25 billion m² with a mean consumption of 200 kWh/m²) is boosted from 1 % to 2 %, and that the BIMEET help to save 30 % more energy, the annually saved energy by the project is 30 TWh.

Note:

This estimation is based on the whole European building stock. The trainings have been held in Luxembourg, South of France, Greece and in Finland, and therefore the calculation should rely on the building stock of the countries in question. Renovation is very local business and the benefits of better skill, knowledge and competence on BIM and EE will impact the quality of buildings locally.

4.2.5 Estimation of the volume of coming trainings and courses in 2020

Several BIM-EE trainings will happen during 2020. The partners of BIMEET project are planning several BIM and EE related courses and trainings during March- end of 2020. Also partners from BIM Alliance network will launch courses and trainings this year and the coming years. Below the estimations of participant from BIMEET partners. The estimation covers courses by end of 2020. Summary of estimated participants is introduced in Table 10.

- Metropolia: 40 professionals (in BIM related continues education courses) and 500 students.
- Cardiff University: In BIM MSc program around 40 students enrolled.
- INES: 30 professionals and 20 students are attending in webinar in May and BIMEET training in October.
- LIST: 20 professionals in training days.
- Greece (CRES and BIM Design Hub): 20 professionals, mainly designers in yearly BIM tool courses.

Table 10: Summary table of estimated participants on trainings and courses.

Estimated participants for BIM-EE education and courses by the end of 2020		
Provider	students	professionals
Metropolia	500	40
Cardiff UNI	40	0
INES	20	30
HoT	0	0
CSTB	0	20
Greece	0	20
TOTAL	560	120

4.2.6 Estimation/ forecasting the volume of audience for the eLearning

Audience which could reached by dissemination the eLearning training schemes, available from INES Platform, is estimated by each education / training provider. The estimation cover courses by end of 2020.

Metropolia University of Applied Sciences education is grouped into 4 different themes of Culture, Business, Technology and Health Care and Social Service. A total of around 8000 students (2018) are enrolled in “Technology” where real estate and construction studies are provided. A total number of **1977 students are currently enrolled in real estate and construction field** (Metropolia internal database, 2020). The eLearning modules are planned to be implemented as a part of a BIM course (1ECTS) for a first year students of 2020 intake (**around 500**) and the information about the course is provided to all the students linked with real estate and construction studies (around 1980).

Cardiff University, Ines, LIST (and HoT) and CRES (and BIM design hub) are all is going to disseminate the eLearning courses within BIM MSc programs, student of construction and real estate, participants of BIM continues education courses and trainings (for professionals). Further BIMEET partners are dissemination the existence of free eLearning course in their networks amongst community of interest in each countries.

The estimated audience for eLearning course, by end of 2020, is introduced in Table 11: Summary table of estimated participants on trainings and courses.

Table 11: Summary table of estimated participants on trainings and courses.

Estimated audience for BIMEET eLearning courses (eLearning 1 and 2) by the end of 2020		
Provider	students	professionals
Metropolia	1990	40
Cardiff UNI	40	-
INES	200	400
LIST/HoT	-	100
CSTB	-	50
Greece	-	100
TOTAL	2230	690

5 Further development of impact performance indicators

5.1 Used impact performance indicators

The impact monitoring of BIMEET project focuses on BIM and EE trainings and the amount of participants. In the impact monitoring calculations, the used performance indicators are primary energy and renewal energy. Calculations are also based on average estimations on the amount of building/renovation projects the professionals are participating per year and the scale of projects.

5.1.1 Primary energy savings in Renovation projects

Amount of project per professionals.

The calculation formula estimates that the average amount of projects are 8 renovation projects per year per professionals. In some countries design professionals are working in larger consultancy companies and they will be taken part of much more projects. From this viewpoint up-scaling of their competence have a stronger impact to the final performance target.

Scale of project and amount project per professional

The calculation formula estimates an average project size is one family house. Some professionals of trainings are working in larger projects than 100m², very often in projects on multi-family houses a, row houses and offices or public buildings. From this viewpoint up-scaling of their competence have a stronger impact to the final performance target.

5.1.2 Renewal energy

The calculating formula is using the estimation which generates 25 % more renewable energy produced in buildings. The location of the building will affect this percentage (wind, solar geothermal energy), as well as the share of renewable energy sources in primary energy production.

5.2 Potential new impact performance indicators

5.2.1 Greenhouse gases

It is possible to estimate the greenhouse cases connected to energy (especially CO₂) from the mix of primary energy- amount of fossil and amount of RES. To start, we should know what would be the possible energy mix profiles in different locations/ different countries. In order to estimate total greenhouse reduction we should take the main structural materials into account, which exists in great variety.

