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 will be used for those two projects. Until January 2019 the ULO's defined in Excel folders QF1 and QF2 will be 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

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.

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.

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

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

whole value chain. The 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.

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.

BIMplement flexible qualification methodology that can anticipate 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.

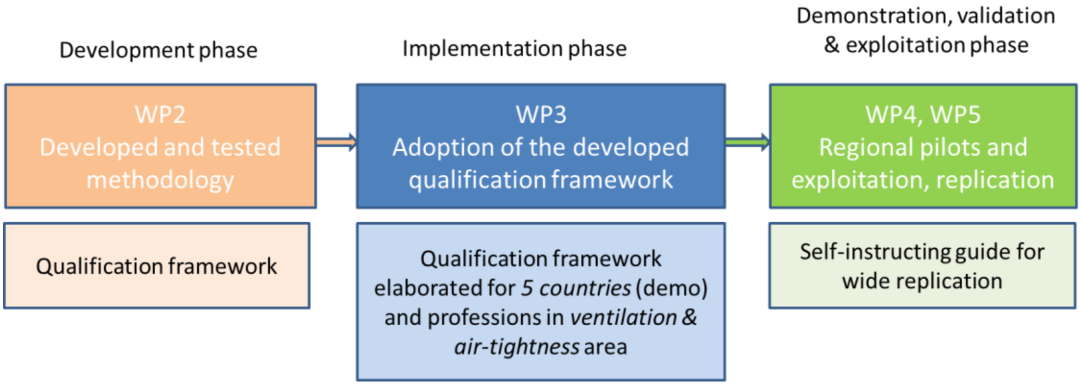


Figure 1: The developed BIMplement methodology is elaborated and adopted in task 3.1 (resulting in D3.1) for the activities of the professions throughout all the project phases related to the building aspects of air-tightness and ventilation. Later on in the project, these results will be applied and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

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

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.

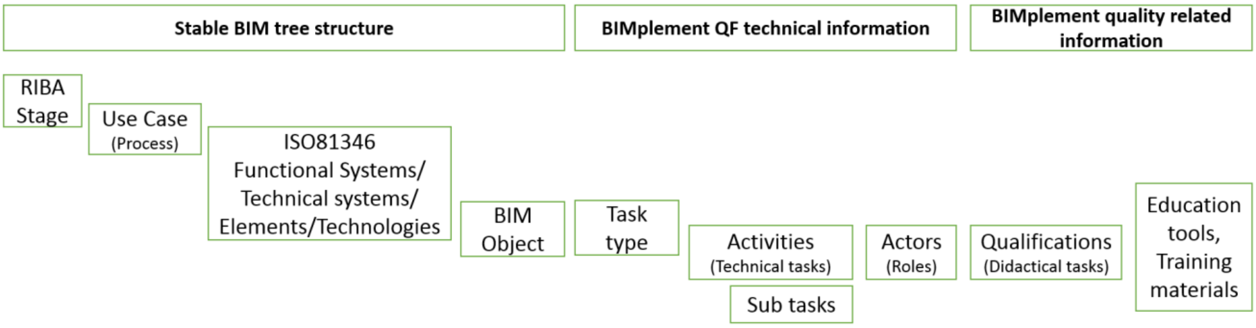


Figure 2: BIMplement QF structure (including the BIM tree stable structure, nZEB related technical information, related quality and qualifications requirements).

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.

2.1 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; 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 2). Use cases are used to describe the process, where within each used case the roles and input information and output information is defined.

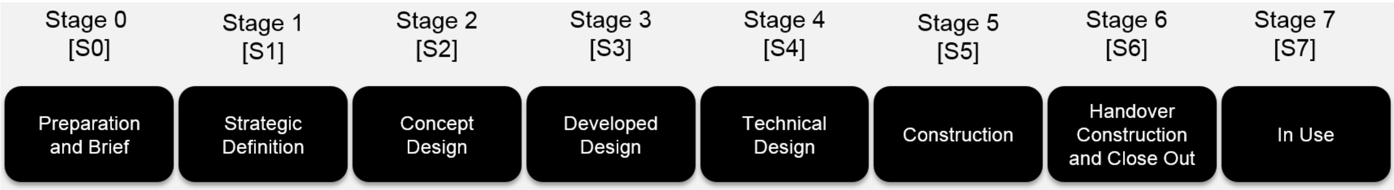


Figure 2: Project stages in the UK's RIBA Plan of Work 2013.

2.2 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.

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 - Cost information definition - Agreement of Project Quality Plan	- Developed architectural, structural, MEP model – Intial models - Change control procedures to allow exchange within as also between the project stages (S5 input back to S3) -	- Analysis of the QF database to map the right content for the specific area - Prepare the QF with selected content

[2] https://vdcscorecard.stanford.edu/sites/default/files/BIM_Project%20Execution%20Planning%20Guide-v2.0.pdf
[3] https://www.ribaplanofwork.com/Default.aspx

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.

2.3 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 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)

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

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;

[5] http://proftrac.eu
[6] https://ec.europa.eu/ploteus/en/content/descriptors-page

- 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 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,

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

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

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:

- 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;

[9] http://proftrac.eu/
[10] https://ec.europa.eu/ploteus/en/content/descriptors-page
[11] http://www.train-to-nzeb.com/
[12] https://ec.europa.eu/ploteus/en/content/descriptors-page

– 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

3.2.1 BIMplement qualifications for the 5 types of ventilation systems/technologies 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:

