BIMplement

Towards a learning building sector by setting up a large-scale and flexible qualification methodology integrating technical, cross-craft and BIM related skills and competences.

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Report: **D3.1 Filled Qualification Framework**
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Executive summary

This report is the summary of the work done in the BIMplement T3.1 *Filling in the Qualification Framework* resulting in an overview of the professional activities (technical tasks) and related skills and competences for all professions (blue and white collars) throughout the different project phases, for the two selected topics, important to come to high quality nZEB, air-tightness and ventilation. This document should be read together with the filled BIMplement Qualification Framework (annexes: BIMplement QF1 related to ventilation and BIMplement QF2 related to air-tightness).

It is recommended to read the work reported in T3.1 together with the work done in other work packages, WP2 and WP3. The work done in T3.1 started with testing the methodology proposed in D2.1. However, once putting the QF in use in T3.1, it was learned that some iterations are still needed to improve the methodology to satisfy the needs and help reaching the improved quality in nZEB. Therefore, the T3.1 is an additional iteration process where feedback from the implementation phase was used to improve the methodology as reported in D2.3.

Nevertheless, as the BIMplement QF are implemented and tested at the pilot field labs and experimental sites, this task (T3.1) is ongoing. The resulting QF from T3.1 are going to be applied and put in use at national (regional) level for the identified experimental sites. This will serve as a last iteration improving and enforcing the usefulness of the developed framework. Both, methodology elaboration and its testing in real construction projects is closely interrelated and is therefore ongoing process during the whole project duration.

In the current QF1 and QF2, a careful consideration was given on how to connect with the identified qualifications to perform a task with the relevant training material, appropriate learning tools, education material and identify the quality checkpoints needed to assure the desired quality. To come to a normalized standardized qualification framework, the structure of the framework was restructured to separate the tasks-based approach (task definition, subtasks) and ULO's. The work resulted in *reusable ULO's* (database of ULO's) that can be linked to tasks and subtasks of relevant actors to achieve quality in the area of air-tightness and ventilation (in nZEB construction/renovation project).

*The collaboration with the H2020 NEWCOM project is ongoing where same structure of QF is used for those two projects. Until January 2019 the ULO's defined in Excel folders QF1 and QF2 is added to the ULO-database – in collaboration with H2020 NEWCOM.

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List of acronyms and abbreviations

Abbreviation	Meaning
Ad	Associate degree
Ba	Bachelor
BIM	Building information Model
CPD	Continuing Professional development
ECTS	the European Credit Transfer and Accumulation System
EHEA	Qualifications Framework of the European Higher Education Area
EQF	European qualification format
EQF-IP	EQF intake level for the educational or training program
EQF-OP	EQF output level for the educational or training program
IAQ	Indoor air quality
ISO/IEC 81346	International Standard 81346, published jointly by IEC and ISO defines classes and subclasses of objects based on a purpose- or task-related view of the objects, together with their associated letter codes to be used in reference designations
ISCO-08	The International Standard Classification of Occupations (ISCO) is an International Labour Organization (ILO) classification structure for organizing information on labour and jobs.
IN	Initial education
Ma	Master
PhD	Doctor of philosophy / Doctorate
PI	Post initial education
nZEB	Nearly Zero Energy Building

1. Putting BIMplement methodology in a nZEB related context

1.1 Introduction

To improve quality in nZEB construction in renovation, upskilling of the current actors is needed, and this is also the main aim of the BIMplement methodology. With the digitalization of the construction sector in the recent years, BIM can help by creating the link between the knowledge sources and the professionals and craftsmen involved in different phases of the construction project. In BIMplement it is explored how utilizing BIM allows storing relevant learning and process metadata in an efficient structured way. As explained in D2.1, the developed BIMplement qualification framework (QF) should be therefore enough flexible to be adapted for the different activities, technologies, different project types, sizes and phases. In Task 3.1, extensive testing and implementation of the QF is done for the two important areas in nZEB (air-tightness and ventilation) to see that the methodology works and results in a useful description of the activities, skills and competences for all professions through all the building stages.

The work done in T3.1 also helped improving the BIMplement methodology itself. The lessons learnt during the elaboration in this task were used to finalize and adjust the methodology as reported in D2.3, Chapter 5.

It should be kept in mind that the end objective of the task here, is the implementation of the BIM-integrated Qualification Framework (QF), as developed in methodology framework for the two specific topics:

- ventilation;
- air tightness.

1.2 Why air-tightness and ventilation?

The reason for selecting these two specific topics is that both ventilation and air tightness have a large impact on energy use, indoor air quality, thermal comfort and health. About 9% of the total energy use in EU is related to ventilation and infiltration[1].

Improving the buildings to become more energy efficient (nZEB) requires a new thinking in the field of ventilation and air tightness. With buildings becoming more air-tight, sufficient and efficient ventilation techniques need to be ensured in order to satisfy both: energy efficiency and indoor environmental quality (IEQ). Moreover, the selection, execution and performance of ventilation systems is directly related to the level of air tightness. The BIMplement therefore focuses on implementation of the methodology to these two areas of nZEB.

1.3 BIM as a coordination and management tool

If BIM is used in construction projects, most often is used for planning purposes during building construction and for renovation design phase. However, in BIMplement, BIM is not only to be used over a certain (most often design) phase but through the whole construction process (as better performing buildings is the ultimate goal). It is believed that BIM can improve a collaboration between different disciplines and management of works and allows synchronization of design and construction phase over one single model. To go even further, the aim is to have high quality collaboration over a single model also later, when building is put in use, in operation and maintenance phase.

Furthermore, besides being able to store relevant technical information in BIM, it is investigated in BIMplement how to enhance and store relevant didactic information to facilitate the learning process over the whole value chain. The

[1]FP7 RESHYVENT project; http://www.aivc.org/sites/default/files/medias/pdf/LitList%2033_Reshyvent.pdf

idea is to enrich BIM models with definition of quality levels, needed skills and linked trainings and therefore BIM can serve as a multidisciplinary data repository.