5.2.2 Indicators related to the BIM EE trainings and education

The survey in Deliverable 3.3 resulted that today most of the offered trainings are either BIM trainings or energy performance related trainings, but there is not to many trainings connecting these subjects. By setting targets for increasing the trainings and education in construction field as such, and setting up indicators to follow the targets, could boost also the amount of BIM EE trainings.

Build Up Skills Pilar I projects resulted country specific roadmaps and defined impact indicators for trainings and educations, mainly for vocational training. The defined indicators (Table 12 and Table 13) are useful for following up all types of education levels: university levels and

universities of sciences as well as training courses for skill to master the EE- BIM authoring tools or knowledge related to energy performance solutions and working in EE-BIM processes, and for continuous education programs building up further competence for professionals (BUILD UP Skills 3).

Energy -efficient building highlights the need for some skills more than the before. Best practices for energy efficient construction need to be disseminated. In the development of teaching the following areas need to be in focus for all worker groups (defined 2012 for vocational level experts/workers):

- Understanding of the hydrothermal performance eg. structures and airtightness
- Understanding mould and moisture risks linked to different material and installations
- Understanding novel designs and instructions such as data models
- Understanding the performance of a facility and its systems as whole. Knowing how to guide its energy-efficient and moisture safe use
- Ability to speak foreign languages, to understand cultural differences, and to collaborate with construction workers from different countries

Table 12: Indicators for the progress in development of learning and knowledge. Themes: Development of learning and knowledge and Dissemination of know-how and verification.

	Themes and actions	Objectives and indicators	Progress indicator
1	Development of learning and knowledge	Raising the level of learning indicators: content and amount of new learning material, content and amount of further training of teachers and workers, number of worker training days	
1.1	Identifying, documenting and further developing best practices in energy-efficient construction.	Forming a basis for future work. Preparing learning materials. Motivating parties for energy-efficient construction and its overall management.	Contents and volume of published material.
1.2	Updating curricula, supplementing teaching materials, further education of teachers.	Integrating best practices and results of latest research in teaching materials and vocational training. Motivating teachers to address energy issues.	Curriculum contents. Content and amount of produced learning material. Content and number of days for further education of teachers.
1.3	Developing new teaching methods to support on-the-job learning. Utilizing information technology in teaching.	Improving quality of teaching, making learning more effective. Making participation more attractive for employers and employees. Developing teaching on learners' terms. Developing precision training.	Number of worker training days.

2	Dissemination of know-how, verification.	Raising the level of workers' skills Indicators: Number of graduates, amount of further training for mentors and workers, development in the number of complaints.	
2.1	Dissemination of best practices in energy-efficient building.	Implementing best teaching methods, increasing awareness of energy-efficient construction. Employing mentors and attitude builders to promote knowledge.	Number of worker training days. Number of training days for mentors and attitude builders.
2.2	Developing competences and skills demonstrations, encouraging workers to complete qualifications.	Increasing and securing the know-how of untrained workers and immigrant workers. Increasing the number of those completing qualifications.	Number of graduates.
2.3	Including criteria of energy-efficient building in quality assurance of construction sites.	Improving the quality of energy-efficient building. Guidance of the workers. Ensuring the quality of their work regardless of qualifications.	Declining number of quality defects and complaints.

Table 13. Indicators for the progress in development of learning and knowledge. Theme: Supporting measures.

3	Supporting measures	Steering and encouraging development Indicators: Indicators of sections 1-2, stakeholder satisfaction, visibility in media, number of graduates and training days	
3.1	Assessing the effectiveness of measures, co-ordinating with other development programmes in the industry.	Steering development activities and resources towards high-leverage projects. Securing, sharing and implementing outcomes.	Indicators of sections 1-2. Measuring stakeholder satisfaction.
3.2	Communicating outcomes to stakeholders and media.	Transfer of energy-efficient building know-how to builders, clients, designers, and authorities. Increasing the support of stakeholder groups in energy-efficient construction.	Number of media hits, newspaper articles, TV minutes. Quality of public discussion. Visibility in stakeholder actions.
3.3	Increasing incentives, motivating to developing knowledge and doing quality work.	Improving attitudes and reducing resistance to change, influencing attitudes, removing barriers to development.	Number of graduates. Number of training days for workers and attitude builders.

Measures to meet skills requirements for energy-efficient construction

Figure 8 shows the different measurement level when assessing the impact of training. When the final goal is in increasing the knowledge of vocational blue-collar workers/ labour force (white area), there are at least three layers of development we need to face and tackle. Firstly we need to identify and create the ways and mean for increasing knowledge (light blue frame) Secondly we need to implements the ways and means in teaching, further education and at construction site (orange frame). Thirdly guidance and support need to be developed (blue frame).