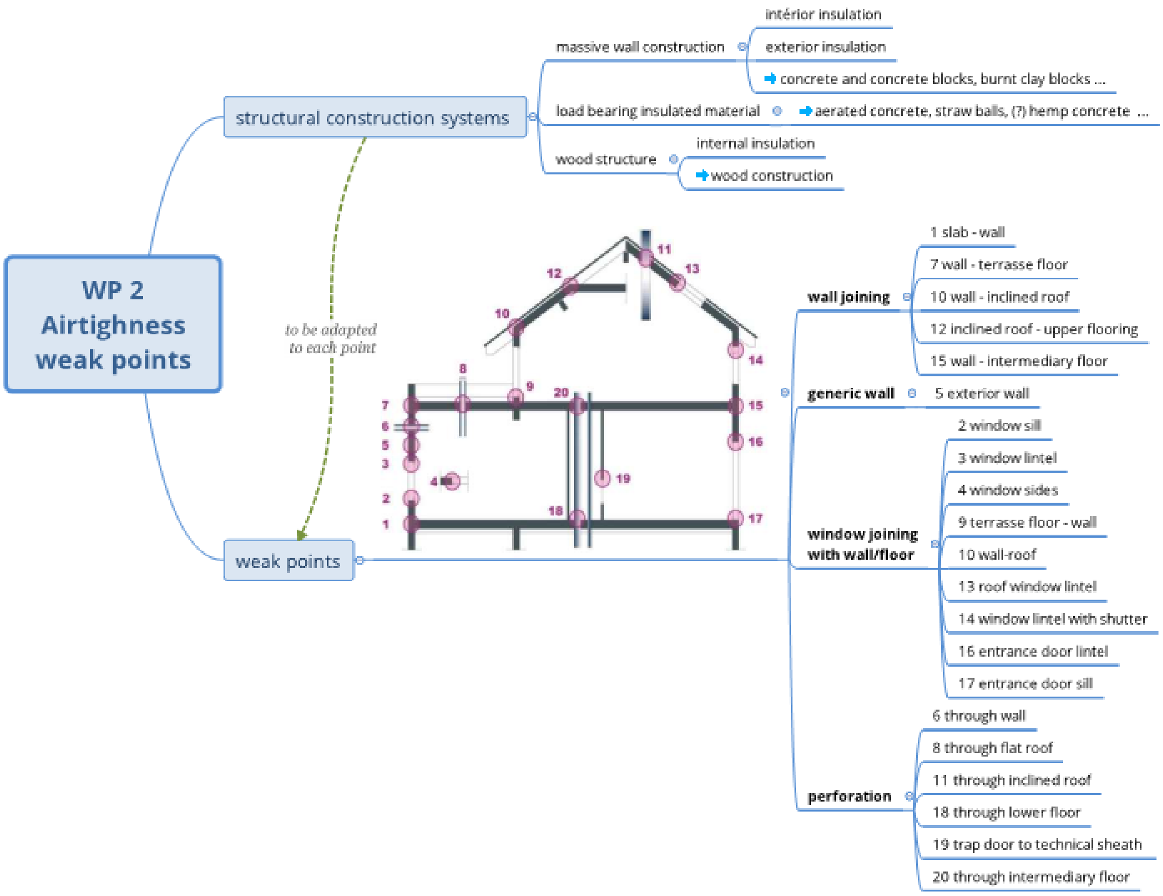
- some of them are the same as weak points for airtightness (e.g. ductwork through walls);
- some of them are related to fire-safety (needs to be addressed):
  - ductwork through walls, floors;
  - fire-safe is also airtight.

Please see the Annex - BIMplement QF1 related to ventilation.

3.2.2 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. 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.



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.

6. 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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Qualification scheme Ventilation Designer

Project phase	Tasks	Sub-tasks	ULO Nr.	Newcom ULO
Project development	**Make schedule of requirements**			
		determine supply airflow rate	1.1	1.1.1, 1.3.1
		determine maximum air speed in the living zone	1.2	1.1.4
		determine minimum supply air temperature	1.3	1.1.4
		prevent noise pollution	1.4	1.3.15
		determine minimum discharge flow	1.5	1.3.1
		determine requirements regarding airtightness of ducts	1.6	
		determine the use of sustainable materials	1.7	
		Set demands for energy efficiency	1.8	1.1.3
	Make a list of extra requirements in case of renovation			
		judge the existing situation / technical state of installation		
		record extra preconditions by building and installation		
Make a global design	**define ventilation requirements in the rooms**		2.1	2.1
	choose the type of ventilation system based on the building and the schedule of requirements		1.1, 1.2, 1.3, 1.4 ,1.8, 2.3	
	determine location ventilation unit (s)		1.4, 3.2	
	determine the location of the air supply and discharge in each room		2.2	2.4.2
	design the global layout of air ducts		3.1	
		determine zones where no ducts can come	3.8	2.6.1
		design passages through wal(s) and/or floor(s)	3.5	2.6.3
		collective systems determine : fire safety and check valves in the wall(s)/floor needed?	3.4	2.6.2
	choose the control system (CO2, humidity, presence, time, capacity switch)		1.8, 3.3	1.3.6
	choosing and roughly dimensioning of register on the glass (if needed)			
		choose the type of register	3.8	
		determine the global dimensions of the register	2.1, 3.6	
		calculate the size of the glass taking into account the register dimensions	3.7	
	Predesign fire safety in collective systems			
		record where the fire-safe throughput should be and what the overall dimensions are	3.10	
		choose principle for fire-safe passage	3.4, 3.5, 3.9	
	Functioning and technical state of system in renovation			
		determine which parts are reusable and which parts/systems need to be replaced	3.11	
	Making the air balance			2.1.3
		determine the required amount of air supply per room	4.1	2.1.2
		determine required amount of air discharge per room	4.2	2.1.2
		make the air balance for the entire house	4.3	2.1.3
	Make holes in wall(s) and/or floor(s)			
		determine air duct dimensions	5.4, 6.9, 8.3	2.7.1
		record number and type of fasteners	5.7	

Designing		Determine dimensions of bearing profile	5.8	
		Determine diameter / dimensions of threaded rods / carrying brackets	5.9	
		determine the location of the opening in the wall for passage of air duct	5.5	
		determine dimensions of the recess in the wall	5.6	
	Determine the register on the glass			
		make a final choice for the register	3.8, 5.1	
		record the dimensions of the glass	5.2	
		determine the dimensions of the glazing beads	5.3	
	Design the natural air supply			
		natural supply; determine the size of the register on / above the window	3.8, 5.1 , 6.1	
		if necessary, provisions for regulation air supply	6.2	
		natural air supply through a shaft	6.3	
		select register in the outside wall	6.4	
	Design the centralized mechanical air supply			
		choose a decentralized unit for mechanical air supply	6.5	2.1.6
		needed facilities for decentral mechanical ventilation unit such as electricity and data connections	6.6, 9.2, 9.5, 10.8,	2.1.8, 2.1.9, 2.1.10, 2.1.11
		Size and location of gap in the wall	6.7	
		select grill in the wall	6.8	2.4.3
	Design the centralized mechanical air supply			
		dimension of ducts	6.9, 8.3	2.7.1
		record number and type of fasteners	6.10	
		Determine dimensions of bearing profile	6.11	
		Determine diameter / dimensions of threaded rods / carrying brackets	6.12	
		select the air supply valves	6.13	2.4.2
	Design overflow devices			2.5
		design overflow via grill (in wall / door)	7.1	2.5.1
		design overflow through the aperture under the door	7.2	2.5.1
	Design the natural exhaust			
		dimension natural exhaust via shaft	8.1	
		select the air exhaust grilles	8.2	
	Design the mechanical exhaust			
		design ducts air exhaust	8.3	2.7.1
		select exhaust valves	8.4	2.4.2
	Design the centralized mechanical ventilation unit			
		select the mechanical ventilation unit	9.1	2.1.6
		record needed facilities for central mechanical ventilation unit such as electricity and data connections	9.2	2.1.8, 2.1.9, 2.1.10, 2.1.11
		determine the use of silencers	9.3	2.1.7
		design drainage facility for heat recovery (if needed)	9.4	2.1.8
	Design mechanical exhaust unit			
		select the mechanical exhaust unit	9.5	
		determine the use of silencers	9.3	
		record needed facilities for mechanical exhaust unit such as electricity and data connections	9.4	
	design manual operation			
		determine location(s) of the manual selector(s)	10.1	1.3.7