However, first it is compulsory for the design office to create a BIM model of sufficient (good) quality as this is a basis for enrichment with BIMplement related metadata. A 'good' BIM model is a BIM model where:

- all BIM objects according to the chosen BIM classification system (decision on project level, e.g. Uniclass 2015);
- compatibility between BIM models is achieved (by checking and solving all conflicts, data exchange specifications are met);
- organization of MEP model with BIM system when appropriate (common data environment);
- link of BIM object with technical documentation when available (description, implementation, maintenance etc.).

The above presented concepts require a new thinking, which is very different from the traditional way where all the work is organized around one single model. In which based on the various project phases and information requests, different levels of information (LoI) are shared in different phases with different stakeholders/involved parties (different maturity of the shared BIM model/knowledge level for blue and white collars). It is critical to understand that BIM does not change the construction project goals but only the means by which the goal is achieved.

The main concepts and methodology that have been developed in BIMplement WP2 and WP3 are tested and put in use in WP4. WP4 is consequently promoting the design of the BIM model during the design phase, use of the BIM model on the construction site and use of the BIM management tools to optimize the data introduced in the model and workflow. BIM process structure according to CEN442 is used to describe items in a standardized, unified way and link them to involved technology, project-stages and involved actors.

After discussion on a national level, it seems there is sufficient knowledge, which is fragmented. BIMplement aims to map this knowledge sources on a national level and structure in the right way (by using BIM) the existing knowledge sources that are for now ''lost'' – the right person is not aware that there exist trainings, educational courses etc. Besides having a better designed project, utilizing BIM also allows storing relevant learning and process metadata in an efficient way. The BIMplement understanding is that the real quality can be only be achieved when all the actors during all phases (programme, design, construction, maintenance) in the involved project are aware on what they should do where, they share a common vision and have the skills and training to deliver it. Therefore BIM is brought in.

1.4 Quality and quality control

As practice shows, quality problems are often identified due to insufficiently qualified workforce. Furthermore, often the white collar workers involved in the design phase are not aware of what information should be given and is important for the blue collar workers in the construction phase. As identified in many projects, often there are errors and mistakes in the construction due to low or no collaboration between the different disciplines and levels. Furthermore, due to poor collaboration, similar can happen once a building enters the operation and maintenance phase. It is needed to educate and upskill also involved professions that will be in charge of the maintenance activities once the building is delivered. During the awareness campaigns (Task 4.2) in Spain, is has become clear that some entities are focusing on the use of BIM for maintenance activities, because they underline the main added value of BIM methodology is in this phase. This shows a need for sufficient upskilling of the current workforce in all phases by providing suitable trainings as also creation of collaboration between the different disciplines, trades throughout all project phases. BIM supported coordination of the work allows a collaboration between white- and blue-collar workers and also decreases the difficulties for the different professions to work together at interfaces (e.g. wall-window).

Advanced BIM based management and quality control techniques used in each project phase as in between the phases can improve the whole construction process and overall quality. To improve the quality of the works in nZEB construction, first the current situation should be understood in order to gain enough insights and overview of the

current practice and reasons for poor quality. In BIMplement, a careful consideration was given on how to connect identified qualifications to perform a task with the relevant training material, appropriate learning tools, education material and identify the quality checkpoints needed to assure the desired quality. This is done as part of tasks T3.2-T3.4 as well as part of implementation at the selected regional pilots.

By performing tasks T2.2 and T3.2- T3.4 on a national/project level, focus points in the construction or renovation process, where most often poor quality is recognized, are identified. Based on this assessment, clear description of the professional activities and related skills and competences for all the mentioned professions for the two specific areas can be elaborated and the level of importance of appropriate quality control can be assessed. As identified, there can be a wide range of reasons for poor quality (poor specification at level of projects/regulations, lack of competences at design or execution level, language barrier, critical timing, lack of control etc.). This analysis together with relevant stakeholders helps naming focus points in the construction or renovation process for integrating cross-trade clash-moments/action learning as part of the BIMplement approach which is another objective of WP3.

1.5 BIMplement flexible qualification methodology anticipating new products and processes in different countries

As the implementation of the BIMplement QF in WP3 is limited only to the professions involved in ventilation technologies and air tightness, it is important to initiate and organize further exploitation and replication of the project to increase the number of skilled building professionals and craftsmen across the building value chain. This will be done in work package 5 (WP5) Explication and Replication as shown in the Figure 1.

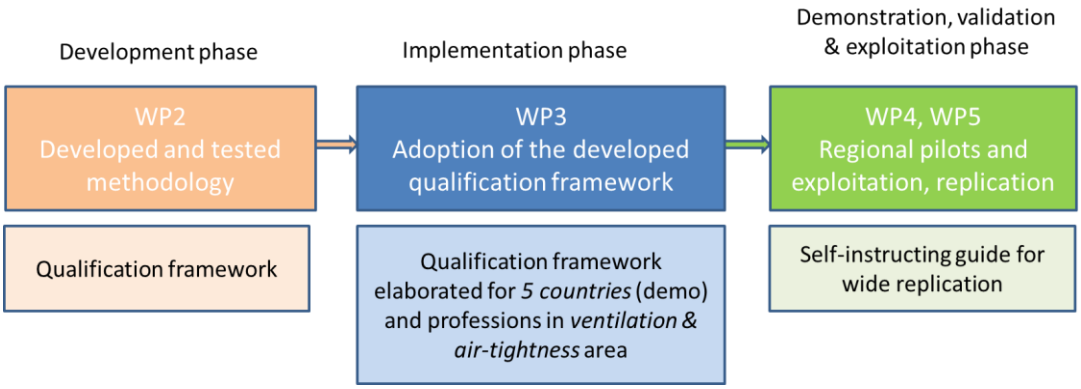

Figure 1: The developed BIMplement methodology is elaborated and adopted in task 3.1 (resulting in D3.1) for the activities of the professions throughout all the project phases related to the building aspects of air-tightness and ventilation. Later on in the project, these results will be applied and implemented for the regional pilots.