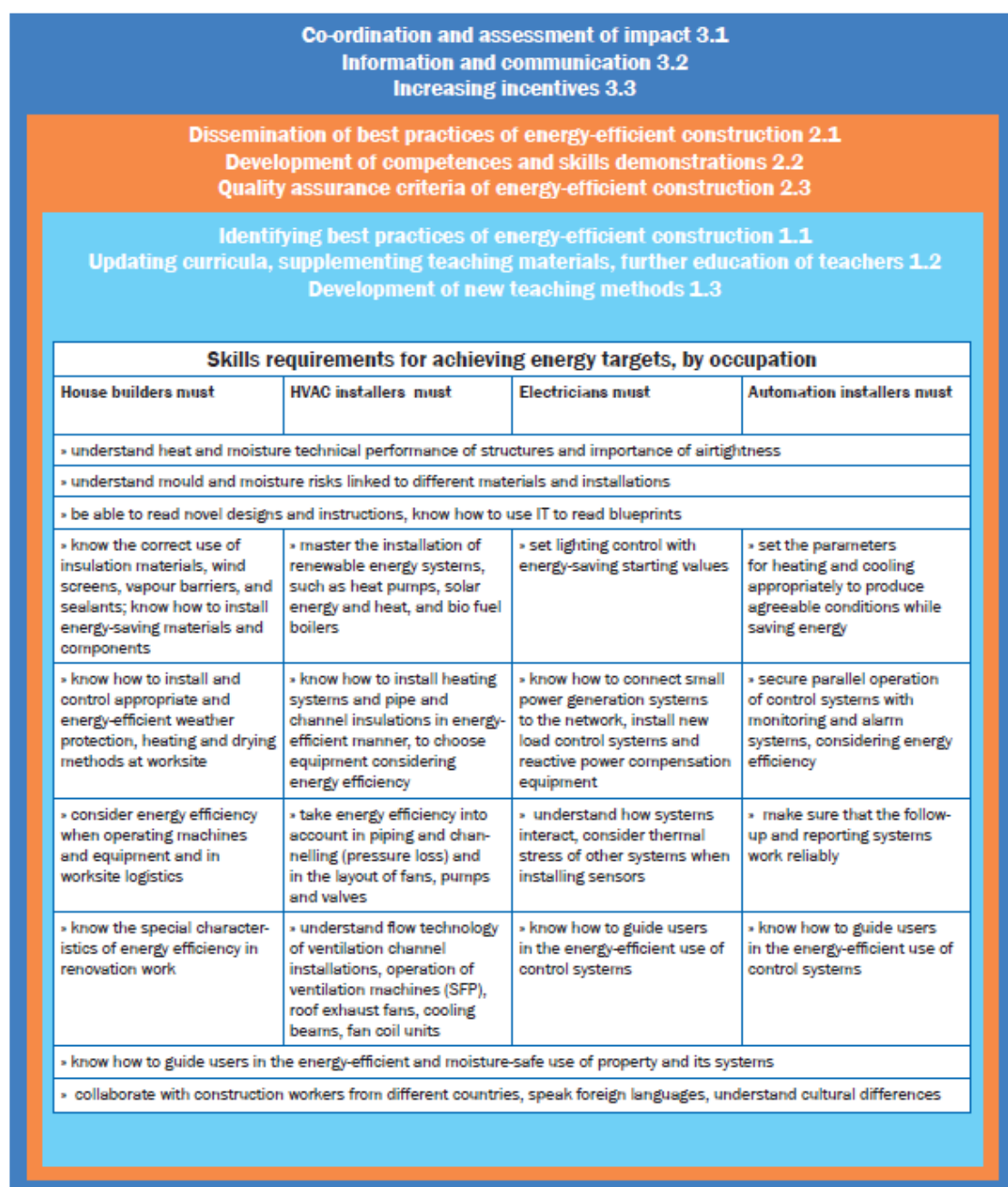


Figure 8: Metamodel of assessment - different measurement levels

Tracking the impact

Strategical Knowledge on Build Up Skills is an emerging area of expertise. The more we know on the impact frame and impact of different activities in different levels (policies, managerial, operational), the better we can focus the resources for competence building. Figure 9 shows the recent publications on this area.