	Design automatic operation / sensor operation			1.3.6
		Determine the use of Relative humidity sensors	10.2	
		Determine the use of CO2 sensors	10.3	
		Determine the use of TVOC sensors	10.4	
		Determine the use of Presence sensors	10.5	
		Determine the use of Timer	10.6	
		Determine the use of Manual control	10.7	
		determine facilities such as electricity and data connections	9.4	
	Determine special needs in case of collective systems			
		Select check valve(s)	11.1	
		Selecting fire dampers	11.2	
		Determine the sealing between fire damper and wall	11.3	
execution fase	Making holes in wall(s) and/or floor(s)			3.2
		check/mark position and dimensions of the recess in the wall	12.1	3.2.1.
		make the recess or correct the sizes if necessary	12.2	3.2.2
		Completly airtight seal at the location of MVHR unit and penetration of the thermal envelope	12.3	
	Safety of the work			
		Safe working platform	13.1	
		Observe occupational safety and health protection	13.2	
		Use dangerous substances safe and environmental friendly??	13.3	
	Install air ducts			3.3
		optimise the position of the supply and extract register	14.1	3.3.1
		construct the duct system (supply and discharge)	14.2	3.3.2
		fix ducts in floors against flooding	14.3	
		apply adjoining screed / finishing passages in walls	14.4	
		install supply valves on the ducting with preset flow rates	14.5	3.3.1, 4.1.1
		connect ducts airtight	14.6	3.3.1
		instal exhaust valves with preset flow rates	14.7	3.3.1, 4.1.1
		insulate both channels from the outside to the unit in systems with heat recovery	14.8	
		install the sound attenators	14.9	3.6.2
		prevent contamination	14.10	3.1, 3.3.4
	Mount central ventilation unit			3.6
		mount the ventilation unit	15.1	3.6.1
		connect the ventilation unit to the duct system	15.2	3.6.2
		connect the ventilation unit to the discharge water system	15.3	3.6.4
		assemble silencers between unit and duct system	15.4	3.6.2
		construct facilities such as electricity and apply data cables	15.5	3.6.3
	Mount decentrally ventilation unit			
		locate the position of the ventilation-unit	16.1	
		make needed passage(s) through the wall	16.2	
		mount the unit on the wall and connect controls	16.3	
		make powersupply if necessary	15.5	
	Mount supports of the ducts the duct			
		drill fixing holes	17.1	

		mount suspension material	17.2	
		fix support profile	17.3	
		fasten threaded rods / mounting brackets	17.4	
	Apply safety measures in collective systems			
		Executions of fire and smoke dampers	18.1	
		mount check valves	18.2	
		mount fire damper(s)	18.3	
		seal space between fire damper and wall/floor	18.4	
	mounting and connecting of sensors			3.6.3
		Installation of smart detection and control system	19.1	3.6.3
		insert and connect the sensors	19.2	3.6.3
		connecting the controller	19.3	3.6.3
	Apply overflow			3.4
		mount grill(s) in wall or door	20.1	3.4.1
Set in operation and handover	**Balance the ventialtion system**			4.1
		adjust the fan capacity of the supply with the dip switches (if mechnical supply ispresent)	21.1	4.1.3, 4.1.4
		adjust the fan capacity of the supply valves	21.2	4.1.4
		adjust the fan capacity of the exhaust with the dip switches (if mechanical exhaust is present)	21.3	4.1.3, 4.1.4
		check and if necessary correct air exhaust	21.4	4.1.4
	handover the ventilation system			
		create the manual	22.1	4.1.5, 4.1.6, 4.1.7
		Add the adjustment state to the manual	22.2	4.2.1
		Add the maintenance schedule to the manual	22.3	4.2.2
		Transfer the installation to the user	22.4	4.2.2
		Raising awareness for regular maintenance need	22.5	4.2.2
	Testing (optional)			
		Testing the airtightness of the building	23.1	4.1.3
		Testing and evaluation of the airtightness of the system	23.2	4.1.6
		Testing and evaluation of the noise protection of the system	23.3	4.1.5
operation and maintenance	Maintain the system			
		Check annual operation	24.1	5.1.2
		cleaning the valves annually	24.2	5.1.3
		cleaning of fans	24.3	5.1.3
		cleaning/replacing filters	24.4	5.1.3
		cleaning ducts every ten years or earlier as necessary	24.5	5.1.3

also in newcom

other ventilation system(s)

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ULOs for the NZEB Ventilation