2. BIMplement Qualification Framework (QF) as part of a project programme

2.1 Introduction

This chapter presents a structured method for the implementation of the BIMplement QF methodology as part of a single BIM based construction project (process). Figure 2 presents the BIMplement QF structure to define the coding of each proprietary information to be linked to BIM object/technology/functional system where it starts with a stable BIM tree.

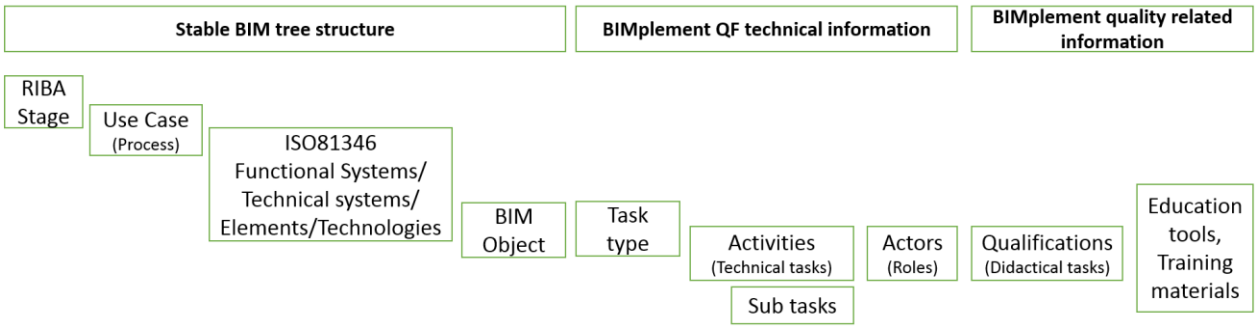

Figure 2: BIMplement QF structure (including the BIM tree stable structure, nZEB related technical information, related quality and qualifications requirements).

Tasks and activities are linked to a relevant BIM object (if no BIM object yet, the activity related to high quality of the previous tree level – functional system or technology system) with relevant roles and needed qualifications. This requires linking the qualifications (didactical information) with the technologies table. Qualifications describing the didactical details (knowledge, skills, responsibility and autonomy) can be the same for different technologies (re-usable database).

After the technologies are identified, the specific product information can be chosen and linked in the BIM model:

a. Product specific instructions (free format)
b. Product specific checklists (format for manufacturers)
c. Product specific unit of learning outcomes (ULO's) (format for manufacturers)

If an actor appointed to execute an activity (technical task) does not possess the required qualifications, reference to the relevant (national) training programmes and (e-learning) education material is available. Such a QF database structure can be coupled to the BIM-model through different link/plug in possibilities. In BIMplement, this is tested via BIMAXON and relevant ISO standards which allow direct plug-in in any BIM based software tool. Nevertheless, other possibilities to connect qualifications with BIM-models are:

- Using BIMaxon and plugins for Navisworks, Revit (already available), Stabicad and other tools (will be available);
- Creating details and making them available for IFC viewers;
- Integrating it into national/EU/world object libraries (done by manufacturer, suppliers).

In collaboration with another Construction Skills project NEWCOM, the structure for defition of the tasks and related ULO's has been harmonized. More information about this work is available in D2.3.

2.2 BIM project management proccess document (e.g. project quality plan)

It is essential to understand the foundation upon which the BIMplement QF is built. As a foundation, the project programme for any nZEB construction/renovation should be defined adopting a clear BIM project management process structure (project quality plan). It should be identified what are the BIM processes that will be implemented on the project having a clear BIM model structure. Afterwards, BIMplement QF can be implemented as part of such organized BIM based building project.

To successfully implement the BIMplement methodology the protocol document '*BIM project execution planning guide*' published by the buildingSMART alliance™ [2] was followed and its BIM Use definition. However, any similar execution planning guide can be used that allows elaboration of a clear BIM project management process structure;

[2] https://vdcscorecard.stanford.edu/sites/default/files/BIM_Project%20Execution%20Planning%20Guide-v2.0.pdf

allowing detailing the BIM execution process (integrating BIMplement methodology) throughout the project lifecycle. RIBA simplified stage definition[3] was used to cover all the building stages (see Figure 3). Use cases are used to describe the process, where within each used case the roles and input information and output information is defined.

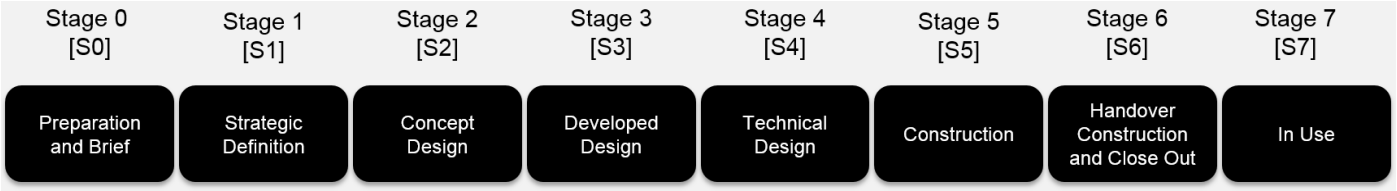

Figure 3: Project stages in the UK's RIBA Plan of Work 2013.

2.3 Identification of BIMplement QF objectives inside a BIM project management process document (e.g. project quality plan)

When considering implementing BIMplement methodology in a nZEB project, it should be investigated what are the BIMplement objectives related to each work stage (project phase) – focus points. This should be done in order to ensure that the BIMplement QF will in the end bring an added value to the current working process in nZEB projects. To implement QF, the overall project goal should be on improving the quality where the filled QF helps identifying the needed qualifications to preform high quality nZEB related tasks.