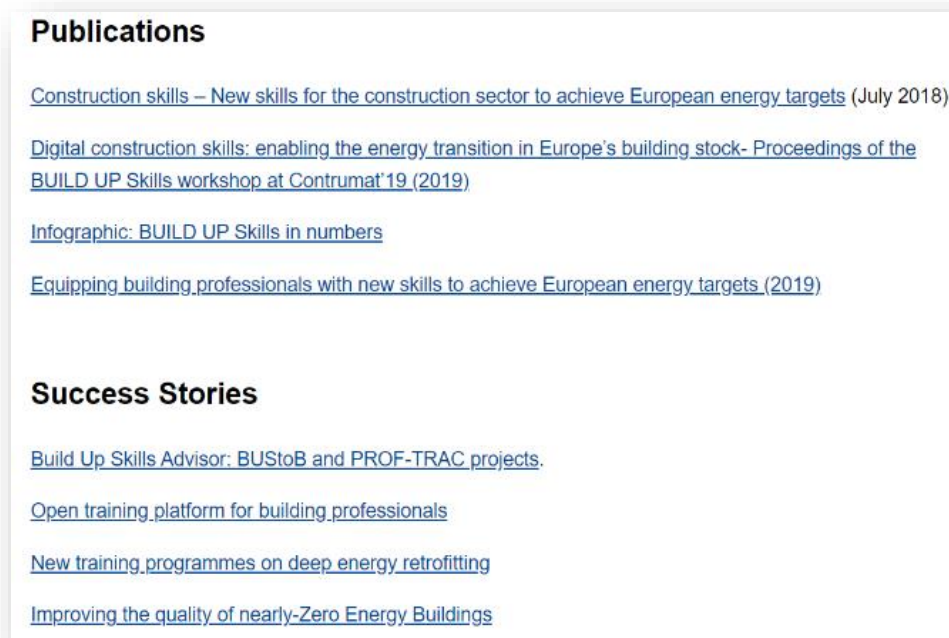


Figure 9: Recent publications on Strategical Knowledge on Build Up Skills. Source: EASME web page.

5.3 Activities to maximize accumulation of impact

The impact of BIMEET project results will be accumulated also after the project time due to planned training courses, dissemination and communication program for eLearning and distribution through BIMEET BIM-EE Portal. The plan for exploitation, including a business model for BIMEET labeling (based on BIMEET LO's) and production of further eLearning is a starting point for impact predicted, monitored and accomplished in the future.

5.3.1 Dissemination and Exploitation plan of BIMEET

Exploitation plan is introduced in D5.4 and Dissemination plan in D6.5. They describe the activities after BIMEET project during the year 2020 which will support the accumulation of impact during the coming years, as the number of BIM-EE trainings will increase.

Dissemination includes the distribution of eLearning material and invitations for joining the BIMEET community. Main target groups are BIMEET community of interest, educational and training institutes and expert panel members.

The role of the Energy-BIM portal is an important vector to disseminate training resources and important training information, well as the two BIMEET eLearning courses.

Exploitation plan covers an idea of the further development of BIMEET services, mainly adaptation of BIMEET labeling process, and raising-up and maintaining repository of BIM-EE

trainings and courses and eLearning material in Energy BIM portal. Invitations for training organization and providers of BIM EE software- trainings to up-load their trainings to the portal is one key activity in this process.

5.3.2 Impact chain and BIMEET portal

Impact chain is based on education and training where BIM and EE are learned. BIMEET Energy BIM portal is a one-stop-shop solution to access BIM for energy, trainings and education, knowledge, expertise and best practices.

The primary use for the portal is to find BIM-EE trainings and for the training institute to locate cities and clients needing training with a tangible table connecting data to locations. When the trainings are uploaded to the portal (following BIMEET labeling process), also impact can be estimated, the way explained in this report. Energy related indicators can be assessed taking into account all the trainings in the portal. Using the calculation method (introduced in section 3.2.) it is possible to estimate the decreasing of primary energy and increasing or use of renewal energy in renovation buildings. Further, as the BIMEET labeled trainings are matches with the LO's, it will be possible to plan trainings taking care of good coverage of all the LO's for all professional roles in building projects.

5.4 Significance of adapting LO's (learning outcome)

Trainings of EE BIM as key asset in building up the needed competence, with a comprehensive learning paths developing skills and knowledge are supported by BIMEET frame of learning outcomes (LOs)

BIMEET learning outcomes as defined in D3.2 refer to the intended leaning outcomes rather than achieved learning outcomes, and serve in the planning phase of a training or educational program. *"Learning outcomes are attributed to individual educational components and to programmes at a whole. Learning outcomes are specified in three categories – as knowledge, skills and competence. This signals that qualifications – in different combinations – capture a broad scope of learning outcomes, including theoretical knowledge, practical and technical skills, and social competences where the ability to work with others will be crucial."*

5.4.1 Feedback to BIMEET LO's

The feedback of Defined LO's shows the interest on them among education professionals, training providers and company HR specialists. In general the reaction to the BIMEET frame of LOs has been very positive emphasizing the importance of a holistic frameworks in order to guide the discussion and assessment on competence needs, and the ways they should be trained. This enthusiasm may generate many different kind of learning courses and activities. Some examples of interest shown amongst teachers and companies in Finland is introduced in D6.5.