No.	Fields of knowledge/Course Modules	Knowledge	Skills	Competence	Who?	Type
1.1	Planning/quality aspects	health requirements	describe air quality	determine supply airflow rate	project developer / client	Basic
1.2		how draft occurs, relation with air velocity	explain when draft occurs	prevent draft complaints	project developer / client	Basic
1.3		how draft occurs and the relation with air velocity and preheating	explain when draft occurs	explain how to prevent draft complaints	project developer / client	Basic
1.4		how complaints occur with regard to sound, dB, acceptable noise levels	explain which noise levels are acceptable in each type of room	determine acceptable noise levels and measures to establish low noise rates	project developer / client	Basic
1.4		exhaust, discharge flow, moist problems	describe how to prevent moist or odour complaints	apply requirements concerning health or prevention of damage due to moisture	project developer / client	Basic
1.6		requirements regarding airtightness of ducts	describe the relation between air tightness and energy consumption	understand the need for airtightness of ducts, what airtight ducts are, classes, relevant standards	project developer / client	nZEB
1.7		sustainable materials	gain insight in building durable systems and the use of durable materials	durability of installation components	project developer / client	nZEB
1.8		energy efficient ventilation systems	explain using heat recovery and demand control without spoiling the indoor climate	understand energy efficiency, influence of heat recovery and/or demand control	project developer / client	nZEB
2.1		regulations about ventilation requirements	explain why and when ventilation is needed	define ventilation requirements in the rooms	counsellor	Basic
2.2		draft, effective air circulation, room uses and effects of those uses	explain: - when draft occurs; - what is needed for an effective air circulation; - the use of a room depending on form/layout and the use function	prevent draft complaints and ensure air circulation through the room	counsellor	Basic
2.3		properties of the different ventilation systems	comparing of the importance of the different items in the schedule of requirements	choosing the type of ventilation system based on the building and the schedule of requirements	counsellor	Basic
3.1	predesign and preparation	global knowledge of needed airflows and corresponding dimensions of ducts	plan the air ducting with as little resistance as possible;	plan the air ducting with as little resistance as possible in regards to the zones where no ducts are possible;	counsellor / installation designer	Basic
3.2		requirements for mounting a ventilation unit	describe the suitability of a location for mounting a ventilation unit	determine location of the ventilation unit (s)	counsellor / installation designer	Basic
3.3		control systems for comfort and energy consumption, types of regulation	describe the types of regulation and explain when to use them	make the choice for regulation system(s)	counsellor / installation designer	nZEB
3.4		interaction of different ventilation systems in collective buildings	explain when check valves and/or fire safety measures are needed	decide on fire safety and check valves in the wall(s)/floor	counsellor / installation designer	Basic
3.5		principles of fire safe passages	explain application of the principles of fire safe passages	design passages through wall(s)/floor(s) and if needed fireproof passage	counsellor / fire safety expert	Basic
3.6		global dimensions of the register	calculate size of registers	determine the global dimensions of the register	counsellor / installation designer	Basic
3.7		properties of registers	placing of glass with register in frame	calculate the size of the glass taking into account the register dimensions	counsellor / installation designer	Basic
3.8		parts of the building where holes can be made for ducts passing from one space to another	locate beams and support structure of the building	determine zones where ducts are not possible	counsellor / installation designer	Basic
3.9		possibilities for a fire safe transit & principles for fire resistant passages	locate fire resistant passages through a wall/floor	choose the best fire safe transit	counsellor / fire safety expert	Basic
3.10		dimensions of cross sections of gaps to be is bigger than the air duct and needed extra space for the fire damper	the operating principle of the fire-proof passage	record where the fire-safe throughput should be and what the overall dimensions are	counsellor / installation designer	Basic
3.11		knowledge of the reusability of components, wear indications	describe allowable wear for reuse	determine which parts are reusable and which parts/systems need to be replaced	counsellor / installation designer	nZEB
4.1	making the air balance	required air supplies	describe the legal requirements	determine the required amount of air supply per room	installation designer	Basic
4.2		knowledge of air discharge related to the function of the room	determine the amount of discharge air	determine required amount of air discharge per room	installation designer	Basic
4.3		functioning of ventilation systems and principles of thermal comfort	give the distribution of air quantities over the discharge points	make the air balance for the entire house	installation designer	Basic
5.1	influence on the building	registers on the glass	determine the dimensions of registers	make a final choice for the register	installation designer	Basic
5.2		dimensions ofregisters on the glass	determine the dimensions of registers	record the dimensions of the glass	installation designer	Basic
5.3		knowledge of airtightness of glazing systems with registers	mounting register on the glass and in the frame	determine the dimensions of the glazing beads	installation designer	nZEB
5.4		pressure loss calculations	perform pressure loss calculations	to determine the dimensions of the air duct and layout of the air duct system using a pressure loss calculation	installation designer	
5.5		supporting structures of buildings	locate suitable locations for the ducting	to determine the layout of the ducting system and to determine the location of the recess in the wall	installation designer / constructor	Basic
5.6		knowledge of space needed for fitting purposes	determine space needed for fitting purposes	determine the dimensions of the recess in the wall to determine the dimensions of the gap based on choosen fire safe solution and dimensions of the air duct	installation designer / fire safety expert	Basic
6.1	air supply	relation between ventilation capacity and register dimensions	relationship between ventilation capacity and dimensions of the register	calculate the size of the air supply register	installation designer	Basic
6.2		properties of wind pressure controlled valves	select adjustable registers	implementing silencers and pressure controlled valves	installation designer	nZEB
6.3		thermal draft and wind pressure-dependent air flows	dimension the shaft size	calculate the size of the shaft	installation designer	nZEB
6.4		knowledge of properties of grills	size grills in outside wall	select grill in the outside wall	installation designer	
6.5		knowledge of properties of units for decentralized mechanical air supply	explain which quantities are important in a system choice	choose a decentralized unit for mechanical air supply	installation designer	Basic
6.6		knowledge of needed facilities	determine data connections and any necessary facilities	determine needed facilities for decentral mechanical ventilation unit such as electricity and data connections	installation designer / electrician	Basic
6.7		measuring techniques	determine location of the grill	Size and location of gap in the wall	installation designer	Basic
6.8		properties of grills	locate and dimension grills	select type of grill in the wall	installation designer	Basic
6.9		- energy efficient ductwork; - low-noise ductwork	explain air duct calculations	perform air duct calculations	installation designer	nZEB
6.10		fasteners	determine fasteners	record number and type of fasteners	installation designer	Basic
6.11		bearing profiles for ducts	choose the t type of bearings	determine dimensions of bearing profile	installation designer	Basic
6.12		strength of rods and brackets	determine locations for rods and brackets	determine diameter / dimensions of threaded rods / carrying brackets	installation designer	Basic
6.13		properties of supply valves	influence of induction on valves	select the valves	installation designer	Basic
7.1	overflo	airflows through homes	explain calculation of airflow through valves	design overflow via grill (in wall / door)	installation designer	Basic
7.2		overflows	explain calculation of airflow through apertures	design overflow through the aperture under the door	installation designer	Basic
8.1	Exhaust	natural ventilation	calculation of natural airflow in a home	dimension natural ventilation via shaft	installation designer	Basic
8.2		properties of grills	selecting grills	select a grill	installation designer	Basic
8.3		- how to make an energy efficient ductwork - how to make a low-noise ductwork	explain air duct calculations	perform air duct calculations	installation designer	nZEB
8.4		properties of exhaust valves	selecting valves	select a valve	installation designer	Basic
9.1	central ventilation unit	knowledge of properties of central ventilation units	collect data to be able to make a selection of a centralized ventilation unit	select a centralised ventilation unit	installation designer	Basic
9.2		knowledge of the legislation connecting electrical appliances	possibilities of data connections and any necessary facilities	determine facilities such as electricity and data connections	installation designer / electrician	Basic
9.3		noise calculations	explain noise reduction calculations	perform noise calculation and select, if necessary, silencers	sound expert	Basic
9.4		construction of waste water systems	calculation of discharge water systems	design water discharge systems in buildings	installation designer	Basic
9.5		properties of mechanical exhaust units	collect data to be able to make a selection of a mechanical exhaust unit	select a centralised ventilation unit	installation designer	Basic
10.1	control and sensors	suitable locations for selectors	locate selectors	Determine the number and locations of manual selector(s)	installation designer / adjust expert	Basic
10.2		properties of sensor(s) and influence on health, comfort and energy use	know when to use relative humidity sensor and what are the advantages / disadvantages	Determine the use of Relative humidity sensors	installation designer / adjust expert	Basic
10.3		properties of sensor(s) and influence on health, comfort and energy use	know when to use CO_2-sensor and what are the advantages / disadvantages	Determine the use of CO2 sensors	installation designer / adjust expert	nZEB
10.4		properties of sensor(s) and influence on health, comfort and energy use	know when to use TVOC-sensor and what are the advantages / disadvantages	Determine the use of TVOC sensors	installation designer / adjust expert	Basic
10.5		properties of sensor(s) and influence on health, comfort and energy use	know when to use presence sensor(s) and what are the advantages / disadvantages	Determine the use of Presence sensors	installation designer / adjust expert	nZEB
10.6		location(s) of timer display(s)	know when to use timer(s) and what are the advantages / disadvantages	Determine the use of Timer	installation designer / adjust expert	Basic
10.7		locations for manual operation switch	know advantages / disadvantages of manual operation	Determine the use of manual control	installation designer / adjust expert	Basic
11.1	collective	functioning of check valves	know when to use check valves	properties of check valves	installation designer	Basic
11.2		properties of fire dampers	capture data on the various dampers and the needed space to be able to select a type of fire damper	to select a fire damper based on the data of sizes and fire resistance	installation designer / fire safety expert	Basic
11.3		fire safe sealing the gap	know how to make a good sealing	determine the kind of sealing to be used	installation designer / fire safety expert	Basic
12.1	hole in wall	reading technical drawings	how technical drawing are made and the coherence between different technical drawings	be able to check the position and dimensions of the recess	installer	Basic
12.2		making holes in walls/floors	drilling techniques	making holes in wall or floor or correct the sizes if necessary	constructor	Basic
12.3		where and how to seal the air ducts and its joints	Be able to secure a completely airtight seal of the two external air ducts at the locations where (a) they connect to the MVHR unit and (b) where they penetrate the thermal envelope	Take responsibility for completion of tasks related to ensuring that all connections are completely airtight and that the two air ducts which penetrate the envelope are entirely and completely insulated with vapour tight insulation	fire safety expert	nZEB
13.1	safety	related H & S rules as Working on Height, working on scaffolding etc.	Able to assess the rightness of the necessary working platform before using	Use adequate and safe working platform(s), where it is needed	safety expert	Basic
13.2		related H & S rules regarding material transport, electrical hand tools, etc.	Secure the necessary collective and personal protection measures	Use adequate and safe protection measures, (both collective and personal), where it is needed	safety expert	Basic
13.3						
14.1	alling ducts	common solutions for optimising the position of the supply and extract registers and its impact on the Indoor Air Quality and comfort	Optimise the position of supply and extract registers to ensure optimal flow rates in the spaces in which they serve and to avoid potential annoyance or irritation to occupants due to	Take responsibility to ensure optimal flow rate in the room with positioning of supply and exract registers	ventilation installer	nZEB
14.2		airtightness of connecting ducts	know how to make airtight connections and the difference between the types of ducts	constructing a duct system	installer	nZEB
14.3		fixing ducts against flooding	know how to fix ducts against flooding	fix ducts in floors against flooding	constructor	Basic
14.4		pouring concrete of floor slab	know how to pour the concrete	produce the adjoining screed / finishing passages in walls	constructor	Basic