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Table 1: The construction/renovation project consisting of 0-7 project stages according to RIBA with the identification main project coordination, BIM and BIMplement tasks in each of these project stages

RIBA work stage		Key tasks	Core BIM activities & processes (related requirements and BIM maturity level)	BIMplement QF objectives
S0	Strategic definition	- Identification of client's needs and objectives; - Identification of core project requirements - Preparation of feasibility studies - Initial considerations for assembling the project team.	- Advise client on purpose of BIM (including benefits when using BIM as information carrier),	- Organization of the BIMplement awareness campaigns - Define the BIMplement application scope - Define main actor groups involved in all building stages and their qualifications fundamentals (evaluation)
S1	Preparation and Brief	- Identification of client's needs and objectives - Feasibility studies - Risk assessment	- Agree on level and extent of BIM - Evaluate (the importance) of the BIM uses related to each building stage	- Mapping of current skills of the actor groups involved (identifying the needs) - Identify scope and area of application based on project targets and requirements
S2	Concept project	- Development of a strategy to be followed through all the project phases	- Define BIM inputs and outputs, level of development	- Define the level of detailing task definition per building stage
S3	Developed Design	- Project strategies for different groups, areas developed sufficiently in details	- Developed architectural, structural, MEP model – Intial models - Change control procedures to allow	- Analysis of the QF database to map the right content for the specific area - Prepare the QF with selected content

[3] https://www.ribaplanofwork.com/Default.aspx

		- Cost information definition - Agreement of Project Quality Plan	exchange within as also between the project stages (S5 input back to S3) -	
S4	Technical Design	- Design Responsibility Matrix (how design tasks will be managed) - Confirmed Construction programme	- The three models from S3 further refined – Completed BIM model -Design programme confirmed Schedule of Services prepares	- Link the selected QF to BIM model (plug-in to the BIM tool) - Quality checklist added - Assigned and confirmed roles to be taken by BIMplement trainers in S5
S5	Construction	- Construction according to Construction programme.	- BIM model in use - Design queries in BIM according to the Schedule of Services - Output here is 'As constructed' model	- Transfer of the design BIM model to construction BIM model with all metadata (technical as didactical information) - Active cross-trade cross-level collaboration
S6	Handover Construction and closure	- All aspetcs of Project programe, Building contract met - Handover strategy - Certification – met quality	- Prepared information that useful for 'In Use' phase – for maintenance and operation	- Final quality control via BIM based techniques and methods - BIMplement objectives met
S7	Use and maintenance	- Commissioning and regular service maintenance - Project performance evaluation	- Design queries in BIM according to the Schedule of Services - Harnessing information in 'In Use' model (connection with BMS systems)	- Transfer of the information from Construction to in Use phase (the core lies within single coherent database) - BIMplement Evaluation

The core BIM activities and BIMplement QF objectives adjacent to each RIBA stage in Table 1 are indicative. The main aim is to clarify the BIM requirements and BIM maturity levels to be realized in each work stage. Based on company experiences, this can be already adopted in the project management process. If not yet experiences in BIM, a company needs to first invest in education towards BIM and understanding on how to organize a BIM working process. BIM planning can be used within procurement language to define the precise requirements for the involved actors. To define BIM and nZEB related goals and identify the BIM uses is also one of the tasks to be done during the BIMplement awareness campaigns. The requirements defined in Table 1 are to be defined, discussed and agreed for each project specifically. Overall, it is believed that the classification of BIM Uses allows for better communication of the purposes and methods for implementing BIM throughout the lifecycle of a facility.

In the BIMplement implementation examples, *BIM uses* are used as defined by Penn State University[4]. However, any BIM Use cases (national adaptations) can be used if they aim to accurately communicate 'why' we are implementing BIM, where there can be the same BIM use in multiple building stages.

2.4 Basic skills and qualifications of the involved actors

Before executing nZEB tasks, evaluation of the actors' basic qualifications must be done to ensure that each involved actor has all the qualifications needed to perform the basic tasks in the investigated area (e.g. air-tightness, ventilation). There have to be existing national qualification systems available. The BIMplement methodology only

[4] http://bim.psu.edu/Uses/default.aspx

adds upon these fundamental qualifications with the new competences for existing professionals and/or new professionals' profiles to achieve nZEB.

The following definitions are used bearing in mind the newest European Qualifications Framework definitions:

1. **'knowledge'** is the body of facts, principles, theories and practices that is related to a field of work or study
2. **'skills'** means the ability to use know-how to complete tasks and solve problems, and they can be cognitive (involving the use of logical, intuitive and creative thinking) or practical (involving manual dexterity and the use of methods, materials, tools and instruments)
3. **'responsibility and autonomy'** is the ability of the learner to apply knowledge and skills autonomously and with responsibility.

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

3. BIMplement QF implementation for the area of air-tightness and ventilation

The focus is on *nZEB tasks* where *BIM tasks* help reaching desired quality of nZEB task. This to ensure that experienced workers are able to deliver nZEB-Quality by using BIMplement methodology and by using BIM empowered quality is ensured. It is assumed that basic construction tasks are known to the user of this qualification matrix. Commonly, the description of basic tasks can be found in national qualifications of each European member state. Depending on the project requirements, following steps should always be followed:

1. Agree and enlist nZEB specific tasks for all the building stages and all the BIM uses.
2. Agree who is responsible for each task.
3. Enlist the appropriate task-based qualifications needed to perform the nZEB tasks.
4. Identify quality control issues related to the tasks and responsible parties for quality control.

3.1 Qualifications fundamentals

Where in the QF certain tasks are marked as BAS (basic tasks), this means that assumption is made that relevant actors already possess these fundamental qualifications - relevant knowledge, skills and competences required for the work due to their basic training. The fundamental qualifications one must possess for the area of the airtightness and ventilation are mentioned below.