5.4.2 Different usages of LO's and impact tracking

An outlook for the possible use of LOs can boost the number of BIM -EE trainings in near future, and this way having influence to the final impact. Figure 10 shows different approaches and usage possibilities of the BIMEET LOs. The usage possibilities are acknowledged during dissemination activities and discussions with the experts.

The main usage area certainly will be different level of educations and trainings, which include a variety of types, like:

- training courses,
- education programs and courses in universities of applied science,
- education courses in universities,
- education courses in vocational training,
- continuous education courses,
- courses for BIM authoring tools,
- companies in-house training courses.

For qualification and accreditation the BIMEET LOs formulations give a solid ground. Many certified professional courses can be developed after implementing national (or European) qualification system.

Some other possible usage area include using LOs for maturity matrix and using them in procurement when requiring level of competence, knowledge and skills. The matrix can as well be a guideline while defining maturity levels of different stakeholders. Moreover, linkage between what a role is required to learn can easily be visualised for instance using tabletop interface that integrates LO's and the level of competence a person has or is required.

The LO structure thus also serves the training providers through placement tests aligned with LO's to map a learner's level of skills and knowledge before the training. This provides the training organizations or trainers to provide on demand personalized solution and also supports in the process of creating eLearning courses and material. The LO repository has a wide array of usefulness in many ways, for e.g. Development and creation of specific learning goals for events like BIM summer schools, short trainings as well as organizational in-house trainings.

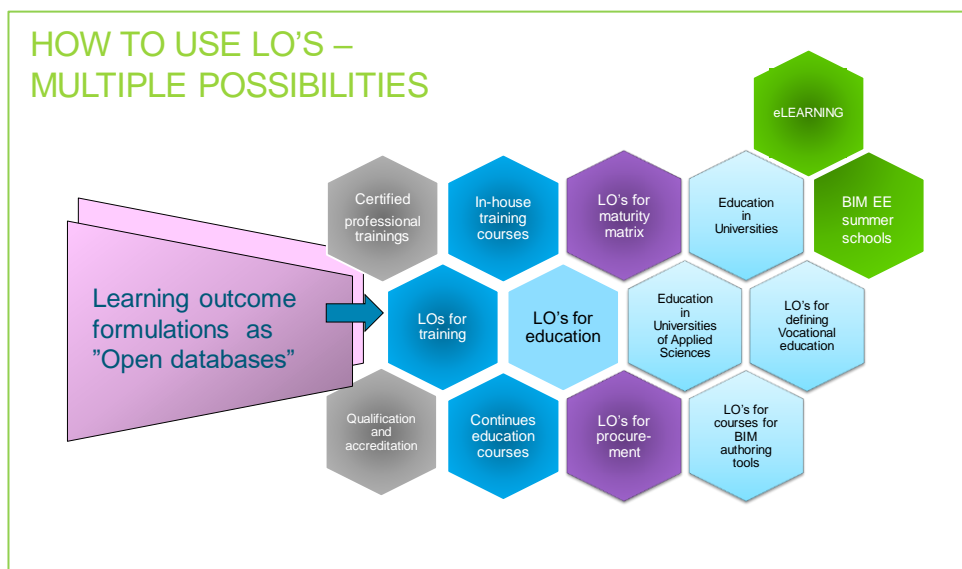


Figure 10: Multiple use of LO's and maintaining LO formulations as "open database"

5.4.3 Scenario on future impact tracking

BIMEET project have developed technologies providing service for trainings and competence development in the area of BIM enabled energy management. Energy-BIM platform and BIMEET training repository and visualisation with a tangible table are specified in reports D 4.2. and D4.4 (WP4).

Figure 11 shows element of future scenario with key Energy-BIM platform services (taking advantages of the BIMEET learning outcome framework and formulations). Services helping to

find labelled trainings and visual search with tangible table are developed in BIMEET as proof of concept.

In the future the services could include also impact tracking. As introduced in this report, the impact estimation starts from the amount of trainees in BIM-EE trainings and educations. When uploading most of the BIM-EE trainings in Europe to Energy-BIM platform, and collecting the feedback and amount of participants, we could estimate the impact of trainings. In the future this would enable impact prediction too and give information for decisions on the use of different policy steering instruments and weighting between them. BIMEET LO's framework enables to track also the most relevant trainings for the best impact for energy efficiency and environmental friendly renovations. The technical and service layer development of Energy-BIM platform will continue in upcoming research projects.