14.5	inst	supply valves and present them	influence of valve on airflows in rooms and influence of air speed on comfort	set up and mount supply valves	installer	Basic
14.6		making airtight connections in ducts	necessity of airtight connections	make airtight connections	installer	NZEB
14.7		exhaust valves and present them	influence of valve on airflows in rooms and influence of air speed on comfort	set up and mount valve	installer	Basic
14.8		vapour-tight insulation	insulating air ducts and know when and how to do so vapour-tight	isolating channels from the outside to the unit in systems with heat recovery	installer / isolator	Basic
14.9		most common assessories related to the extended performance of the ventilation	Able to install all specified ancillary components such as sound attenuators	Responsibility for full execution of the ventilation system design including provision of all specified ancillary components such as sound attenuators	ventilation installer/sound engineer	nZEB
14.10		storing, fixing and laying technics of ducts , registers and other elements	Cognitive and practical skills required to securely fix the routing and positions of ducts and registers so that there is minimal risk of adjustment or movement post-occupancy which would compromise their performance	responsibility for hygienic protection of the air-ducts and components of the venitlaiton system prior tomounting the system from risks presented by contaminants and / or moisture / humidity	ventilation installer	nZEB
15.1	Mount centrally ventilation unit	vibration-free assembly of units	describe the mounting of the ventilation unit	mounting the ventilation unit	installer	Basic
15.2		airtight of connecting ducts	know how to make airtight connections and the difference between the types of ducts	connecting the ventilation unit to the duct system	installer	nZEB
15.3		waste water systems	know how to connect the unit to the waste water system	connecting the ventilation unit to the discharge water system	installer / adjust expert	Basic
15.4		knowledge of airtight connecting ducts	know how to make airtight connections and the difference between the types of ducts	assembling silencers between unit and duct system	installer	nZEB
15.5		knowledge of building decree regarding electricity and working safely	making a safe and reliable power supply and/or data communication	construct facilities such as electricity and data cables	installer / electrician	Basic
16.1	m ou nt de ce nt	installation instructions	spacious to the unit for maintenance and proper operation	locate the position of the ventilation-unit	installer	Basic
16.2		different possibilities for passages through the wall	drill passage(s) in the wall	make needed passage(s) through the wall	constructor / drilling company / installer	Basic
16.3		making airtight and watertight connections	mounting the ventilation unit on the wall and connecting sensors/control(s)	mount the unit on the wall and connect controls	constructor / installer	Basic
17.1	Mount supports of ducts	drilling techniques	know how to drill holes	drill fixing holes	installer	Basic
17.2		mounting brackets	know how to use mounting brackets	mount brackets	installer	Basic
17.3		support profiles	know how to use support profiles	mount support profiles	installer	Basic
17.4		using threaded rod	know how to use threaded rods and mounting brackets	fasten threaded rods / mounting brackets	installer	Basic
18.1	services in collective system		Cognitive skills and practice for installation of fire and smoke dampers	Responsibility for full execution of the ventilation system design including provision of all specified ancillary components such as fire and	ventilation installer	Basic
18.2		mounting of check valves	know how to use check valves	Mount check valve (s)	installer	Basic
18.3		mounting fire dampers	know how to mount fire dampers	mount the fire damper	installer / fire safety expert	Basic
18.4		sealing techniques	be able to seal the gap between damper an d wall/floor	seal the gap between fire damper and wall/floor	installer / fire safety expert	nZEB
19.1	connecting sensors and controls	smart detection and control systems	Cognitive skills and practice for installation of the smart detection	Ensure the usability and easy access to the detection and control system	electrician	nZEB
19.2		sensors and characteristics of sensor(s)	know how to mount sensors and how to put them to work	mount the sensors and put them to work	installer / electrician	nZEB
19.3		mounting controls and connecting sensors	know how to mount the controller and how to connect the sensors	mount control(s) and put them to work	installer / electrician	nZEB
20.1	realise overflow	mounting grills in inner doors/inner walls	know how to mount grills in door/wall	mount grill in interior door/wall	carpenter	Basic
21.1	adjusting	adjusting the supply valves	know how to balance ventilation systems	set the supply valves	installer / adjust expert	Basic
21.2		adjusting fan capacities	know how to balance ventilation systems	adjust the supply fan	installer / adjust expert	NZEB
21.3		adjusting the exhaust valves	know how to balance ventilation systems	set the exhaust valves	installer / adjust expert	Basic
21.4		set exhaust valves	know how to balance ventilation systems	adjust the exhaust fan	installer / adjust expert	Basic
22.1	handover the installation	contents of a good manual	be able to compose a manua	to compose a user-oriented manua	installer	Basic
22.2		contents of a good manual	add information to the manual	add the adjustment state to the manual	installer	Basic
22.3		necessary maintenance and lifespan of components	know what is needed for good maintenance and what has to be done to keep the system in a good condition	add the maintenance schedule to the manual	installer	Basic
22.4		how to put the system into operation	what the user needs to know for proper use	transferring required information to the user / owner	installer	Basic
22.5		common regular maintenance need of the installed systems	Cognitive and practical skills raising the awarenes of the client towatrds the importance of the regular maintenance	Ensure that the homeowner knows why they should replace the MVHR filter at regular intervals and how they can replace them	ventilation installer	Basic
23.1	testing (optional)	Blower Door Test and its requirements	Cognitive skills and knows how to perform an airtightness test of the buildings (Blower Door test)	Ability to perform a blower door test	ventilation installer	nZEB
23.2		airtightness test of ducts and its requirements	Cognitive skills and knows how te perform for airtightness tests on the ventilation system	Ability to perform airtightness tests of the duct systems related a HR performance and the NZEB requirements	ventilation installer	nZEB
23.3		acoustic/noise protection requirements and applicable solutions	Able to perform testing and evaluation of the acoustic performance of the system comparing to the requirements	Ensure compliance regarding noise levels of ventilation system with recommendations for different room occupancy types	ventilation installer/sound engineer	Basic
24.1	Maintenance	what is needed for good maintenance of ventilation systems	which maintenance is necessary for a good and safe functioning	checking annual operation	service engineer / installer	Basic
24.2		cleaning valves	knows how to clean valves	cleaning of valves	service engineer / client	Basic
24.3		cleaning fans	know how to clean fans	cleaning of fans	service engineer / installer	Basic
24.4		cleaning/replacing filters	know how to replace or clean filters	cleaning/replacing filters	service engineer / client	Basic
24.5		assessing pollution of duct and knowledge of cleaning methods	be able to decide if cleaning is necessary and what cleaning method has to be used	determining pollution and cleaning duct(s)	service engineer / installer	Basic
24.6		opportunities of the data collection and BEMS interface connection, about the role of MVHR impact on achieving and maintaining the NZEB level	Cognitive and practical skills on measurements of the achieved performance of the MVHR and recommendation and best practice for the necessary correction either the system, or the user side.	Responsibility for ensuring the long term energy efficient performance of the building proved by measured date	ventilation installer	nZEB