3.1.1 Qualification fundamentals – basic principles of ventilation

- **For white collar workers:**

Qualifications fundamentals for white-collar workers in the area of ventilation are adopted from earlier H2020 project, PROF-TRAC, funded under Grant Agreement No 649473[5]. Therefore, for more information, detailed description and identification process of basic qualifications, it is referred to the project's website. Below are described basic qualifications according to the European Qualifications Framework terminology, where: green text indicates knowledge, orange text highlights skills, red text summarises responsibility and autonomy[6].

- Knowledge and understanding of the different ventilation systems;
- Relationship between airtightness, ventilation, air humidity, air hygiene and the necessity for ventilation systems;
- Relationship between air quality and comfort;
- Various concepts of ventilation systems and its principles (heat recovery of cross ventilation, centralized and decentralized ventilation);
- Feasibility studies for the different systems;
- Engineering of the ventilation system, regarding future aspects of maintenance. From predesign to contract documents and drawings;
- Specify the design, describe important specifications, make drawings;
- Building envelope interface: airtight and thermal bridge free connection of penetrations for outdoor air and exhaust air ducts;
- Being able to commission the ventilation system on functionality under all conditions;
- Analyse the structure and influence of a ventilation system in nZEB;
- Being able to commission the ventilation system on functionality under all conditions.

- **For blue collars:**

Qualifications fundamentals for blue collar workers in the area of ventilation are adopted from earlier H2020 project, Train-to-NZEB, funded under Grant Agreement No 648810[7]. Therefore, for more information, detailed description and identification process of basic qualifications, it is referred to the project's website. Below are described basic

[5] http://proftrac.eu
[6] https://ec.europa.eu/ploteus/en/content/descriptors-page
[7] http://www.train-to-nzeb.com/

qualifications according to the European Qualifications Framework terminology, where: green text indicates knowledge, orange text highlights skills, red text summarises responsibility and autonomy[8].

- Basic knowledge regarding sizing, selection and adjustment of ventilation systems;
- Build-up of a ventilation system – main components (interdisciplinary):
  - Central unit with heat exchanger;
  - Ductwork and insulation of ducts, diffusion-impermeable materials;
  - Air tightness of ducts;
  - Fresh air inlets/extract air outlets;
  - Transferred air elements: understanding the necessity and types;
  - Outdoor air intake and exhaust air outlet and their positioning;
- The principle of heat recovery;
- Service requirements, filter changes, recommended filter grades;
- Explain the importance of ventilation for air quality, comfort and energy efficiency;
- Explain the constituents and operation of a ventilation system with heat recovery;
- Identify and name the components of a mechanical or balanced ventilation system with heat recovery in drawings and buildings.

3.1.2 Qualification fundamentals – basic principles of airtightness

As for the ventilation, there can be a task/activity connected with the BIM object or technology. Nevertheless, air-tightness is a more complex building application area as it is related to almost all the different building envelope components (transparent as opaque) as to joints application inbetween. Therefore, air tightness should be assessed more holistically with objective to control air leakage and heat losses through the building fabric and at interfaces, joints & junctions.

As discovered during the BIMplement methodology development (WP2), the different tasks can be elaborated by different professions – depending on company, member states way of working as also on company and project characteristics (e.g. company size, construction site size). Still, general knowledge can be distinguished for the following groups:

White collar workers:

- Basic design concept: Architects need to know what makes a building inherently airtight, and where air leakage paths are most likely to occur, so they can be designed out or at least sealed properly by the contractors. Architect needs to be aware of what information needs to be given further to the different groups that develop air-tightness aspect design sufficiently in details.
- Different design offices: Check all possible weak points and propose specific solution, including sketches, technical details, list of technologies, materials and products to be implemented, relevant technical documents etc. linked to BIM model. As mentioned earlier, depending on the countries, different professions can do this job (including architect) or specific groups (building service design office).

Qualifications fundamentals for white-collar workers in the area of ventilation are adopted from earlier H2020 project, PROF-TRAC, funded under Grant Agreement No 649473[9]. Therefore, for more information, detailed description of the skills levels for each discipline, it is referred to the project's website. Below are described basic qualifications according to the European Qualifications Framework terminology, where: green text indicates knowledge, orange text highlights skills, red text summarises responsibility and autonomy[10].

- Knowledge and understanding of the influence of air-tightness of buildings on energy performance;
- Guide the design on air tightness towards the desired lebel of air-tightness;
- Specification of air-tightness for contracting pruposes;
- Manage, instruct and audit contractors on critical points on the site;
- Commissioning of air-tightness of the building.

For blue collar workers:

[8] https://ec.europa.eu/ploteus/en/content/descriptors-page
[9] http://proftrac.eu/
[10] https://ec.europa.eu/ploteus/en/content/descriptors-page

- Contractors: The contractor is critical for ensuring the airtightness of the building, by good construction. Contractors or a client are generally the procurers of airtightness testing – project design team need through the QF framework definition tell them how to seal buildings, how to procure a test and what will happen at the test.
- Building service contractors: Building services contractors (installers) need to know why it is vital to reduce air leakage from shafts, raised floors and ductwork systems.

Qualifications fundamentals for blue collar workers in the area of airtightness are adopted from earlier H2020 project, Train-to-NZEB, funded under Grant Agreement No 648810[11]. Therefore, for more information, detailed description and identification process of basic qualifications, it is referred to the project's website. Below are described basic qualifications according to the European Qualifications Framework terminology, where: green text indicates knowledge, orange text highlights skills, red text summarises responsibility and autonomy[12].

- Necessity of airtightness in a building (in relation to ventilation);
- Ability to explain and understand the importance of airtightness in buildings;
- The principle of an airtight layer (red pencil method and single airtight layer);
- Difference between airtightness and wind resistance;
- Typical weak points in case of poor airtightness;
- Test procedures for airtightness measurement (preparation, execution, magnitudes of error), typical measurement results, methods of detecting weak points;
- Explain the principle of the pressurisation test method & procedures for measuring airtightness test (these tests are in general done by specialized companies that will afterward give a report to the building company);
- Assessment of different leaks & methods for measuring airtightness: blower door test, alone and coupled with thermal imaging;
- Suitable and unsuitable materials for airtight surfaces and connections (for different construction methods such as solid, lightweight and mixed constructions), suitable airtightness measures for penetrations, special products where this information should be given within the BIM model;
- Procedure/sequence of work with reference to airtightness;
- Durability of solutions for airtightness;
- Identify the airtight layer and its constituent parts in drawings and buildings and ensure its continuity.