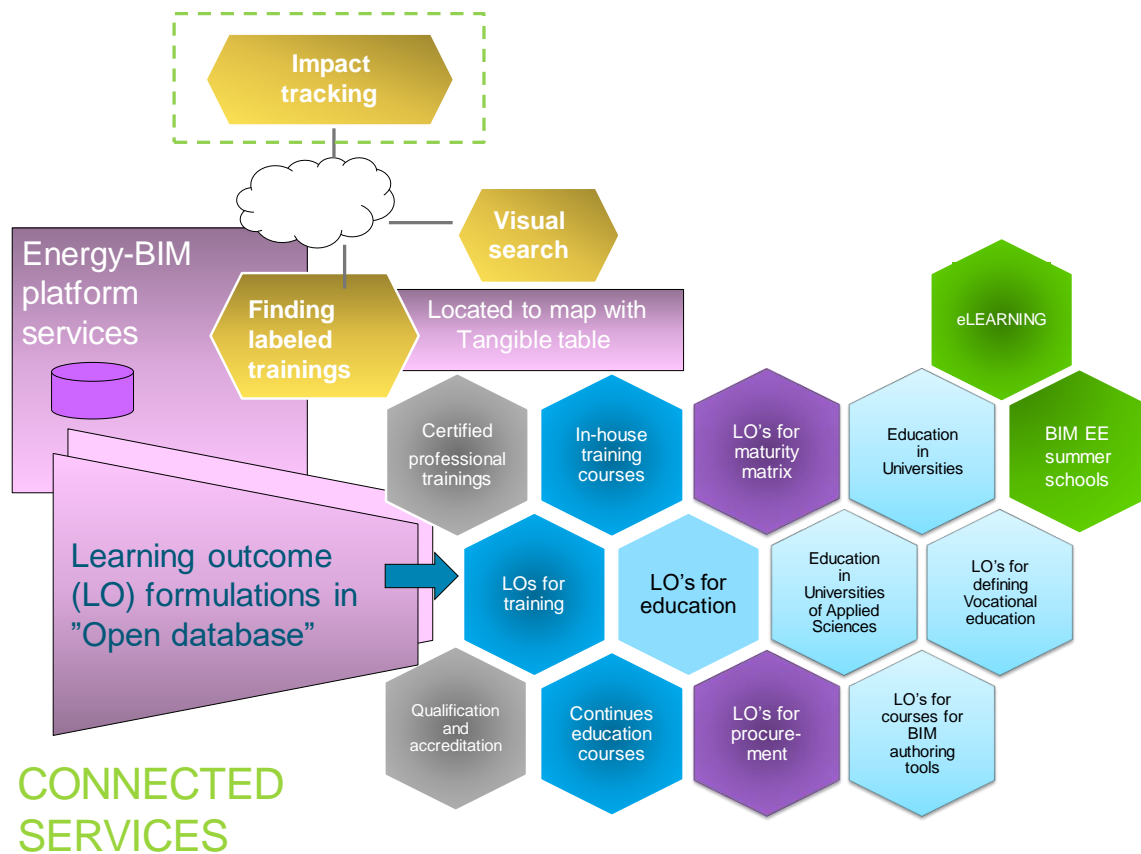


Figure 11: Different services and functions supporting BIMEET LO- based training and education with connections to impact tracking.

6 Conclusions

The Final Report on the assessment of the BUILD UP Skills Pillar II is listing clear and concrete steps for supporting the training of energy efficiency in European countries (see Appendix 1). Several ideas are listed for increasing the number of trainings by supporting continuing learning and education, and further upskilling of the workforce and should foster communication and awareness raising, of both construction professionals and the general public, concerning the importance of energy efficiency in buildings. Elements that should be added in trainings and educational programmes include circular economy implications (lifecycle of buildings), Building Information Models (BIM) and use of IT in construction, Near Zero Energy Buildings (NZEBs), energy efficiency in existing buildings both in blue collar and white collar (professional) sectors. This all might need different stakeholders and political commitment at Member State level.

The attendees to BIMEET trainings for BIM and EE knowledge and skills has been smaller as estimated in DoW. At that point the idea was to involve and invite the organizations from community of interest and expert panel to provide trainings.