Qualification scheme airtightness

Project phase	Tasks	Sub-tasks	ULO Nr.	BIM
Strategic Definition	Apply general architectural strategies to prevent air leakages and ensure airtightness		1.1	nZT
	Specify the level of airtightness to be obtained			
		Determine the desired level of airtightness	2.1	nZT
		Define the relation between airtightness and energy consumption	2.2	nZT
		Define the relation with infiltration	2.3	nZT
preparation	Specify the for airtightness required level of detail of the BIM model			
		Have/Develop a specific level of BIM-knowledge	3.1	
		Set the level of detail in the BIM model required to address airtightness weakpoints	3.2	BIT
	Propose the level of airtightness to be obtained			
		Provide insight into the air-infiltration determinators	2.4, 4.1	nZT
		Explain the benefits of an airtight building	2.1, 2.2, 2.3, 4.2	nZT
		Set levels of air permeability	2.1, 2.2, 4.3	nZT
concept design	**Propose the level of details of the BIM model (more information = needed to define the task)**			
		Make BIM request	3.1	
		Use BIM as a tool to avoid and anticipate airtightness weak points	3.2	BIT
	Take into account the impact the level of airtightness to be obtained			
		Analyse the impact of the project airtightness	4.1, 4.2, 5.1	nZT
		Use BIM for designing (the required level of airtightness)	3.2	BIT
Design	**Ensure and Integrate in the project the level of airtightness to be obtained**			
		Set airtightness level	6.1	nZT
		Determine the position of the airtightness layer identifying the boundary limits of the building air barriers	5.1	nZT
		Determine the zone or zones to be controlled and tested for air leakage	6.2	nZT
		Avoid breaking the airtightness layer(s): minimum penetrations	6.3	nZT
		Minimize the length of joints in the design	6.4	nZT
		Intregrate the additional data in the BIM model	3.2, 6.5	BIT
	Introduce BIM request in the project			
		Make BIM request	3.1	BIT
		Set level of details of the BIM model	3.2	BIT
	Choose optimal position of perforations			
		Evaluate the number of perforations needed	7.1	BAS
		Reduce the number of perforations to the strict minimum	7.2	nZT
		Determine the optimum position(s) of perforation(s) needed	7.3	nZT
		Check the impact on the structural construction	7.4	nZT
		Check the impact on interior fittings	7.5	nZT
		Check impact on constructive methods and localisation	7.6	nZT
	Technical design of the airtightness treatment of perforation			
		Design of the airtight perforation	8.1	nZT
		Update BIM data related to the perforation and air tightness measures	3.2, 6.5, 8.2	BIT
	Technical drawings of the airtightness treatment of perforation			
		Produce technical drawing of the perforation and air tightness measures of the solution	9.1	BIT
		Update BIM data (needed on the construction site) related to the perforation and air tightness measures	3.2, 6.5, 9.2	BIT
	Final Technical drawings of the airtightness treatment of perforation			
		Analyse of the project design technical details	10.1	nZT
		Precise design of the solution	8.2, 9.2, 10.2	BIT
		Evaluate the intrinsic performance of the design	10.3	BIT
		Update BIM data related to the perforation and air tightness measures (both for calculation and instruction site)	8.2, 9.2	BIT
	Technical design of seal solutions for air leakage in walls with opening joints and shutters			
		Evaluate the different possibilities for sealing solutions	11.1	nZT
		Design and describe the solution for the specific case including notes for the optimal implementation in the construction site	11.2	nZT
		Calculate the impact on energy performance of the building	11.3	nZT
		Create or find appropriate constructive details drawings	11.4	BAS
		Check the intended life cycle of materials and joints	11.5	nZT
	Associate data about seal solutions used to the BIM model: description, drawings, explanatory notes for the implementation			
		Make description, drawings, explanatory notes for implementation of the seal solutions	12.1	BIT