3.2 BIMplement qualifications

3.1.1 BIMplement qualifications for the 5 types of ventilation systems used commonly in nZEB

The focus in ventilation area is on five types of ventilation systems where some activities are the same for the different ventilation systems: (early stages 0-2, later stages 7):

- mechanical;
- balanced;
- decentral with heat recovery;
- humidity controlled extract ventilation system (*represents more than 90% of present dwelling construction in France);
- natural.

A combination between two different systems can be found, as example: natural supply and mechanical exhaust or mechanical supply and mechanical exhaust etc.

Furthermore, it is important to focus on weak points for ventilation systems (stage 4 and stage 5) where:

- some of them are the same as weak points for airtightness (e.g. ductwork through walls);
- some of them are related to fire-safety (needs to be addressed):
    - ductwork through walls, floors;

[11] http://www.train-to-nzeb.com/

[12] https://ec.europa.eu/ploteus/en/content/descriptors-page

- fire-safe is also airtight.

Please see the Annex - BIMplement QF1 related to ventilation.

3.1.2 BIMplement qualifications for the 10 typical weak points for the area of air-tightness

As already explained, the airtightness topic is related to different building components, joints and elements conjunctions and therefore the same tasks to ensure airtightness are relevant for different components and different joints between different elements. To keep the focus, the BIMplement testing and implementation of the QF in in this task limited to the 10 most influential weak points in the area of air-tightness (see figure 4). As there are quite some activities and connected qualifications related to the same components, joints and intersections. This proves a need that BIMplement QF should be flexible enough to adapt to these different applications and that defined BIMplement qualifications are reusable. Depending on the product, manufacturers can assign the didactic information (qualifications needed) to the BIM object (library) and details on how to treat weak points.

Please see the Annex - BIMplement QF2 related to air-tightness.

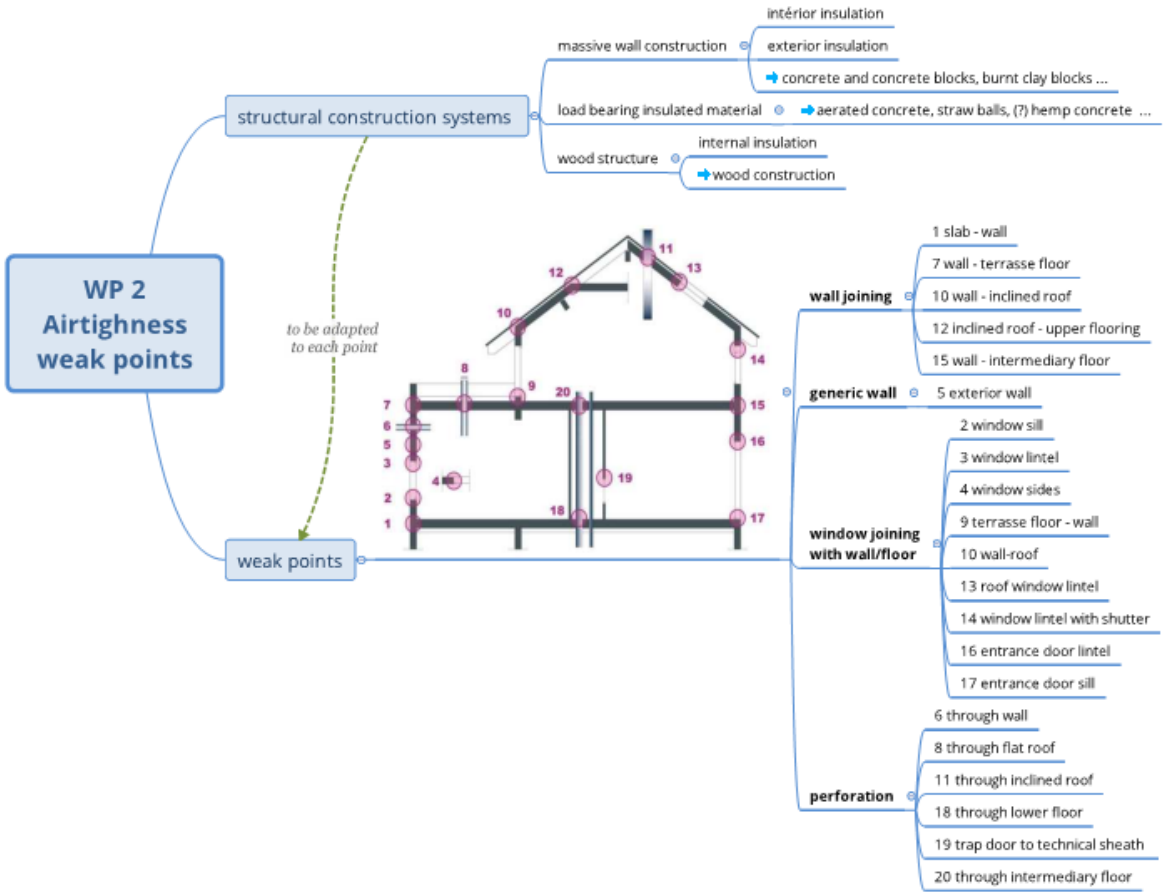


Figure 4 Overview of the most influential weak points in the area of air-tightness

4. BIMplement implementation in real projects

As mentioned in Chapter 1, the implementation of the BIMplement QF needs to be reinforced and supported via the BIMplement implementation and awareness campaigns that will be organized in the countries where are identified experimental sites.

The work done in this task and applied to real projects in later project stage leads to an understanding that some trainings are to be organized beforehand in order to implement BIMplement efficiently. This is part of the next steps in work package 4.