BIMEET consortium focused on development of the learning outcome structure and the strong role of the trainings was adapting Los and testing them. Therefore only the trainings provided by the partners and one member of expert group have been considered as BIMEET trainings, altogether 11 courses. The low number of trainings connecting to BIM and EE available on the market and low market pull in some countries, as well as low number of teachers in this field, can be seen as reasons which affected the low involvement of existing training organisations.

The BIMEET partners developed BIMEET eLearning courses with materials on BIM and EE to support the situation on the market. BIMEET partners have estimated that they will organise BIM-EE courses and trainings for **560 students and 120 professionals** by the end of the year 2020. The audience of BIMEET eLearning courses will reach up to **2230 students and 690 professionals**, by the end of the year.

The BIMEET core team will pursue its dissemination and impact efforts in the context of the INSTRUCT project (grant number: 894756, start in June 2020). The INSTRUCT project aims to act at a market level by providing an operational framework and set of services serving a new generation of skilled and certified workers and fitters and paving the way to legislative changes that overall will stimulate the demand for energy skills across lifecycle and supply chains.

In particular, the objective of the INSTRUCT's demonstration work package is to run demonstration pilots and to get feedback and evidence on different geographical regions in Europe. One of these pilots focuses on "BIM for Energy Efficiency Training and Standard" in West Europe, and will be carried out by Cardiff University, LIST and METROPOLIA. It will leverage on BIMEET elearning courses, as well as on the training platform, to continue delivering impact by training thanks to the work started within BIMEET.

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8 APPENDIX 1: EXECUTIVE SUMMARY of Final Report on the assessment of the BUILD UP Skills Pillar II

This report aims at assessing BUILD UP Skills' Pillar II initiative and constitutes the final deliverable of the contract EASME/H2020/EE/2015/008 'Support for BUILD UP Skills EU exchanges and analysis on construction skills' for the Executive Agency for Small and Medium-sized Enterprises (EASME) in the evaluation report form of the.

The overall approach to the assessment of the BUILD UP Skills initiative is based on the standard evaluation methodology for European programmes. The assessment framework consists of evaluation questions against six evaluation criteria: Relevance, EU added value, Efficiency, Effectiveness, Coherence and Sustainability. The methods used to collect and analyse the data include desk review of project Interim and Final reports and Common Performance Indicator reports and stakeholder consultation, mainly through interviews.

Findings and overall conclusions

Relevance

Relevance is 'built in' to the BUILD UP SKILLS Pillar II projects through their links to the Pillar I projects (which mapped the skills and other needs in the construction sector in the majority of Member States). Projects have been also adapted based on ongoing customer feedback relating to the nature of the training courses, delivery style and timing.

The original roadmap actions are largely complete, so in theory the roadmaps need to be updated. Updates could focus on supporting uptake as demand grows, as well as on updating course content to keep it up to date. Elements that could be added are the circular economy implications (lifecycle of buildings), Building Information Models (BIM) and use of IT in construction (and IT literacy generally), Near Zero Energy Buildings (NZEBs), energy efficiency in existing buildings and white collar (professional) sectors. This might need different stakeholders and political commitment at Member State level.

EU added value

The European element of the BUILD UP Skills programme enabled the EU Exchange Meetings which provided the main networking and learning opportunities. In some cases new networks created during the EU Exchange Meetings have resulted in new follow-up projects (e.g. H2020 projects). In addition, some project training schemes have been (or will shortly be) recognised at EU level. Finally, in most countries, national funding would not be available for projects such as those supported by BUILD UP SKILLS. In the very few cases where national funding is available, the projects would have been more fragmented compared to the BUILD UP Skills projects and would not include activities beyond the national level.

Efficiency

The quantitative analysis showed that the BUILD UP Skills initiative was relatively efficient in terms of costs to qualify each trainee compared with other programmes. The majority of the BUILD UP Skills projects met their ex ante target in terms of cost per trainee. The BUILD UP Skills initiative has also been relatively efficient in terms of cost / trainee in comparison to other international programmes or similar national initiatives.

Economic barriers (lack of time for training, cost of training), awareness-related barriers (lack of understanding of the importance of skilled / trained workers), legal barriers (delays in introducing energy efficiency related definitions), market barriers (low demand for energy efficient buildings and thus for the skills required to build them), and knowledge barriers (language, varying levels of competence of the trainees, and lack of facilities for practical training) were the most common issues to Final Report on the assessment of the BUILD UP

Skills Pillar II adversely affect the efficiency of the projects. Overall, the administrative burden of the BUILD UP Skills initiative was considered low and not higher than in similar programmes.