Construction	**Verify the construction team skills**			
		Check the company general references	13.1	BAS
		Check the company airtightness references	13.2	nZT
		Check the company BIM references	13.3	BIT
	General implementation of the project			
		Present the technical solution	11.2, 14.1	BAS
		Make follow-up of the technical solution	8.2, 9.2, 10.2, 14.2	nZT
		Update BIM data related to the perforation and air tightness measures	3.2, 6.5, 9.2, 14.3	BIT
	General presentation of the implementation of the airtightness treatment			
		On-site presentation of the technical prescription	11.2, 13.2, 15.1	nZT
	Implementation of the airtightness treatment of perforations (wall, roof, floor)			
		Presentation of the technical solution	11.2, 13.2, 16.1, 16.1	nZT
		Make follow-up of the technical solution	8.2, 9.2, 10.2, 15.2, 16.2	nZT
		Drill hole (using tools adapted to the construction)	16.3	BAS
		Place expanded polyethylene around the vent (interior and exterior)	16.4	nZT
		Anticipate on the to be expected weak points	16.5	nZT
	Check materials used and the correct implementation in joints and shutter(s) (only 1 task beneath..)			
		Update BIM data related to the perforation and air tightness measures	3.2, 6.5, 9.2, 16.3	BIT
handover	Quality check of the different airtightness tasks			
		Quality checking and reporting	17.1	nZT
		Quality checking at the step handover of the construction	17.2	nZT
		Report quality of airtightness	17.3	BIT
	As-built plans of the project			
		Specification of the demands in terms of airtightness	18.1	nZT
		Update BIM data related to the perforation and air tightness measures (to the as-built model)	3.2, 6.5, 9.2, 15.3, 18.2	BIT
In use	Keep the airtightness performance intact along time			
		Realize modifications (holes, fastening, ...)	19.1	nZT
		Update BIM data related to the perforation and air tightness measures		
		Follow-up the airtightness quality of a buiding	19.2	nZT

ULOs for the NZEB Airtightness

No.	Fields of knowledge/ Course Modules	Knowledge	Skills	Competence	Who?
1.1	prevent air leakage	Strategies to prevent air leakage and heat loss	Design of the building to reduce heat losses and air leakages	Design the building selecting the most appropiated strategies for the specific case	Architect
2.1	level of air-tightness	Legal specification for airtightness	Application of the legal levels of air permeability	be able to combine the above objectives to establish the needed airtightness level / specify the right airtightness level	Client
2.2		Relation between airtightness and energy consumption	Recognizes the importance of airtightness as part of energy conservation concept	Draft precise specification - be able to analyse the project objectives in terms of : energy, health, cost, implementation, financial impacts	Client
2.3		Relation between infiltration and airtightness	Understands the air-infiltration determinators	be able to combine the above objectives to establish the needed airtightness level / specify the right airtightness level	Programmist /Architect / engineer
3.1	BIM-model	What is a BIM model (compared to a 3-D model)	Use of BIM as a tool to obtain the specified level	Draft precise specifications for airtightness	Client
3.2		Quality levels in a BIM model (instead of 3.1)	Understand how to use BIM as a tool to integrate the airtighness level set	draft precise specifications for the stakeholders to anticipate airtightness weakpoints OR (Now it are two competences) Integrate the data and share it with other relevant project management stakeholders (HVAC systems)	Programmist
4.1	Need for air-tightness	Legal requirements on airtightness= 2.1, 2.3	Understands the air-infiltration determinators		Designer/programmist
4.2		Need for air tightness = 2.2	Understands the benefits of an airtight building	be able to analyse the project objectives in terms of : energy, health, cost, implementation ...	Designer
4.3		Levels or air permeability =2.3	Understands the normal levels of air permeability	be able to combine the above objectives to establish the needed airtightness level	Designer
5.1	Demands about airtightness	Benefits of an airtight building = 2.2	Understands the effects of airtightness on energy, health, economy ...	draft precise specifications for the projet management stakeholders	Architect, structural engineer, construction manager
6.1	passage through airtight construction	National regulations about energy performance of buildings and airtightness conditions	understand the importance of airtightness and the influence of air leakages in the energy performance of the building (what is the link with regulation)	Set air-tightness level for the specific project	Architect (Building arquitect according to ISCO-08)
6.2		Airtightness and its influence in other aspects such as condensation	understand the importance of airtightness and the influence of air leakages in the energy performance of the building (missing the link to other aspects)	Create an optimal developed design of the building being able to consider those	Architect (Building arquitect according to ISCO-08)
6.3		Passage through airtight constructions	Understands that breaking the airtightness layer generates air leakage that affects the energy performance of the building	Create an optimal design avoiding breaking the air-tightness layer	Architect (Building arquitect according to ISCO-08)
6.4		Minimize the length of intersections	Understands that minimizing the lenght of intersections minimizes the air leakages	Create an optimal design minimizing the lenght of joints	Architect (Building arquitect according to ISCO-08)
6.5		Enter data in a BIM model = 3.2	Understand how to use BIM as a tool to integrate the airtighness level set	Integrate the data and share it with other relevant project management stakeholders (HVAC systems)	BIM engineer / BIM arquitect
7.1	limitation of number of perforations	Effect of a limited number of perforations on energy consumption	Avoid of quality implementation perforations on energy consumption	optimize/modify project according to energy objective	architect/construction manager
7.2		Effectuate a single passage without drilling the airtight building envelope	Understand the principle one network, one perforation (explain)	optimize/modify project and draw design details (can you be more precise)	architect/construction manager
7.3		Organise power and HVAC networks	impact of quality implementation on energy consumption What are the differents technical solutions to minimize passage through airtight membrane	optimize/modify project according to energy objective(can you be more precise)	architect/construction manager
7.4		Impact of the structural construction system on nZEB objectives	what are the different technical solutions	optimize/modify project according to energy objective (can you be more precise)	architect/construction manager
7.5		Create plenum as space for networks	what are the different technical solutions	optimize/modify project and draw design details (can you be more precise)	architect/construction manager
7.6		Place the switchboards inside the heated volume	what are the differents technical solutions to minimize passage through airtight membrane	optimize/modify project and draw design details (can you be more precise)	architect/construction manager
8.1	gn of tion	Products and solutions related to the perforation (weak point)	Understands the difference between the solutions & materials related to perforation	choose the appropriate solution and products related to perforation	structural eng. (linked to project manager)