5. Conclusion

This task resulted in a complete overview of the professional activities (technical tasks) and related skills and competences for all proffessions (blue and white collars) throughout the different project phases, for the two selected topics: air-tightness and ventilation (reported in Annexes, BIMplement QF1 related to ventilation and BIMplement QF2 related to air-tightness).

As learned during this task, several issued were identified:

- how to define basic skills -> reference to the national qualification schemes and programmes;
- flexibility of the qualification framework to be adapted for both aspects;
- separation of the QF database structure - a table with technical task description (including subtasks) and a table with ULO's where ULO is a link between the technical task and a required qualifications and suitable training and education material -> still ongoing in collaboration with NEWCOM project;
- how to connect BIM tools when no BIM model yet, stages 0-2 -> technology is the missing link;
- depending on the needs of the project, the definition of subtasks can be added – extending the list of technologies too.

Appendix

BIMplement ISCO-08 classifications of professions
Classification system: ISCO-08 Code: ISCO on http://bp.ics.infinibim.com/classifiers/43/tables/214

ISCO-08	Name	Description
Construction		
2142	Civil Engineers	
2142	Structural Engineers	Deals with statics, mechanics, solid mechanics, and with the conception, analysis, design and construction of components or assemblies to resist loads arising from internal and external forces.
HVAC and Energy systems		
2144	Mechanical Engineers	Designer of materials and systems for HVAC and sanitary equipment, considering the limitations imposed by practicality, regulation, safety, and cost.
2142	Energy System Engineer	Designer of materials and systems for HVAC and sanitary equipment, considering the limitations imposed by practicality, regulation, safety, and cost. In charge of energy consumption optimization
1330	Building Automation Engineer ICT technology services managers	Designer of building automation systems, system engineer / system integrator, considering the limitations imposed by practicality, regulation, safety, and cost
2143	Environmental engineer	In charge of energy consumption optimization, as well as environmental impacts (water, air, comfort, health ...)
Electrical systems & domotics		
2151	Electrical Engineers	Designer of power, lighting, (data and or communication installations), considering the limitations imposed by practicality, regulation, safety, and cost.
1330	ICT Engineer	Designer of data and or communication installations, considering the limitations imposed by practicality, regulation, safety, and cost. + GTB Consulting with clients, management, technicians to assess the needs and system requirements Directing the selection and installation of ICT Overseeing security of ICT systems
Construction management		
1323	Construction manager/ Manager of Building Process	The person responsible for economy, health, delay, quality assurance during on-site construction works in the realization of nZEB buildings Interpreting architectural drawings and specifications Preparing tenders and contract bids Ensuring adherence to building legislation and standards of perofmance, quality, cost and safety
1323	Project Manager	The person responsible for the planning, execution and closing of any (nZEB) building project and contracts. Negotiating with building owners, property the construction process to ensure projects are completed on time and within budget

		Building under contract, or subcontracting Coordinating, operating and implementing the work programme for the site. - Also in charge of the realization of the as-built building files. Overseeing the selection, training and performance of staff and subcontractors. Arranging inspections by relevant authorities
3123	Building construction supervisor	Coordinate, supervise and schedule activities of workers engaged in the construction/renovation
1211	Cost Expert, Cost Engineer Finance manager	The person responsible for financial aspects during planning, execution and closing of any (nZEB) building project. (Not meant is financing of the project)…. Including the additional unexpected work
Facility management		
No code	Facility Manager	The person responsible to maintain the real estate as it was realized at the end of the nZEB building process (including facility management).
No code	Technical Energy Engineer	Person responsible for management, monitoring, energy optimisation and improvement of operation of facilities.
Financing and procurement		
1323	Procurer, Chief Procurement Officer 1323 Construction manager (also 1211 Finance manager)	The person responsible for facilitating the process of nZEB tenders and (sub)contracts c) negotiating with building owners, property the construction process to ensure projects are completed on time and within budget d) preparing tenders and contract bids h) building under contract, or subcontracting specialized building services
No code	Project Developer	The project developer takes responsibility for the associated risks involved in the building process for the customer and hands over the project to the tenant / buyer after completion and use of the building
Architects		
2161	Building Architects	Architects investigate, design and oversee the implementation of buildings and urban spaces taking into account functional, architectural, aesthetic, structural, technical, regulatory, cost and contextual requirements with due regard to public health and safety. Architects' work takes account of social factors and obligations and addresses the relationship between people and buildings and buildings and the environment (definition ESCO).
BIM		
No code	BIM manager	Coordinate the BIM correspondants check the different trade BIM model verify the compatibility of the different trade BIM models assemble the as-built final model
	Company BIM correspondent	Realize, modify and adapt the company BIM model (companies that are requested to realize a BIM model by the client)
2161, 2142, 2144	BIM engineer	Realize, modify and adapt the technical design office BIM model
2161	BIM architects	Realize, modify and adapt the architect BIM model,