Effectiveness

The results show that BUILD UP Skills projects boosted education and training of craftsmen and other on-site construction workers and system installers in the building sector and increased the number of qualified workers across Europe. All projects developed and piloted new qualifications and training schemes and/or upgraded existing ones. The majority of projects have achieved the targets they initially set. Overall, this evaluation considers that the programme has been very successful (this is also perceived at the national level by the stakeholders consulted).

Coherence

Sharing experience between BUILD UP Skills projects has been almost exclusively prompted by the EU Exchange Meetings. For many projects this was the only way to share experience and learn from each other (and adjust approaches), for others, these meetings were the beginning of further collaboration. The relationships initiated here also led to new projects and hence to establishing links between BUILD UP Skills projects and projects from other initiatives, like Horizon 2020. It appears that synergies are enhanced when having a consortium partner in the project who is involved in policymaking.

Sustainability

BUILD UP Skills training courses, methods to establish voluntary qualification schemes, competence frameworks, and methodologies for the recognition of previous learning developed by BUILD UP Skills projects can be replicated in other countries, by other construction occupations, and, in some cases, possibly by other sectors. Continuation is ensured firstly through the outputs e.g. learning materials, which are largely available through the BUILD UP Skills project websites. The work is already continuing or is planned to be continued at local level (e.g. implementing the training courses), national level (e.g. trying to influence policymaking, legislation) and at EU level (e.g. replicating the project in other countries, taking part in H2020 follow-up projects).

Conclusion and Recommendations for all levels of stakeholders

BUILD UP Skills has been a successful, relevant, unique and timely initiative. In many countries, similar training courses did not previously exist, neither were any efforts made to analyse the need for such skills or to bring together the relevant stakeholders. The projects have helped set the basis for education of construction workers, developed high quality and innovative materials, developed a good network and raised awareness among construction workers and policy makers of the importance of energy efficiency and RES and cross-craft skills for blue collar workers.

Below, a set of recommendations addressed to specific stakeholder groups is listed.

Recommendations for the European Commission

The EC should continue to support continuing learning and further upskilling of the workforce and should foster communication and awareness raising, of both construction professionals and the general public, concerning the importance of energy efficiency in buildings and the quality of the construction work to achieve this, by:

- a) *Setting more ambitious targets for energy efficiency in buildings.*
- b) *Adapting the legislative framework. For example, by:*
 - *Setting a requirement for mandatory training courses for blue-collarworkers for energy efficiency related construction skills.*

- *Tackling the issue of mutual recognition so that training accredited in one EU country is recognised in another EU country.*
- *Ensuring that every EU country has a working definition of nZEB and that this and other concepts are harmonised and promoted across the EU.*

Recommendations for EASME

EASME should also continue to support ongoing learning and further upskilling of the workforce and should foster communication and awareness raising, of both construction professionals and the general public, concerning the importance of energy efficiency in buildings and the quality of the construction works to achieve this.

Concrete ways to do this include:

- a) *(Continue to) Fund projects for knowledge and skills development as well as projects with strong awareness-raising component addressed to the general public as well as to blue- and white- collar workers.*
- b) *A prerequisite should be that projects pursue national recognition, so that the training courses developed are embedded in the national systems.*
- c) *Harmonising Common Performance Indicators. Adopt clearer, single methodologies for calculating project impacts (Common Performance Indicators) and their cost-efficiency.*
- d) *Maintaining the BUILD UP Skills network through for instance EU Exchange Meeting-like events in the (near) future.*
- e) *If future programmes foresee Technical Working Groups, the topics dealt with by these should be directly connected to the projects, addressing actual challenges that the projects are facing and grouping comparable projects into one Working Group.*
- f) *Support the update of national skills Roadmaps, possibly inviting new stakeholders (e.g. building managers, construction ICT experts etc.) to participate.*

Recommendations for national authorities

- a. *Offering long-term support in terms of funding (i.e. long-term, stable, continuous funding) and implementation.*
- b. *Providing recognition of the skills obtained.*
- c. *Green procurement: Demand qualifications / skills in their tendering procedures.*
- d. *Support awareness raising campaigns.*
- e. *Creating a register of companies that employ skilled workers.*
- f. *Setting a requirement for mandatory training courses.*
- g. *Requesting / Funding new / updating the national skills Roadmaps regardless of whether the EU does (or does not) request / suggest an update.*

Recommendations for project coordinators and other training developers

- a. *Awareness-raising of the importance of skills and training.*
- b. *Offer practical, flexible training courses adjusted to the various needs of workers.*
- c. *Involve target groups and other stakeholders from the beginning.*
- d. *Proactive promotion of training courses and marketing training courses. Consider timing for promotion e.g. marketing courses immediately before periods when there tends to be less work.*

- e. *Active participation in the update or development of new national Skills Roadmaps.*