8.2	design solu	Quality of the airtightness solution	Understands where and how airtightness is implemented in the calculation model	introduce the airtightness solution into the calculation model	structural eng. (linked to project manager)
9.1	Technical drawings	Data and implementation methods for the wall perforation(s)	understand the difference between the solutions & materials for wall perforations	Choose the appropriate products for wall perforations Design precisely the solution (scale, materials ...)	structural eng. (linked to project manager)
9.2		Data for a good implementation of ... = 10.2	What data will be needed in the construction site	Include/link the data in the BIM model	structural eng. (linked to project manager) Or BIM correspondant
10.1	final airtightness treatment of perforation	Materials and solutions to create the « perforation »	What are the similarities and differences depending on the structural construction system	Check that the solution proposed by the project manager is fine/feasible	Company structural eng.
10.2		Data, implementation methods and solutions for the perforation = 9.2	Understand how to implement the materials and industrial products	Design precisely the solution (scale, materials ...) Include the design in the BIM model	Company structural eng.
10.3		Performance of the design	Each intersection can be a source of faults	optimize/modify project and draw design details	architect/construction manager
11.1	seal solutions	Characteristics of different solutions	Evaluate advantages and disadvantanges of different materials and solutions for insulating and sealling	Choose the optimal material and solution for the specific case	Architect (Building arquitect according to ISCO-08)
11.2		Data required to implement the solution = 9.2?	Understand that if the solution is not completely defined, probably it won't be well implemented.	To design and describe the solution for the specific case including notes for the optimal implementation in the construction site and identifying critical points	Architect (Building arquitect according to ISCO-08).
11.3		National regulations about energy performance and air-tightness conditions = 6.1	understand where and how airtighness is implemented in the calculation model	introduce the solution into the calculation model - being able to use the software needed	Architect (Building arquitect according to ISCO-08)
11.4		Detail airtight passages	Understand how to detail airtight passages	Create constructive details for airtight passage	Architect (Building arquitect according to ISCO-08).
11.5		Knowledge about characteristics of different materials	Understands what implications a solution exceeding its life cycle has on energy performance	To define the life cycle of the solution (needed for the maintenance plan)	Architect (Building arquitect according to ISCO-08)
12.1	BIM-model	Know what is a BIM model (compared to a 3-D model) = 10.2	Understand how to use BIM as a tool to include all the data associated to the seal solution selected	Associate the data to the BIM model	BIM engineer / BIM architect
13.1	team skills	The quality of a company = how to define this as knowledge	Understand when a company delivers good projects	Analyse the company results in terms of projects	project manager
13.2		Legal requirements about airtightness = 6.1	Understand the air-infiltration determinators	analyse the company results in terms of airtightness tests for similar projects	project manager
13.3		Use of a BIM model	understand the necessity of using a BIM model on site, including by blue collars	verify that the implementation team is able to read a BIM model	project manager
14.1	implement ation	Explain the technical solution	Pedagogical skills	Present a technical solution to blue collars	Company structural eng.
14.2		Benefits of an air-tight building	Understand the technical solution for airtight perforation	Organize full-size on-site test of the solution Verify that the implementation is done according with the design	General/works foreman
14.3		Benefits of BIM models	Use of BIM viewers	Verify that the implementation team is able to read a BIM model	General/works foreman
15.1	presen tation	All material and products to be used = 14.1	pedagogical skills	Present the technical rules to blue collars	Company structural eng., project manager
16.1	make airtight passage	All material and products to be used	Understands how the passage has to be made and what difficultes may be encountered	use the materials and products for the airtight passage	Company structural eng.
16.2		All material and products to be used	what difficultes may be encountered	make the airtight passage	blue collars /works foreman
16.3		Knows where the perforations are located in the model	Sees what difficultes may be encountered	Indicate the diameters of the holes as close as possible to the required penetrations	General/works foreman
16.4		Update BIM model	to visualize a BIM model on a device and to identify passages/joints in the BIM model	Check if the BIM designed position is compatible with actual state of realization	General/works foreman
16.5		Correct implementation = 16.2	Understand how to complete the work	Outside : Place a PU or silicone seal Inside : place a acrilic seal	blue collars
17.1	quality check	Intermediate airtightness test(s) = 14.2?	Understand how to evaluate - the moment to perform the internediate test - the part of the project on which perform the test - how to check the origine of each leakage	evaluate the quality of the results In case of low performance, establish a remediation programme	General/works foreman
17.2		Quality of the realisation of the final airtightness test	how to check the origine of each leakage	evaluate the quality of the results In case of low performance, establish a remediation programme	General/works foreman
17.3		What are the weakest points	Why did these tasks entailed a poor airtightness	Draft a quality management program	General/works foreman
18.1	as build plans	Why is the requested level specified	How to obtain this level	Specify the modalities of airtightness tests (during construction, at the end of construction)	client, architect,
18.2		Impact of further works on airtightness	Understand how other works can have influence on the realised airtightness	Specify the informations to be given in the final/as-built BIM model (in order to be able to made modifications, without any effect on airtightness)	client, architect,

19.1	maintaining airtightness	Meaning of building airtighness	Understands the benefits of an air-tight building & Understands the importance of air-tightness as part of energy conservation concept	Draft specifications in order to keep the origina airtightness level	Facility manager
19.2		Keep a high level of airtightness	Understands the impact of small (and large) modification(s) on airtightness	Explain the concept of airtightness to janitor, users, small companies and craftmen	Facility manager