Technicians and Associate Professionals		
3112	Civil Engineering Technician	Inspecting buildings and structure during and after construction/renovation to ensure they comply with nZEB building laws and approved plans, specifications and standards as well with rules concerning quality and safety of buildings
3112	Building inspector	ensuring compliance inspecting buildings and structures during and after construction to ensure that they comply with building, grading, zoning and and standards, as well as with other rules concerning quality and safety.
3113	Electrical Engineering Technicians	Assist the electrical engineer
3114	E-installations service mechanicElectronics engineering technicians	Assisting in design, development, installation, operation and maintenance of electronic installations and systems. Supporting electronics engineers
3115	Mechanical Engineering Technicians	Designing and preparing layouts of machines and mechanical installations, facilities and components, according to the specifications
No code	Engineering service mechanic	From BUS-NL
Craft and Related Trades Workers		
7111	House Builders	Decide to realize a building, or realize it for a client Pilote the constructions, draft the general specifications, hire the architects and the different contractors Is responsible, in front of the client, for the perfect realization of the building Contrarily to most owner/client, house builder is a full time occupation.
7112	Bricklayers and Related Workers	Implement different type of elements for wall building, such as burnt bricks, concrete blocks, stone, but also, earth blocks, straw, wattle and daub, adobe, ...
7114	Concrete Placers, Concrete Finishers and Related Workers	Realize reinforced concrete walls, panels, beams, slabs, posts, ….
7115	Carpenters	Realize wooden structures for walls, floor, partitions, roof structure, ...
7115	Joiners	Realize small elements such as doors, windows, furniture, ...
7121	Roofers	Realize the covering of roof, openings in roofs,
7123	Plasterers	Implement the finishing interior layer of walls and partitions, including the secondary necessary supporting structure
7124	Insulation Workers	Lays insulation inside wooden beam structures, roofs, slabs, including air-tightness films in relation with plasterers
7122	Tile layer	Lays tile on floors and walls
7125	Glaziers	Lays glass within windows is disappearing because windows are now , in general, manufactured in factories

7126	Plumbers and Pipe Fitters	Install water pipes for fresh and used water, sanitary devices, (often also heating engineer)
3115	Heating engineer	Install pipes for heating system, install heating devices (boiler, water heater, ...) (often also plumber)
7127	Air Conditioning and Refrigeration Mechanics	Install air-conditioning / refrigeration devices
No code	Cooling service mechanic	From BUS-NL
7131	Painter and related workers	Realize the finishing layers of wall, interior and exterior : paint, rendering, coating,
7411	Building and Related Electricians	Realize the building wiring, including the data collectors and electric devices (ex : ventilation)
7412	Electrical Mechanics and Fitters	
No code	Ventilation fitter	New trade, arriving on the market : give advice on the type of ventilation to be chosen, on the installation plans (namely the position of ventilation and air duct …) lays the air ducts and the ventilator, fixes the air entry and extract, controls the installation quality
No code	General/works foreman	Responsible of a blue collar team (around 10 for “small buildings”)
No code	ceiling installer	Install false ceilings
No code	Works planner building sector	In charge of the structural work planning/organization between the different stakeholders/companies
No code	Works planner installation sector	In charge of the finishing work planning/organization between the different stakeholders/companies
No code	maintenance	In charge of the maintenance of buildings - owner or inhabitant - electrical worker - plumber

Definitions

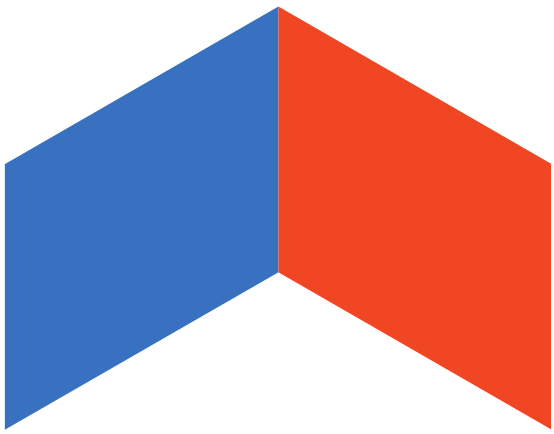
Term	Meaning
Accreditation	Accreditation is a quality assurance process under which services and operations of (educational) institutions or programs are evaluated by an external body to determine if applicable standards are met. If standards are met, accredited status is granted by the appropriate agency. (*Wikipedia*)
BIM-axon	BIMAXON is a human-readable classification of BIM element properties. That would facilitate communication, help fill in gaps in the BIM process, and make it easier for every actor to obtain and understand the information that they need at any given moment. It is based on BIM uses and the needs of specific BIM actors, to ensure that deliverables are right for every drop point and to provide just the right set of information to each actor at every moment.
BIM Use	BIM uses are used as defined by Penn State University: "a method of applying Building Information Modeling during a facility's lifecycle to achieve one or more specific objectives''.
Responsibility and autonomy	The ability of the learner to apply knowledge and skills autonomously and with responsibility.
Initial education	Training people receive before entering the labour market. In general, initial education is based on qualification documents and corresponding professional competency profiles. These qualification documents are drawn up nationally by the knowledge centres of the various professional sectors. Completing initial education results in the earning of a certain EQF level and a diploma, which has an unlimited validity.
Multilayered qualification	A multilayered qualification is a description of tasks that have to be performed to be effective. It consists of a layer with basic tasks and one or more layers of context specific layers. For example nZEB related tasks, BIM-related tasks or Indoor air quality (IAQ) tasks.
Occupation	An occupation is a a job or profession
Post-initial training	Training people receive after leaving initial training. In general, professional post-initial training is based on demand from market parties for retraining. These (short) trainings results most times in a certificate, which offers a limited validity. They do not result in the earning of a certain EQF level.
Profession	A profession is a specialized occupation characterized by profession specific education and training.
RIBA	The RIBA Plan of Work is the definitive UK model for the building design and construction process.
Qualification	A pass of an examination or an official completion of a course, especially one conferring status as a recognized practitioner of a profession or activity.
Qualification document	A qualification file describes what a participant in education should know

	and master at the end of a (intermediate vocational training) course. A qualification file describes the level of starting professional workers (school leavers).
Qualification structure	A formal system describing qualifications It makes visible which qualifications or sets of competences are sought by the labour market, education and society to secure a job, start further studies or participate in society.

Term	**Meaning**
Skill	The ability to do something well; expertise
Specialism	A technology or application of several combined technologies specific set of tasks
Task	A piece of work to be done or undertaken.
Taxonomy	A taxonomy defines classes of objects and relations among them
Training Scheme	A scheme for teaching people skills in a particular field or profession
Trias Energetica	A concept that is based on 3 steps: First, we need to limit energy demand through energy saving. Second, renewable sources should be used to meet the remaining energy demand. Only as last step fossil fuels should be used, as efficiently and cleanly as possible.

COLOFON

BIMplement



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